Australian Government
Rural Industries Research and Development Corporation

Cultivation of Native Food Plants in South-eastern Australia

A report for the Rural Industries Research and Development Corporation

by Maarten Ryder and Yvonne Latham

January 2005

RIRDC Publication No 04/178
RIRDC Project No CSL-11A

ISBN 1 74151 087 2
ISSN 1440-6845

Cultivation of Native Food Plants in South-eastern Australia
Publication No. 04/178
Project No. CSL-11A

Researcher Contact Details
Dr Maarten Ryder
CSIRO Land and Water
PMB 2 Glen Osmond
SA 5064

Phone: (08) 8303 8534
Fax: (08) 8303 8684
Email:Maarten.Ryder@csiro.au

In submitting this report, the researcher has agreed to RIRDC publishing this material in its edited form.

RIRDC Contact Details
Rural Industries Research and Development Corporation
Level 1, AMA House
42 Macquarie Street
BARTON ACT 2600
PO Box 4776
KINGSTON ACT 2604

Phone: 02 6272 4819
Fax: 02 6272 5877
Email: rirdc@rirdc.gov.au.
Website: http://www.rirdc.gov.au

Published in January 2005
Printed on environmentally friendly paper by Canprint

Foreword

The Australian native food industry is an emerging industry, which aims to utilise our country's natural assets to develop new sources of income, both domestically and via export. To date, the industry has largely been based on the wild harvest of produce, however this cannot continue indefinitely. A shift towards cultivation is encouraged, for the sustainability of the industry and for the preservation of native genetic resources for the future.

Some of the native species are being improved through selection and breeding, and some of these projects have been supported by RIRDC. The improved plant material must be produced under cultivation from nursery-propagated plants. The industry needs further improved plant material, as well as knowledge of best production methods and markets for the produce.

The aim of this project was to evaluate the performance in cultivation of key native food species across a range of climates and soil types in South-eastern Australia. A series of field trials has been established in 2001-2003 and this report presents the results of the plant establishment phase since planting.

This project was partially funded from RIRDC Core Funds, which are provided by the Australian Government.

This report, an addition to RIRDC's diverse range of over 1,200 research publications, forms part of our New Plant Products R&D program (Native foods section). This program aims to sponsor research towards the development a profitable, agriculturally and environmentally sustainable plant-based Australian native food industry that is founded on an international reputation for the reliable supply of consistently safe and high quality food, and that recognises Aboriginal culture, food practices and involvement.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- downloads at www.rirdc.gov.au/fullreports/index.html
- purchases at www.rirdc.gov.au/eshop

Tony Byrne
Acting Managing Director
Rural Industries Research and Development Corporation

Acknowledgments

The native foods industry is based upon traditional Aboriginal knowledge and skills in the selection and use of Australian native food plants

Funding: Aboriginal Employment Program, (Department of Further Education, Employment, Science and Technology SA Government; with special acknowledgement of the support and encouragement we received from Rob Lucas); Food South Australia and PIRSA (Kangaroo Is site); Junee Correctional Centre (Junee site); Coles Indigenous Food Fund and especially Chris Mara of Coles; Aboriginal Land Care, Eyre Peninsula SA (via John Hammat, Ceduna site).

Steering Committee: Barry Philp, PIRSA; Andrew Beal, Australian Native Produce Industries; Rosemary Warren, CSIRO Land and Water; Anthony Hele, who also generously gave advice on various aspects of crop maintenance.

Plants: Australian Native Produce Industries, Paringa SA, donated much of the planting material for this project (thanks to Andrew Beal and Graham MacNaughton). Brian King, Kee Technologies Adelaide donated munthari plants.

Trial site owners / operators: a great deal of the work reported here was carried out by our group of field site co-operators, who are thanked sincerely for all their efforts and support of the research.

- Jamestown Community School (Kath and Darren Liddle, Kay Jaeschke, Don Mudge, Jenni Harvie and students);
- Narungga Aboriginal Progress Association, Moonta SA (Lesley and Michael Wanganeen, Ian Dorrell, Keith Hoppo and Kevin Dyson and the team);
- Andermel Pty Ltd, Parndana, Kangaroo Island (John Melbourne and Bernie Putney);
- Simarloo Australia Pty Ltd (Noel and Leroy Sims, Craig Trezise and their team);
- Ken Jones, Lyn Jones, Nancy van Zelst and Greg Philcox;
- John Ruiter and Lies Ruiter;
- Barry Clugston and Dorothy Henty;
- Junee Correctional Centre (Phil Goodman, John I'lijevic, Mark Turner, Geoff Cooke and their team), Latarnie McDonald NSW Agriculture, Wagga Wagga;
- TWT Ceduna (Robyn Schmiechen, Sue Smith, Paula Peel, Ivan Phillips; Bushy and the rest of the team).

Valuable assistance: Rosemary Warren (CSIRO, trial establishment, statistical analysis), Ben Cavuoto (CSIRO, irrigation installation), Marie O'Hanlon (CSIRO, data checking and processing), Richard Merry (CSIRO, soil descriptions), Communications group at CSIRO Land and Water (Lynne Griffiths, Claire Peddie, Greg Rinder and Bob Schuster (graphics and media matters), Adrian Beech and staff (chemical analysis). CSIRO Forestry Mount Gambier for hosting Yvonne Latham.

Irrigation design: Shane Larkin and Don Cameron of Netafim Australia are thanked for their work on irrigation system design.

Field trial design: Dr Emlyn Williams, CSIRO Forestry and Forest Products.

Neville Bonney is thanked for his encouragement, enthusiasm and practical assistance in the early phase of the trial planting.

Other suppliers of planting material: Rhys Freeman and Peter Olarenshaw (mountain pepper), Mike and Gayle Quarmby, Peter Smith, Rick Jacobs and Wildstuf Nursery (quandong), Tim Vercoe (Acacia seed), Russell and Sharon Costin (riberry), George Woodifield (sandalwood).

Mulch and compost: van Schaik's BioGro, Mt Gambier SA.

Photo credits: Figures except Figure 4, CSIRO. Figure 4 Fiona Ryan

Abbreviations

ANPI	Australian Native Produce Industries
CSIRO	Commonwealth Scientific and Industrial Research Organization
LSD	Least Significant Difference
PBR	Plant Breeders' Rights
PIRSA	Primary Industries and Resources South Australia

Contents

FOREWORD ..... **III**

ACKNOWLEDGMENTS ..... **IV**

ABBREVIATIONS ..... **V**

EXECUTIVE SUMMARY ..... **VII**

1. INTRODUCTION **1**

1.1 CULTIVATION OF NATIVE FOOD PLANTS 1
1.2 OBJECTIVES OF THE STUDY 2

2. TRIAL SITES AND PLANTING MATERIAL **4**

2.1 SITES 4
2.2 SOIL TYPE AND ANALYSIS 4
2.3 PLANTING MATERIAL 4

3. FIELD TRIAL DESIGN, ESTABLISHMENT AND MAINTENANCE **10**

3.1 FIELD TRIAL LAYOUT AND DESIGN 10
3.2 FIELD TRIAL LAYOUT AND DESIGN AT CEDUNA 12
3.3 FIELD TRIAL DESIGNS 12
3.4 FIELD TRIAL ESTABLISHMENT 12
3.5 IRRIGATION 14
3.6 TRIAL MAINTENANCE AND CALENDAR OF EVENTS 15
3.7 DATA COLLECTION AND ANALYSIS 16

4. PLANT SURVIVAL, GROWTH AND VIGOUR **17**

4.1 PLANT PERFORMANCE ACROSS TRIAL SITES 17
4.2 PLANT PERFORMANCE AT EACH TRIAL SITE 48

5. DISCUSSION OF RESEARCH FINDINGS **67**

5.1 QUANDONG 67
5.2 ACACIA VICTORIAE 67
5.3 CITRUS 68
5.4 MOUNTAIN PEPPER 68
5.5 LEMON MYRTLE 69
5.6 LEMON ASPEN 69
5.7 RIBERRY 69
5.8 MUNTHARI / MUNTRIES 70
5.9 BUSH TOMATO 70

6. GENERAL CONCLUSIONS **72**

7. REFERENCES **76**

Executive Summary

The emerging native foods industry is beginning to rely more on cultivated produce. Wild harvest of produce still forms an important component of the supply chain, but the cultivation of the native food plants will be necessary for a sustainable industry in the future. The process of plant improvement has begun with some native food species and these improved selections, hybrids and provenances must be grown from nursery-propagated plants.

This project on the cultivation of native foods was undertaken for several major underlying reasons.

1. Encourage a shift from wild harvest to cultivation to:
   - improve sustainability of the native food industry,
   - improve production: quantity, quality and timing (eg from improved planting material)
   - maintain wild genetic diversity as a resource for future industry development
2. Help Australia to maintain its international competitiveness
3. Assist Aboriginal communities to develop greater economic independence, by using native foods, which are a part of Aboriginal culture.
4. Promote diversification of farm and horticultural enterprises in general

Australia now has a mature horticultural industry based on the cultivated production of the native *Macadamia*. However this was not always the case, and Australia has only recently become the world's No. 1 producer of this nut crop. Many cultivars were developed in the USA. We are now at the very early stages of developing more industries based on native food species. If there is a concerted effort across a range of activities (cultivation, plant improvement, product and market development), we may well be able to repeat the success of *Macadamia* with other species.

There has been little information available to growers of native food plants on how best to grow these plants or even where they can be expected to grow and yield well. There has been little attempt to systematically test the performance of native food plants in a range of environments.

The aims of this project were to establish a series of field trials in a range of conditions in south-eastern Australia, to test the survival, growth and yield of key native food species. The species tested were: quandong, *Acacia victoriae*, *Citrus* (selection and hybrids), mountain pepper, lemon myrtle, lemon aspen, riberry, bush tomato and munthari (muntries).

Trials were established in spring 2001 at Jamestown (SA), Moonta (SA), Kangaroo Island (SA), Lyrup (SA Riverland), Pt MacDonnell (SA), Stawell (Vic) and Junee (NSW) as well as a small site at Mt Gambier (SA). An additional site was planted at Ceduna (SA) in spring 2002. The area of the large trials is approximately 2/3 ha with 288 trees and 128 shrubs planted at each site. The trees and shrubs are arranged in separate blocks, each designed for statistical analysis of the data within and across sites. All of the large trials are drip-irrigated. Compost and mulch were applied to all surviving plants in the spring of 2003 in an effort to assist weed control, conserve water and add nutrient to the soil.

Plant survival, and the growth and vigour of surviving plants were recorded between planting and 2 years after planting. The results show that the species tested can be divided into three broad categories. Those that are able to survive and grow well in a range of environments are *Acacia victoriae*, *Citrus* and lemon aspen. Plants with an intermediate range are lemon myrtle, riberry, munthari and quandong as well as bush tomato if grown as an annual crop. Munthari and quandong could be grown successfully in a wide range of environments if seedling establishment problems (cause by soilborne disease?) can be solved and special seedling protection (quandong) is used. Plants with a restricted range are mountain pepper

(which requires moist soil conditions) and bush tomato if grown as a perennial (requiring warmer, well-drained soil conditions).

In addition to these broad categories, suggestions are made for the specific early management of the different species to improve establishment and growth.

Some plant species have begun to flower and set fruit, but most are yet to come into production. Bush tomato and munthari have yielded the greatest amounts of fruit in the first two years. *Acacia*, *Citrus* and lemon aspen have produced fruit sporadically and in very small amounts, at some of the trial sites.

Although many of the species have survived and grown well at a variety of sites, it remains to be seen whether they can produce good yields of reasonable quality. It is hoped that future reports will present yield data and also information about quality of produce.

1. Introduction

1.1 Cultivation of native food plants

There has been increasing interest in the cultivation of Australian native food species in recent years. It should be noted at the outset that the native foods industry (excluding *Macadamia*) is at a very early stage of development, and therefore has the problems of any emerging industry (such as matching production to markets and increasing markets, the need for education etc). Nevertheless, there is a range of people that includes horticulturalists and Aboriginal communities who are interested in the possibility of growing native food plants. There are markets for native food ingredients, and various segments of the market place are keen to use the unique flavours and textures offered by some of the native produce. For best chances of success, both production and markets must be developed in tandem.

There are currently hundreds of growers of native foods in Australia, but few of these are producing substantial amounts of product. There is also a generally agreed "list" of species whose produce is in demand (eg Graham and Hart, 1997; Ahmed and Johnson, 2000). However, there is a dearth of basic knowledge about the cultivation of most of the species that are currently considered as high priority for commercial development. Most growers have had to discover for themselves, or with a minimum of authoritative advice, how best to grow these novel crops.

This project on the cultivation of native foods was undertaken for several major reasons.

1. Encourage a shift from wild harvest to cultivation to:
   - improve sustainability of the native food industry,
   - improve production: quantity, quality and timing (eg from improved planting material)
   - maintain wild genetic diversity as a resource for future industry development
2. Help Australia to maintain its international competitiveness
3. Assist Aboriginal communities to develop greater economic independence, by using native foods, which are a part of Aboriginal culture.
4. Promote diversification of farm and horticultural enterprises in general

The *Macadamia* industry, which barely existed in Australia 50 years ago is now a mature horticultural industry worth A$85 million p.a. at the farm gate and $120 million p.a. value–added. Australia has in recent years become the number one producer of *Macadamia* in the world, but only after adopting the cultivation of this Australian native plant from the USA. We have before us an opportunity to develop similar industries based on other native Australian plants while maintaining our competitive position internationally.

Excluding *Macadamia*, the native food industry in Australia is in transition between relying on wild-harvested produce to the cultivation of native produce. In order to build industry capacity, and to allow increases in the size of the harvest and the quality of produce, it is essential to cultivate the native food species. There are also several other important reasons why cultivation is critical to industry development.

A key to industry success is the development of improved planting material. For several of the native food species, cultivars, hybrids and provenances have been selected for their desirable characteristics (e.g. fruit size, taste, agronomic traits such as erect habit, and produce acceptability traits such as colour and seedlessness). Examples are Mountain Pepper, Riberry, Citrus, Munthari, Quandong, Bush Tomato. This improved planting material must of necessity be grown in cultivation from nursery-propagated stock.

Cultivation of native food plants should result in the harvest of produce being more reliable in its timing, amount and quality. Variation in growing conditions from season to season means that wild harvested produce will vary considerably from year to year in availability and quality, which will cause problems in continuity of supply unless adequate storage methods can be developed.

For a number of native food species there is reasonable capacity for wild harvest to continue to expand at the moment. However, wild harvest does threaten the survival of some of the species which have a limited distribution and for which there is difficulty in propagation, and therefore cultivation. For other species, wild harvest could begin to threaten survival if the demand continues to grow. The retention of native wild genetic resources is of prime importance to the development of new industries based around native foods.

Aboriginal communities, farmers and horticulturalists are three groups who have been looking at native food production as a new way to diversify their activities. In the case of Indigenous communities, who are looking for ways to develop new businesses, and family and community incomes, the intimate connection between native foods and culture is an obvious driver of their interest and desire to be a part of the industry.

From the environmental perspective, there is a need for change in Australia's agricultural systems, to reduce the impact caused by some of the more detrimental farming practices. In the longer term, the successful cultivation of native food plants may be part of this change, as long as efficient production systems (and markets) can be developed for crops that can use less water and/or can be farmed on a broader scale. This must remain a long term goal because neither the production systems nor the markets have yet been developed, but can be considered as a serious ambition.

Information about the suitability of native food species for cultivation in different regions has been lacking. In this project, CSIRO has established a series of 9 native foods field trials in southeastern Australia, working closely with a range of industry and grower partners. The plant list chosen was: quandong, *Acacia victoriae*, native and hybrid *Citrus*, mountain pepper, lemon myrtle, lemon aspen, riberry, bush tomato and munthari (muntries). Different selections, provenances, varieties and hybrids (some of which are protected by PBR) were included wherever these were available. Information on the establishment and early growth of the plants has been collected and analysed since planting in 2001, and is presented in this report.
The collection of yield data has only just begun, and for only one of the species. For the tree species it may take up to 5-7 years for plants to come into reasonable production. This report focuses on the establishment and early growth of the native food species chosen for these trials.

1.2 Objectives of the study

- To establish 6 field trials across south-eastern Australia, in a range of climates and soil types, to evaluate the performance (establishment, growth, vigour, yield) of 6 native food species.
- Communication of findings for informed decision-making on the choice of native food species or cultivars for climatic and soil type zones.
- To provide scientific training of an Aboriginal / Torres Strait Islander.

Figure 1. Meeting of research and field site teams, Adelaide, April 2004

2. Trial sites and planting material

2.1 Sites

Sites were chosen to represent a variety of soil and climatic conditions in south-eastern Australia (Figure 2). Site locations and characteristics are listed in Table 1.

2.2 Soil type and analysis

Soil types were assigned by Richard Merry, CSIRO Land and Water, using the Australian soil classification system of Isbell (1996) and are presented in Tables 1 and 2A. Soil chemical characteristics (top 10 cm, air-dried) were analysed by the by the Analytical Chemistry Services of CSIRO Land and Water Adelaide, and are listed in Table 2A and 2B.

2.3 Planting material

The planting material was sourced from a variety of suppliers as shown in Table 3. All trials were planted from the same batches of plant material obtained from the suppliers listed. All *Citrus* were grafted on to Troyer citrange. Quandongs were either grown from seed or grafted onto seedling rootstocks (Frahn's Paringa Gem and CSIRO selections). The following were produced clonally from cuttings: all mountain pepper provenances, riberry selections and hybrid, lemon aspen, lemon myrtle and munthari selections. *Acacia* and *Solanum* were grown from seed by ANPI nursery, Paringa SA. Desert lime is a selection. Sunrise Lime is a trigeneric finger lime hybrid *Microcitrus* x Calamondin (Calamondin is also a hybrid of *Fortunella* x *Citrus*) (Sykes, 2002); Blood Lime is a finger lime hybrid of *Microcitrus* x exotic *Citrus* (Sykes, 2002).

Figure 2. Location of trial sites

Natural geographic ranges

Quandong: *Santalum acuminatum* (R.Br.) A.DC. (Santalaceae):
semi-arid & arid SA, WA, NT, Qld, western NSW, NW Vic

Elegant wattle *Acacia victoriae* Benth. (Mimosaceae):
wide distribution, semi-arid to arid SA, NT, Qld, WA, NSW, NW Vic.

Desert lime *Citrus glauca* (Lindl.) Swingle (Rutaceae):
arid zone SA, NSW, Qld

Finger lime *Citrus australasica* F.Muell. (Rutaceae):
east coast NSW, Qld

Mountain pepper *Tasmannia lanceolata* (Poir.) A.C.Sm. (Winteraceae):
cool temperate rainforest understorey ACT, NSW, Vic, Tas.

Lemon myrtle *Backhousia citriodora* F.Muell. (Myrtaceae):
east coast Qld

Lemon aspen *Acronychia oblongifolia* (Hook.) Heynh. (Rutaceae):
east coast Qld, NSW, Vic.

Riberry *Syzygium luehmannii* (F.Muell.) L.A.S.Johnson (Myrtaceae):
east coast NSW, Qld.

Bush tomato *Solanum centrale* J.M.Black (Solanaceae):
arid zone NT, SA, WA

Munthari, muntries: *Kunzea pomifera* F.Muell. (Myrtaceae):
coastal and inland southern SA, Vic

Table 1 Location of field trial sites, soil and climate data

Site	Latitude	Longitude	Elevation (m)	Soil type	Average annual rainfall (mm)*	Site owner / operator
Jamestown SA	33°12´S	138°36´E	458	Hypocalcic Calcarosol	556 (Bundaleer Forest Reserve)	Jamestown Community School
Moonta SA	34°04´S	137°35´E	44	Lithocalcic Calcarosol	390 (Kadina)	Narungga Aboriginal Progress Association
Parndana SA	35°47´S	137°15´E	155	Brown Chromosol	629 (Parndana East Res. Stn)	Andermel Pty Ltd
Lyrup SA	34°15´S	140°39´E	66	Hypercalcic Calcarosol	262 (Berri)	Simarloo Australia Pty Ltd
Port MacDonnell SA	38°03´S	140°41´E	5	Black Dermosol	704 (Cape Northumberland)	K Jones
Mt Gambier SA	37°39´S	140°43´E	63	Eutrophic Brown Chromosol / Sodosol	710 (Mt Gambier Aero)	J & L Ruiter
Stawell Vic	37°03´S	142°46´E	203	Red Chromosol	576 (Stawell)	B Clugston & D Henty
Junee NSW	34°52´S	147°34´E	280	(Red earth)	527 (Junee)	Junee Correctional Centre
Ceduna SA	32°07´S	133°40´E	15	Lithocalcic Calcarosol	301 (Aviation Met Office)	Tjutjunaku Worka Tjuta Inc, Ceduna

* long-term average rainfall, nearest weather station (Bureau of Meteorology)

Table 2A												
NATIVE FOOD TRIALS	**SOIL ANALYSES (top 10 cm)**		**E.C. (dS/m)**	**pH (1:5 soil:water)**	**pH (0.01M $CaCl_2$)**	**Chloride (mg/kg)**	**Total Carbon (%)**	**Organic Carbon (%)**	**CO_3 as $CaCO_3$ (%)**	**Total Nitrogen (%)**	**I---- KCl ext. ----I**	
		Sample year									**NH_4-N (mg/kg)**	**NO_3-N (mg/kg)**
Location	Soil description											
Ceduna	Lithocalcic Calcarosol	2002	0.28	9.4	8.6	n.d.	7.7	2.1	47	0.13	2.1	7.3
Jamestown	Hypocalcic Calcarosol	2001	0.39	6.2	5.7	n.d.	2.8	2.8	0.35	0.29	16	67
Moonta	Lithocalcic Calcarosol	2001	0.14	8.5	7.8	17	3.14	1.6	7.7	0.14	3.4	2.0
Kangaroo Island	Brown Chromosol	2001	0.08	5.9	4.9	22	2.8	2.8	0	0.21	6.3	3
Lyrup	Hypercalcic Calcarosol	2001	0.18	9.0	8.1	12	1.66	1.2	2.3	0.13	6.3	26
Pt MacDonnell	Black Dermosol	2001	0.10	6.6	6.0	25	5.2	5.2	<0.1	0.46	13	9.2
Mt Gambier	Eutrophic Brown Chromosol / Sodosol	2003	0.08	6.0	5.3	n.d.	2.0		<0.5	0.18		
Stawell	Red Chromosol	2001	0.04	5.4	4.3	13	1.6	1.6		0.10	7.6	2.2
Junee	(Red earth)	2001	0.06	6.0	4.9	24	3.7	3.7		0.28	5.5	3.1

E.C. = electrical conductivity

Table 2B																					
TRIAL LOCATION	$CaCl_2$ - ext. B (mg/kg)	Total P (mg/kg)	HCO_3 - ext. P (mg/kg)	HCO_3 - ext. K (mg/kg)	|…….Exchangeable cations ……..|						C.E.C.		I---------- DTPA ext ----------I				Clay (%)	Silt (%)	Fine Sand (%)	Coarse Sand (%)	Total (%)
					pH of extract	Ca	Mg	Na	K	Sum	(NH_4^+)	(Cl)	Cu	Fe	Mn	Zn					
					I ……..cmol(+)/kg ……..I								I---------- mg/kg ----------I								
Ceduna	n.d.	280	15	400	8.5	8.0	2.4	0.68	0.99	12	8.2	n.d.	0.3	3.4	2.2	0.9	n.d.	n.d.	n.d.	n.d.	n.d.
Jamestown	n.d.	690	83	1253	7.0	12	3.8	0.16	3.3	18.9	21.2	0.1	2.3	43	121	11	26.4	22.0	37.2	7.4	93
Moonta	2.1	n.d.	30	610	8.5	13.8	1.6	0.13	1.63	17.1	14.7	14.82	3.9	3.8	9.6	0.9	9	38	53		100*
Kangaroo Is +	0.63	n.d.	17	128	4.0	2.4	0.7	0.10	0.27	3.4	6.7	6.8	0.4	47	0.7	0.5	11.4	5.7	39.9		57*
Lyrup	2.0	n.d.	29	600	8.5	9.5	2.0	0.58	1.59	13.6	12.5	12.62	0.7	2.5	4.1	0.6	34	9	57		100*
Pt MacDonnell	2.1	n.d.	150	39	7.0	22.8	1.7	0.15	0.37	25.0	23.5	23.55	2.3	200	12	21	21	15	64		100*
Mt Gambier			26	36																	
Stawell	0.2	n.d.	1	101	7.0	0.8	0.6	<0.10	0.16	1.6	4.6	4.32	<0.1	165	3.5	0.3	2	0	98		100*
Junee	1.1	n.d.	36	390	7.0	3.7	1.2	0.16	0.89	5.8	11.1	12	0.7	72	0.8	1.0	18	10	72		100*

Ext = extractable, B = boron, P = Phosphorus, K = potassium, C.E.C. = cation exchange capacity, DTPA = diethylenetriaminepentaacetic acid
n.d. = not determined

+ Kangaroo Island trial site soil is 43 % gravel
* Estimated from Mid-infra-red spectrocopy

Table 3. List of species and selections

Common Name	Species	Selection / Provenance	Source / Supplier	Origin
Quandong	*Santalum acuminatum*	"Frahn's Paringa Gem" *	Grafted, ANPI, Paringa SA	D. Frahn, Paringa SA
Quandong	*Santalum acuminatum*	Eyre Peninsula provenance	Seed, Wildstuf Nursery, Kimba SA	Eyre Peninsula, SA
Quandong	*Santalum acuminatum*	From orchard, seed	Seed, Reedy Creek Nursery, SA	G. Herde, Nectar Brook SA
Quandong	*Santalum acuminatum*	From orchard, seed	Seed, R Jacobs	R. Jacobs, Pt Augusta SA
Quandong	*Santalum acuminatum*	CSIRO selections (9-26, 6-16, 11-1)	Grafted, Sunraysia Nursery, Mildura, Vic	CSIRO Horticulture
Creeping boobialla	*Myoporum parvifolium*	HOST PLANT for quandong	Coromandel Valley Nursery, SA	
Elegant wattle	*Acacia victoriae*	Hawker provenance	Seed, ANPI	Hawker, SA
Elegant wattle	*Acacia victoriae*	other provenances (Ivanhoe, Wilmington, Copley, Buronga)	Seed, Australian Tree Seed Centre (ATSC, CSIRO) / ANPI	ATSC Collection, Canberra
Blood lime (hybrid finger lime)	*Citrus* sp	Australian Blood Lime *	Grafted on to Troyer citrange, CSIRO / ANPI	Sykes (2002)
Desert lime (selection)	*Citrus glauca*	CR101-13	Grafted on to Troyer citrange, CSIRO / ANPI	Sykes (2002)
Sunrise lime (hybrid finger lime)	*Citrus* sp	Australian Sunrise Lime *	Grafted on to Troyer citrange, CSIRO / ANPI	Sykes (2002)
Mountain Pepper	*Tasmannia lanceolata*	Toora provenance	Cuttings, R. Freeman, Gippsland, Vic	Toora, Vic
Mountain Pepper	*Tasmannia lanceolata*	Captain's Flat Provenance	Cuttings, Bywong Nursery, ACT	Captain's Flat, ACT
Mountain Pepper	*Tasmannia lanceolata*	Other provenances (Mt Macedon, Cape Barren Is, Black Spur)	Cuttings, R. Freeman, Gippsland, Vic	See column 3
Lemon Myrtle	*Backhousia citriodora*	ANPI selection	Cuttings, ANPI	Not available
Lemon Aspen	*Acronychia oblongifolia*	ANPI selection	Cuttings, ANPI	Not available
Riberry	*Syzygium luehmannii*	ANPI selection	Cuttings, ANPI	Not available
Riberry (hybrid)	*S. luehmannii x S. wilsonii*	"Cascade" *	Cuttings, Limpinwood Nursery, NSW	Mike Jessop
Riberry	*Syzygium luehmannii*	"Vic's Choice" (seedless)	Cuttings, Limpinwood Nursery, NSW	via Vic Cherikoff
Munthari	*Kunzea pomifera*	'Rivoli Bay' *	Cuttings, ANPI	Rivoli Bay, SA
Munthari	*Kunzea pomifera*	M4	Cuttings, Brian King, Rhynie SA	Ki Ki, SA
Bush tomato / desert raisin	*Solanum centrale*		Seed, ANPI	Utopia, NT

* PBR protected.

3. Field trial design, establishment and maintenance

3.1 Field trial layout and design

Each trial was laid out with separate tree and shrub blocks. Trees were planted in plots consisting of 12 trees each, in a 4 x 3 arrangement (Figure 3). The 6 plots of different tree species were each planted in 4 replicates. Thus the usual number of trees per species per trial was 48 (i.e. 12 trees per plot x 4 replicates). The exceptions were lemon myrtle (36 trees per trial) and lemon aspen (12 trees per trial) which were placed within the same plot. Total tree number per site was 288 (i.e. 12 trees per plot x 6 species x 4 replicates). The exception was at Port MacDonnell where the tree block was replicated only 3 times, owing to size constraints, giving a total number of 192 trees. The 72 remaining trees that were not planted at Pt MacDonnell, were planted as a small trial just north of Mt Gambier (40 km north of Pt MacDonnell); these 72 trees were planted as plots of four trees, with three replicates (4 trees per plot x 6 species x 3 replicates), again using 4 x 4 metre spacings.

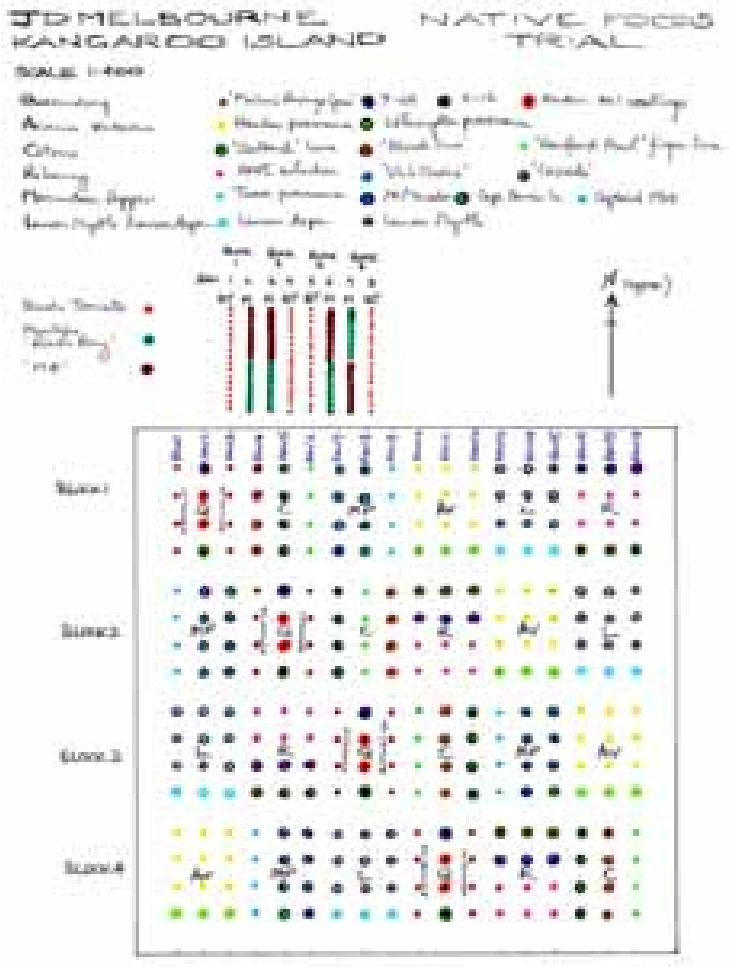


Figure 3. Example of field site layout, Kangaroo Island trial.

Table 4 Numbers of trees of each species / selection per trial (* = PBR protected)

Common Name	Selection / Provenance	Trees per trial	Trees per trial (Port MacDonnell)
Quandong	"Frahn's Paringa Gem" *	16	12
Quandong	Eyre Peninsula provenance	8	6
Quandong	Reedy Creek Nursery	8	6
Quandong	R. Jacobs Pt Augusta	8	6
Quandong	CSIRO selections (9-26, 6-16, 11-1)	8	6
Elegant wattle	Hawker provenance	36	27
Elegant wattle	other provenances (Ivanhoe, Wilmington, Copley, Buronga)	12	9
Blood lime (hybrid)	"Australian Blood Lime" *	16	12
Desert lime (selection)	CR101-13	16	12
Sunrise lime (hybrid)	"Australian Sunrise Lime" *	16	12
Mountain Pepper	Toora provenance	24	18
Mountain Pepper	Captain's Flat Provenance	16	12
Mountain Pepper	Other provenances (Mt Macedon, Cape Barren Is, Black Spur)	8	6
Lemon Myrtle	ANPI selection	36	27
Lemon aspen	ANPI selection	12	9
Riberry	ANPI selection	24	18
Riberry (hybrid)	"Cascade" *	12	9
Riberry	"Vic's Choice"	12	9
TOTAL		**288**	**192**

Within the 12-tree plots, selections, provenances and hybrids were planted in numbers which reflected their availability. Table 4 lists the number of plants per trial for each of the 18 species / selections.

Trees were usually spaced in a grid 4 metres x 4 metres within plots and plots were separated from each other by 6 metres where space permitted. At Lyrup the row spacing was 6.2 metres to accommodate mowing machinery.

Shrubs were planted in 8 rows spaced 3 metres apart. Each row was planted with 16 plants at 1-metre spacings (14 plants per row at some sites). The shrub block was laid out as 4 sets (replicates) of 2 rows (1 row each of munthari and bush tomato). Within each replicate, the two species were randomly assigned to the two rows. Rows of bush tomato were not subdivided. Rows of munthari were divided in half so that the plants at one end were "Rivoli Bay" and at the other end were "M4" selection. There were 8 plants of each munthari selection (or 7 in some trials), randomly assigned to one end of the row or the other.

3.2 Field trial layout and design at Ceduna

The trial at Ceduna, established in August 2002, consisted of separate tree, shrub and "climber" blocks. The tree block contained 48 trees each of Quandong, *Acacia victoriae* and *Citrus* arranged largely as for other sites (see Table 3), plus sandalwood (*Santalum spicatum*) sourced from George Woodifield, Moonta.

The shrub block at Ceduna is planted with two species, in 4 replicate rows, each 15 metres long and 3 metres apart. The species are bush tomato (*S. centrale*) and konker berry (*Carissa lanceolata*) obtained from Reedy Creek Nursery, Kingston SE South Australia, 64 plants (4 x 16) of each.

A block of "climbers" was also established with three species in four replicate rows each 15 metres long, 3 metres apart, with plants at 1-metre spacings. The climber block was planted with 64 plants each of munthari (*Kunzea pomifera*; 32 plants of "Rivoli Bay" and 32 of M4 selection, as for other field trials), bush banana (*Marsdenia australis*) from Reedy Creek Nursery and sweet appleberry (*Billardiera cymosa*) purchased from Alexandrina Community Nursery at Middleton, SA. The plants are being trained on to simple trellises (approx. 1.6m high, with 4 to 5 wires approx. 40cm apart).

Figure 4. Installing irrigation at Ceduna

3.3 Field trial designs

The assignment of tree species to trial plots for every trial was done by Dr Emlyn Williams, CSIRO Forestry and Forest Products, using CycDesigN software (Williams et al., 2002, see Figure 3 for an example).

3.4 Field trial establishment

Site preparation was carried out as indicated in Table 5. Trees and shrubs were planted using either a Hamilton tree planter or narrow spades. Plants were hand watered on the day of planting to ensure good contact to the surrounding soil. Plant height (trees only) was recorded within two days after planting.

Weed control prior to planting was by use of Roundup (low non-target toxicity) at Pt MacDonnell. No herbicide was applied at other sites.

Planting material was obtained in tubes or pots to 15 cm diameter. At planting, trees and shrubs were given 15 g of slow-release fertilizer (Nutricote black; 16% N, 4.4% P, 8.3% K, 270-day release).

Plants were protected at planting by plastic treeguards (43 cm high, 34 cm wide when flat, from Woodchuck, Adelaide) held in a triangular or square shape with bamboo stakes.

Table 5 Site preparation

Site	Site preparation
Jamestown SA	Green manure oats / barley Rotary hoed Oct 2001 Deep ripped to 40 cm Nov 2001 Planted November 2001
Moonta SA	Deep ripped to 40 cm Rotavated to 20 cm Planted September 2001
Kangaroo Is SA	Deep ripped to 60 cm, mounded and then flattened to give 10 cm mound Planted October 2001
Lyrup SA	Rotavated to 15 cm, 1 m wide Holes hand-dug to 25 cm depth, 40 cm across; filled with water, the day before planting Planted November 2001
Pt MacDonnell SA	Deep ripped to 90 cm through a layer of dolomite / limestone; Mounded to 50 cm. Planted October 2001
Mt Gambier SA	Mounded to 25 cm Planted October 2001
Stawell Vic	Deep ripped to 40 cm; Mounded to 15-30 cm Planted November 2001
Junee NSW	Disc plough 35cm, harrowed; Bed-former used to make 30 cm high bed, 1 m across Planted October 2001
Ceduna SA	Deep ripped to 50 cm depth Planted August 2002

3.5 Irrigation

Drip irrigation was laid out either immediately before or after planting. Drip irrigation systems consisted of separate systems for “arid zone” and “high-rainfall zone” plants, except at the small Mt Gambier site, which was hand-watered. Irrigation system manifolds comprised filters, air-release valves and dual solenoids (one for each irrigation zone) controlled by either AC- or DC-powered controllers. Drippers provided 4L per hour, using one dripper per plant. Irrigation systems were designed by Netafim (Australia), Adelaide and were installed by CSIRO staff working with local field site co-operators.

Water was supplied from town supply (Jamestown, Moonta, Junee, Ceduna), dams on the property (Kangaroo Island, Stawell) direct from the River Murray at Pike’s River (Lyrup) or from a bore (Port MacDonnell).

Irrigation regimes

Working with industry consultants, we determined that “arid zone” plants (quandong, *Citrus*, *Acacia*, *Solanum centrale*) should receive 0.6 x as much water as the “high-rainfall zone” plants (mountain pepper, lemon myrtle, lemon aspen, riberry, munthari). The frequency of irrigation was driven by the high water requirement of mountain pepper and was usually every two days or three times per week, except during winter. In the first summer season, the amount of water provided to the high rainfall zone plants varied from 1L to 4L per irrigation event depending on soil type and climatic zone of the site. On a lighter soil, 4L water would wet approx 25 L soil, and on a heavier soil, 1 L would wet approx 10 - 12 L soil. In the second summer, the amounts were doubled at most sites, to be 2L to 4L per irrigation event (wetting approx. 20 - 25 L soil for all soil types). Extra water was given when required at many sites. At the Stawell site, there was a restriction on water available in the second summer. This was caused by low water reserves in the farm dam after a prolonged drought period and careful management was required in an attempt to give plants a reasonable water supply.

Figure 5. Planting shrub block at Stawell

3.6 Trial maintenance and calendar of events

Field trial maintenance

Weeds were controlled by hand weeding around plants inside treeguards and also on mounds (where plants were on raised beds) and by mowing in between the rows. Insect damage was noted from time to time. One insect control treatment was applied: Fenitrothion 1000 to control wingless grasshoppers at the Kangaroo Is. site in the 2002 summer. White snails were controlled using snail bait pellets at Moonta.

Compost and mulch were added to most plants at all trials in the spring of 2003. The main aims were (a) weed control, (b) water conservation and (c) addition of nutrients and carbon to the soils, the latter in an attempt to stimulate soil biological activity. Compost ("Planting Compost") and mulch ("Biomat") was purchased from van Schaik BioGro, Mt Gambier. The main components of the compost (C:N ratio 50) and mulch (C:N ratio 84) are from plantation forest thinning and bark, giving a high cellulose content. Approx 10 L of compost and then 20 L of mulch were applied to each surviving plant in the early summer of 2003-04 (total shipped to each main site was approx. 10 m3).

Calendar of events

The calendar of events is presented in Table 6.

Table 6 Calendar of Events

Date	**Event**
Sept – Nov 2001	Planting, installation of irrigation all sites except Ceduna
May 2002	9-month data collection (shrubs)
June 2002	Meeting of field trial site co-operators and CSIRO, Loxton
July 2002	Additional planting (quandong selections) and re-planting where plants were lost in year 1
Aug 2002	Establishment of Ceduna trial site
Aug – Sep 2002	12-month data collection
Nov – Dec 2002	15-month data collection
Feb 2003	18-month data collection
May 2003	21-month data collection
Aug 2003	24-month data collection
Oct – Dec 2003	Distribution and application of compost and mulch
Mar 2004	30-month data collection
Apr 2004	Meeting of field trial site co-operators and CSIRO, Adelaide

Figure 6. Measurement of plant height (*Acacia*, Jamestown)

3.7 Data collection and analysis

Plant height (to the uppermost leaf) was measured at planting and from 12 months onwards at approximately three-month intervals. Plant vigour was usually recorded at the same time as height. Vigour was assessed on a (subjective) 0 – 100 scale, where 0 = dead; 10 = near dead ("very poor"); 25 = struggling and/or damaged, no new growth ("poor"); 50 = average condition, no new growth ("moderate"); 75 = good condition, some new growth, little or no obvious setback ("good"); 100 = healthy, vigorous, flush of new growth ("very good"). The vigour data were collected by CSIRO project staff for approx half of the observations. Local operators recorded the data at other times. For this reason, data are not strictly comparable between sites at all assessment times.

Plant survival was calculated from either height or vigour data, and the result is presented as the proportion of plants surviving (0 = nil alive; 1 = 100% of plants alive).

Data analysis

Data were analysed using GenStat Release 7.1 © 2003, Lawes Agricultural Trust (Rothamsted Experimental Station) using analysis codes generated by Dr Emlyn Williams, CSIRO. Within-site comparisons for height and vigour were analysed by ANOVA and means were calculated using REML. Survival data (binary) were analysed by ANOVA.

4. Plant survival, growth and vigour

4.1 Plant performance across trial sites

Results for plant establishment during the first 2 years after planting (concluding in August 2003) are presented in Figures 2 - 22. Each Figure presents the results for a different selection, provenance, hybrid or variety, and compares the data recorded across 7 trial sites. Each Figure consists of bar graphs plant survival, growth of surviving plants (height; for trees only) and vigour of surviving plants (for both trees and shrubs).

Table 7 lists the species and selections and where the data can be found in the Figures. Further details on the origin of the various selections and hybrids are found in Table 3.

Table 7 Listing of results by plant species and selection

Species		Selection / provenance / cultivar	Figure
Quandong	*S. acuminatum*	"Frahn's Paringa Gem" * Eyre Peninsula (Wildstuf Nursery) Reedy Creek Nursery R Jacobs, Pt Augusta CSIRO selections (combined)	2 3 4 5 6
Wattle	*A. victoriae*	"Hawker" provenance Other provenances (Wilmington SA, Ivanhoe NSW, Gol Gol NSW or Copley SA, combined	7 8
Citrus	*Citrus* spp.	"Australian Blood Lime" * Desert Lime "Australian Sunrise Lime" *	9 10 11
Mountain Pepper	*Tasmannia lanceolata*	"Toora" provenance "Captain's Flat" provenance Other Provenances (Cape Barren, Mt Macedon, Black Spur) combined	12 13 14
Lemon Myrtle	*B. citriodora*	ANPI selection	15
Lemon Aspen	*A. oblongifolia*	ANPI selection	16
Riberry	*S. luehmannii*	ANPI selection "Cascade" * (hybrid) "Vic's Choice" (selection)	17 18 19
Munthari	*K. pomifera*	"Rivoli Bay" * "M4"	20 21
Bush tomato	*S. centrale*	Utopia provenance	22

* PBR-protected

Key to data Figures 17 – 37: except for Ceduna, time "0" = spring, 12 (months) = August 2002, "15" (months) = November 2002, "18" (months) = February 2003, "21" (months) = May 2003, "24" (months) = August 2003. Thus, **growth between 12 and 15 months = spring; between 15 and 18 months = summer; between 18 and 21 months = autumn; between 21 and 24 months = winter.**

The results are now considered by species and selection / hybrid.

Quandong

(Figures 17 to 21)

Selections

The best survival was shown by the Eyre Peninsula, Reedy Creek Nursery and R. Jacobs planting material, all of which were planted in 2002, approximately 1 year after the host plant (*Myoporum parvifolium*, creeping boobialla). Survival was generally lower for the Frahn's Paringa Gem and CSIRO selections, which were planted in 2001 at the same time as the host.

While initial survival of Frahn's Paringa Gem tended to be lower, those that survived the first year generally continued to survive and show moderate to good vigour. The quandongs from Eyre Peninsula and Reedy Creek Nursery generally showed good growth (height) over the first year.

Sites

At some sites within the natural range of quandong, survival and growth of the later plantings has been good (Moonta, Lyrup). On Kangaroo Island and at Port MacDonnell survival has also been extremely good, though growth and vigour on Kangaroo Island is declining. At Stawell, survival and growth has been excellent, though quandongs do not naturally occur here. It is noteworthy that this soil is nutritionally quite poor (Tables 2A and 2B), and also that plants received less water than originally scheduled owing to restrictions on supply.

Figure 7. Quandong, Lyrup March 2004

Acacia victoriae

(Figures 22 and 23)

Provenances

All provenances of *A. victoriae* survived extremely well in the first two years at all trial sites. Survival was close to 100% in all cases. Vigour was also generally rated as good to very good. The main provenance tested was the Hawker provenance of ANPI (9 trees planted per plot). Other provenances were included (3 trees per plot) to generate additional information on adaptability of the species in relation to source. At this stage all provenances appear to behave very similarly.

Figure 8. *Acacia victoriae* flower buds, Jamestown Oct 2004

Sites

The growth rate varied considerably between sites. Faster growth occurred at Jamestown, Lyrup and Junee and the slowest growth was recorded at Stawell and Kangaroo Island. The growth of *A. victoriae* was distinctly seasonal, with a large increase in height between November (15 months) and February (18 months) at four sites. This growth spurt occurred slightly later in the summer at Moonta and was extended over a longer period at Port MacDonnell.

Where plant growth was much slower (Stawell and Kangaroo Island), there was no clear evidence of seasonality.

A. victoriae has a shrubby habit and has been trained to a moderate extent by pruning at the base to remove lateral branches. The pruning has also necessitated staking in more windy localities.

Flowering and seeding

Occasional flowering and seedpod formation has been seen, in the third summer (2003-04), typically on only one tree of the 12 per plot. This occurred at the sites with faster growth and in the warmer areas (Jamestown, Lyrup, Moonta, Junee).

Citrus

(Figures 24 – 26)

Selections and hybrids

"Australian Blood Lime" (hybrid) and Desert Lime (selection) were planted in year 1. "Australian Sunrise Lime" was planted in year 2. All three were grafted on Troyer Citrange rootstocks. Survival of the Blood Lime and Desert Lime were excellent, with survival near 100% in most locations. Sunrise Lime established well at all locations except Jamestown, Stawell and Ceduna. This hybrid was planted in the second year, which was followed by a much hotter summer. The vigour of Sunrise Limes was generally lower than for the other *Citrus*.

Sites

Growth of the Blood Lime and Desert Lime was greatest at Lyrup and Junee. Overall vigour of the Blood Limes decreased in the order Jamestown = Lyrup = Stawell = Junee (good – very good)> Port MacDonnell > Moonta > Kangaroo Is (poor – moderate). Vigour of the desert limes decreased in the order Jamestown = Lyrup = Junee > Port MacDonnell = Kangaroo Is = Moonta > Stawell (moderate).

Despite not being given much fertiliser, the *Citrus* remained vigorous. The main management has been the regular need to remove shoots from the rootstock.

Flowering and fruiting

Flowering of blood lime has been seen commonly, but fruit usually aborted or did not develop beyond one or two centimetres in size. A small amount of fruit set with good fruit size development occurred at Lyrup. At Junee, the desert lime flowered and produced (rare) fruit in 2003.

Figure 9. Desert Lime, Junee
Figure 10. Blood Lime, Moonta

Mountain Pepper

(Figures 27 – 29)

Provenances

All provenances behaved similarly in survival over the first two years. Toora and Captain's Flat provenances were the main two tested and the results of other provenances (Mt Macedon, Cape Barren Island and Black Spur) were combined as "other" (Figure 29). There were sharp decreases in survival during the second summer at many sites. This decrease was slightly less pronounced for Captain's Flat than for Toora. Growth of all selections occurred mainly during spring and summer (largest increases being from 12 to 18 months after planting). There did not appear to be noticeable differences in vigour between selections.

Figure 11. Mountain pepper (Captain's Flat provenance), Kangaroo Island March 2004

Sites

Two sites, Port MacDonnell and Kangaroo Is (as well as the small site at Mt Gambier) stand out clearly from the other locations as being able to support the continued growth and development of mountain pepper. While this species survived the first (mild) summer relatively well at most sites, the second summer was quite severe and most plants were lost at all trials except those located in the cooler / southern coastal regions of SA. At these sites, most of the Toora and Captain's Flat selections have survived and showed good to very good vigour.

A stem canker of unknown cause has been seen on several plants at Mt Gambier during the 2003-04 summer. This disease can be devastating because it can girdle the stem completely and kill the plant.

Lemon Myrtle

(Figure 30)

Sites

Lemon myrtle has generally survived well across all trial sites. There have been some losses at Jamestown and Stawell. Growth has been greatest at Junee, followed by Pt MacDonnell, Kangaroo Is, Lyrup and Jamestown. Growth has been slowest at Moonta and Stawell. Vigour of lemon myrtle has varied a great deal across time and between sites. Greatest vigour (good to very good) was recorded in summer and autumn (15, 18 and 21 months after planting).

The appearance of the leaves of lemon myrtle has also varied a great deal between sites. At sites with alkaline soils, leaves have shown marked yellowing, and sometimes a reddish / burnt appearance. This type of symptom was rare on the acid to neutral soils.

Figure 12. Lemon myrtle, Port MacDonnell

Lemon Aspen

(Figure 31)

Sites

Lemon aspen has survived extremely well across all trial sites. Survival has been near 100% in every case. Growth has been steady at most locations, with the tallest plants being recorded at Junee. Growth rates were intermediate at Kangaroo Is and Lyrup, followed by Jamestown, Pt MacDonnell, Stawell and Moonta. Changes in height over time suggest that the seasonality is much less pronounced than with other species such as *Acacia victoriae*. The vigour of lemon aspen has ranged from moderate (50) to very good (100), with no major differences between sites.

Despite its generally very healthy appearance, insect attack and a type of witches' broom have commonly been seen on lemon aspen.

Flowering and fruiting

Flowers have been observed at a number of sites and fruit have formed at one site (Mt Gambier, 2003-04 summer).

Figure 13. Lemon Aspen Mt Gambier, Jan 2004

Riberry

(Figures 32 – 34)

Selections / hybrids

The hybrid “Cascade” survived best across all sites, but the ANPI selection was almost as good, only surviving less well than Cascade in the Jamestown trial. “Vic’s choice” was the least hardy, as shown by losses over time at Jamestown, Lyrup and Stawell. “Vic’s Choice” clearly grew better than the other two selections at Pt MacDonnell.

Growth of riberry was greatest at Junee and least at Stawell. The other sites showed similar growth and rates of increase in height were generally low.

Sites

Riberry selections survived, grew best and were most vigorous at Kangaroo Island, Pt MacDonnell, Mt Gambier and Junee.

Figure 14. Riberry, Junee

Munthari / muntries

(Figures 35 and 36)

Selections

Results for “Rivoli Bay” and M4 selections are presented in Figures 19 and 20 respectively. Survival of munthari varied considerably between sites, with best results at Moonta, Kangaroo Island and Mt Gambier followed by Pt MacDonnell, Stawell, then Jamestown and Junee. At Lyrup, M4 established better than Rivoli Bay. On the other hand, “Rivoli Bay” survived better than M4 at Stawell and Junee. Survival declined over time at several sites: Pt MacDonnell, Lyrup and Jamestown.

The mean vigour of surviving “Rivoli Bay” plants was generally good to very good, whereas vigour of M4 selection ranged from moderate (50) to very good (100).

Sites

The site with the best establishment and growth of both selections was Kangaroo Is. Survival was also good at Moonta and Pt MacDonnell. Stawell (“Rivoli Bay”) and Lyrup (M4) also showed moderate to good survival and vigour. At Jamestown, Junee and Lyrup the survival was only moderate, yet the surviving plants grew quite vigorously and have flowered and fruited (Jamestown, Junee). So the vigour of surviving plants was usually good to very good, irrespective of the success or otherwise of seedling establishment. This suggests that the munthari can be grown across a relatively wide range of locations as long as the reason for poor establishment can be ascertained and controlled.

Flowering and fruiting

Flowering and fruit formation were observed at Mt Gambier (2002-03 and 2003-04) and several other sites (Junee, Kangaroo Island, Jamestown 2003-04). Harvest was measured at Jamestown and Mt Gambier in 2004. At Mt Gambier, 0.99 kg of fruit was harvested from 15 of the 19 M4 plants and 6.4 kg fruit of “Rivoli Bay” was harvested from 11 of the 14 plants (average nearly 600 g per plant, with several plants yielding around 1 kg of fruit).

Figure 15. Munthari on trellis, Kangaroo Island

Bush tomato

(Figure 37)

Sites

Survival of the bush tomato was extremely variable between sites. At some sites we completely replanted all four plots in the second spring. This plant usually dies off completely in the winter and then reappears from underground suckers in the following spring or summer when the soil warms. Survival counts can therefore go up and down without any replanting.

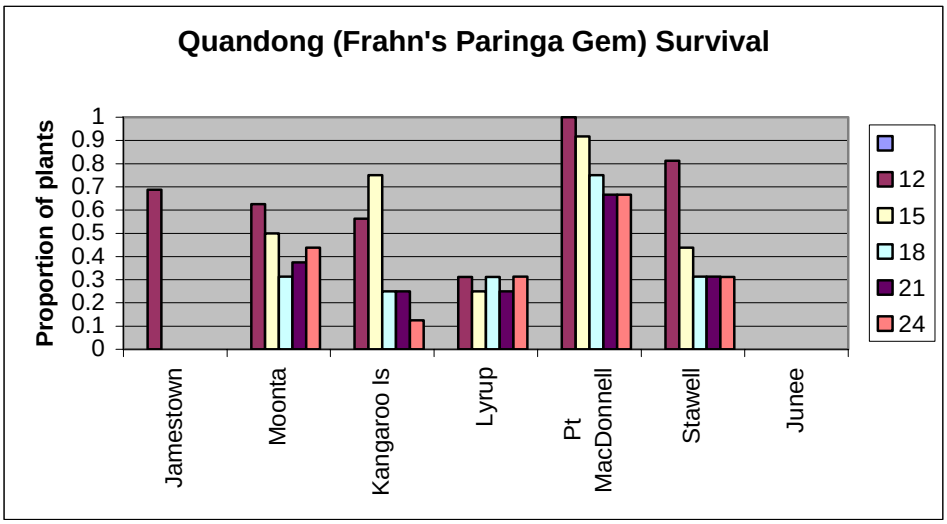
The bush tomato has become locally established in the plots through suckering at several sites, notably Junee, Jamestown, Moonta, Stawell and to a much smaller extent at Lyrup. There was virtually no survival from one summer to the next at Kangaroo Is. and Mt Gambier, and almost no longer-term survival at Pt MacDonnell. The vigour of surviving bush tomatoes also varied considerably between sites and between seasons. The most vigorous growth has occurred at Junee and Jamestown. Bush tomatoes at Moonta, Stawell and Lyrup showed intermediate vigour.

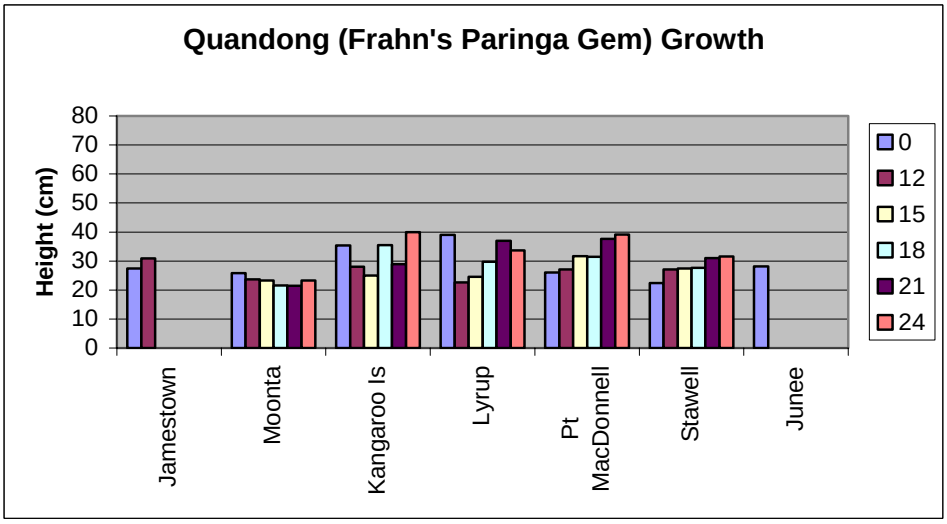
Flowering and fruiting

Flowering and fruit set was relatively common. The best crops were seen at Junee and Moonta, with less fruit set at Jamestown, Stawell and Pt MacDonnell.

Figure 16. Bush tomato, Junee 2003

Figure 17. Survival, growth and vigour of Quandong ('Frahn's Paringa Gem') across trial sites (0 to 24 months after planting, sprng 2001 – following pages





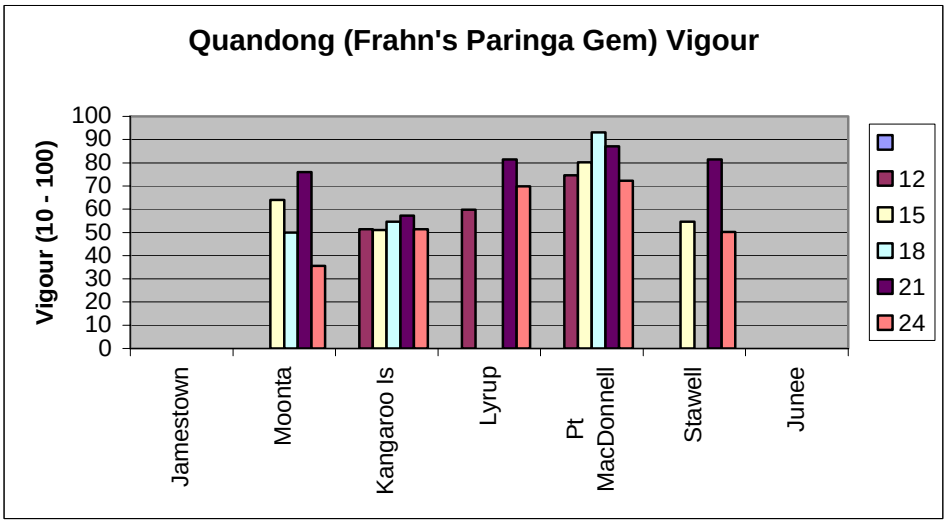
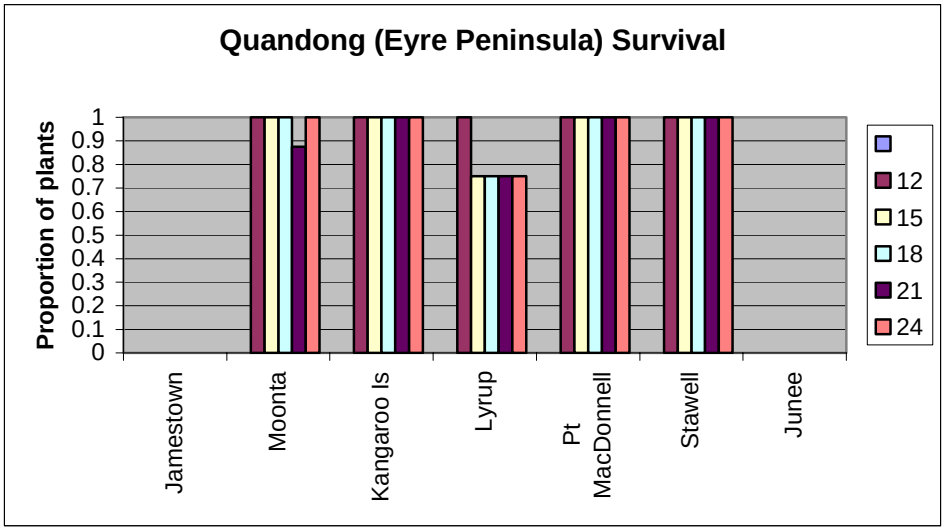
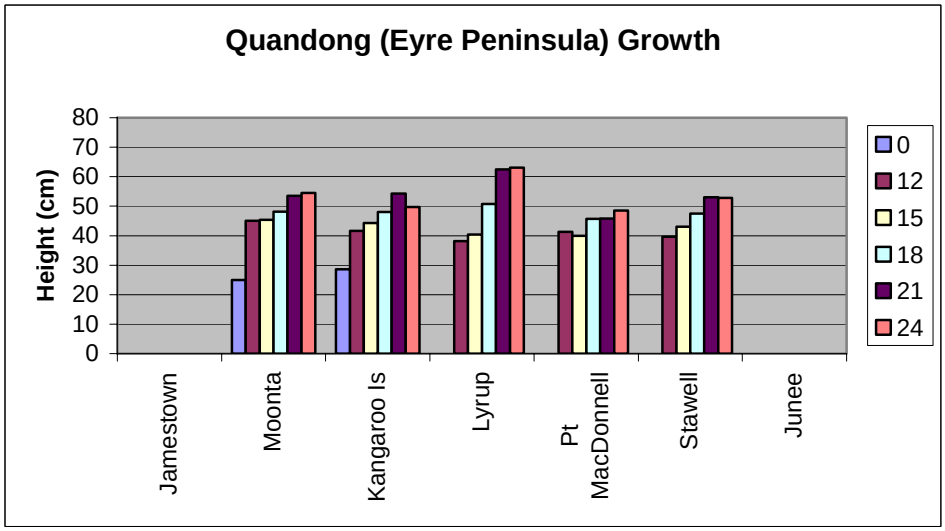


Figure 18 Survival, growth and vigour of Quandong (Wildstuf Nursery, Eyre Peninsula) across trial sites (0 to 24 months after planting, spring 2001)





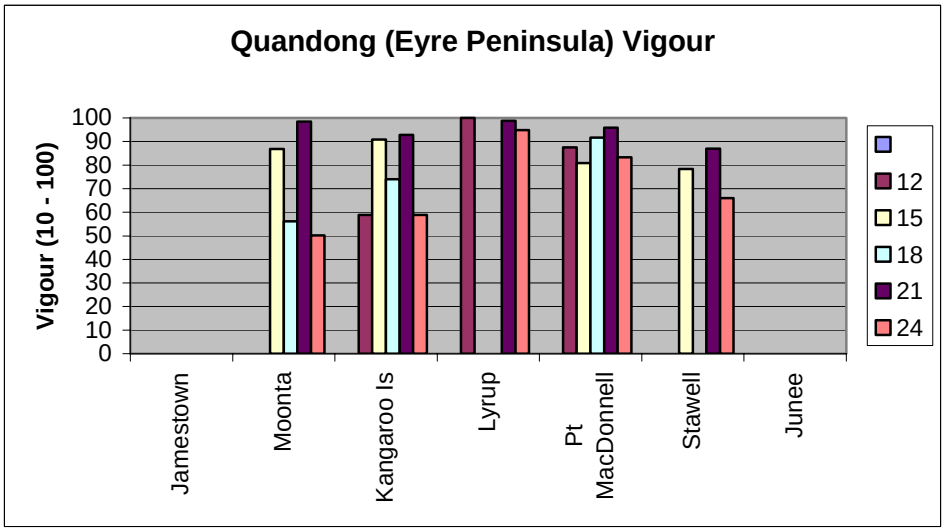
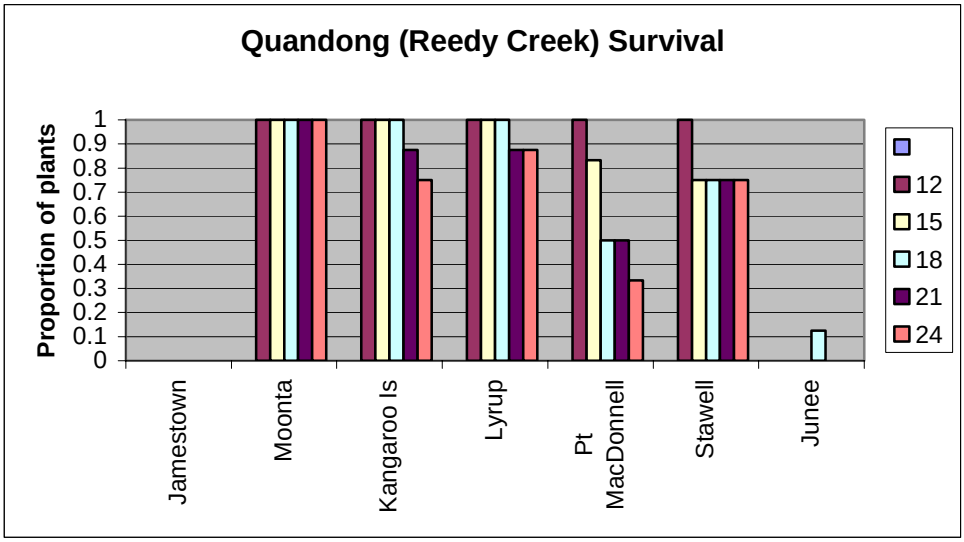
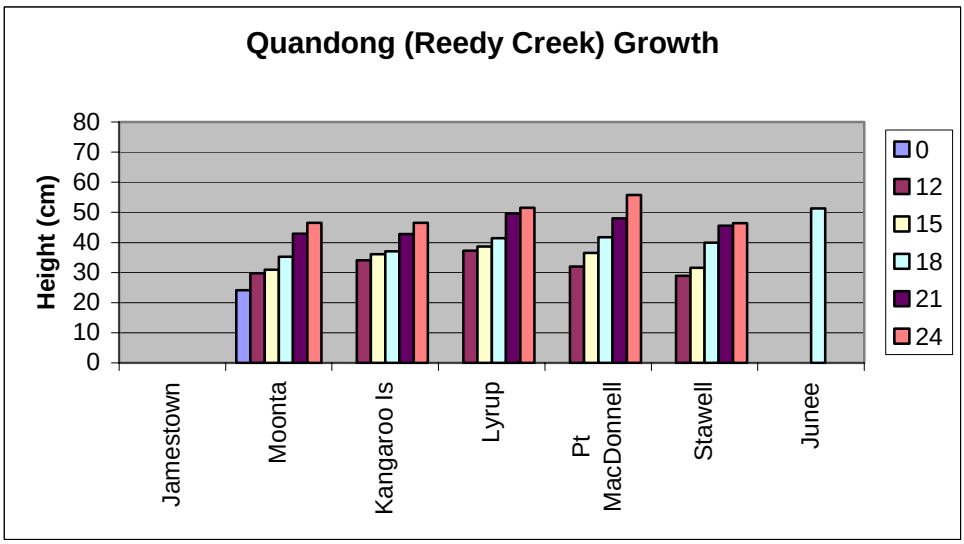


Figure 19 Survival, growth and vigour of Quandong (Quarmby's Reedy Creek Nursery) across trial sites (0 to 24 months after planting, spring 2001)





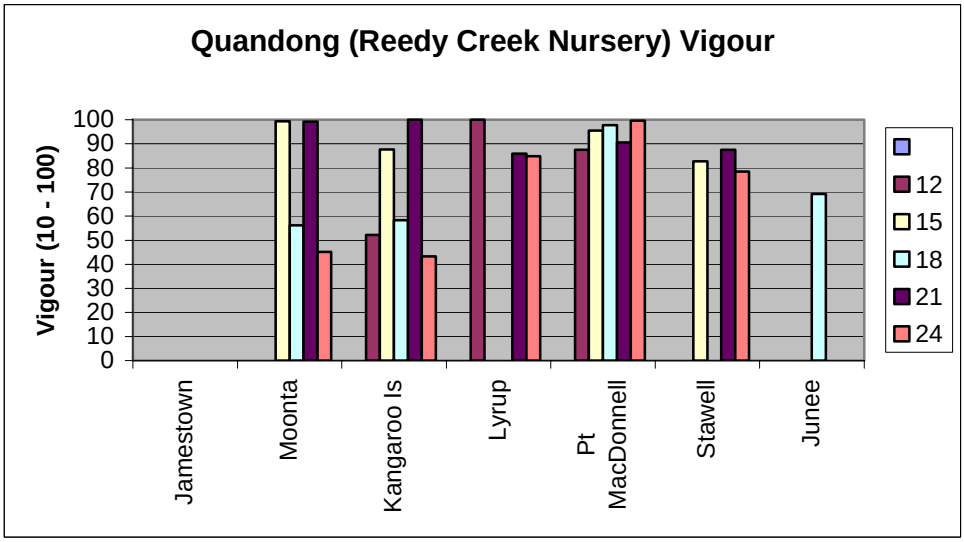
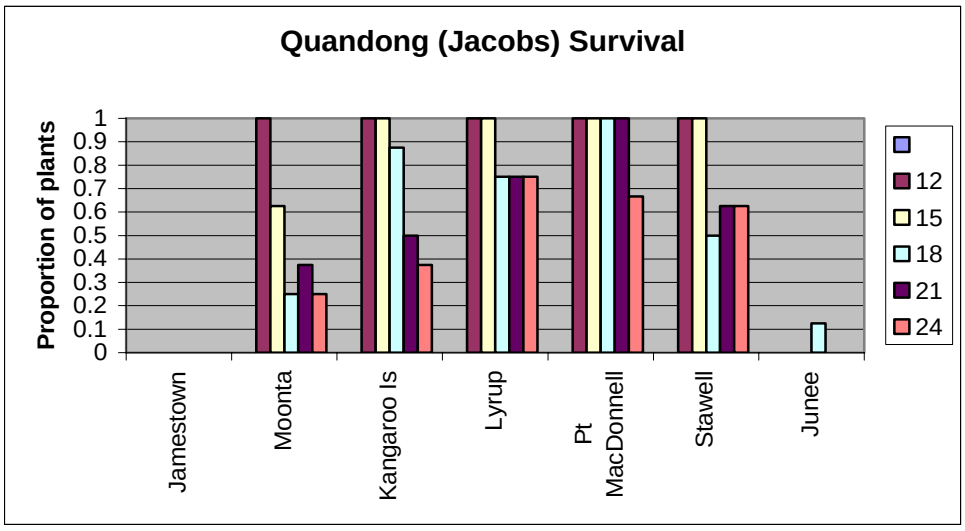
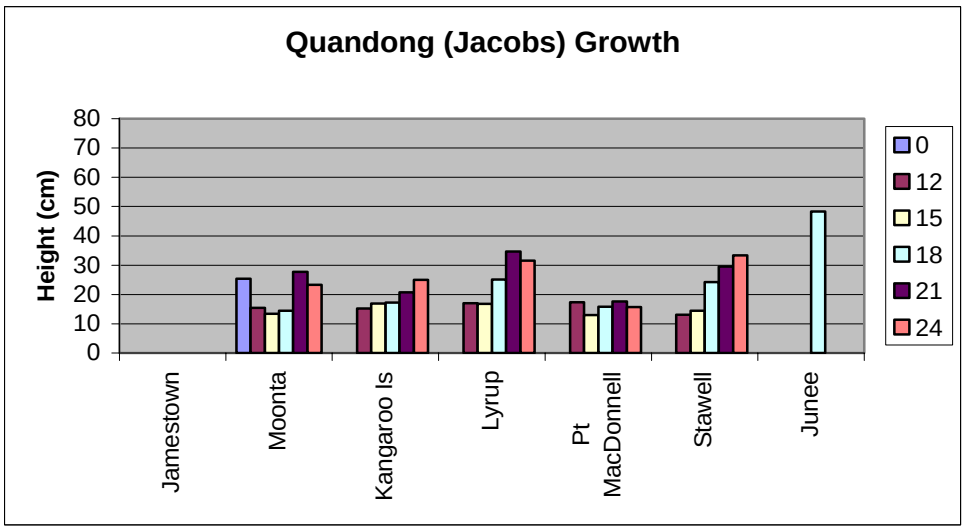


Figure 20 Survival, growth and vigour of Quandong (R Jacobs) across trial sites (0 to 24 months after planting, spring 2001)





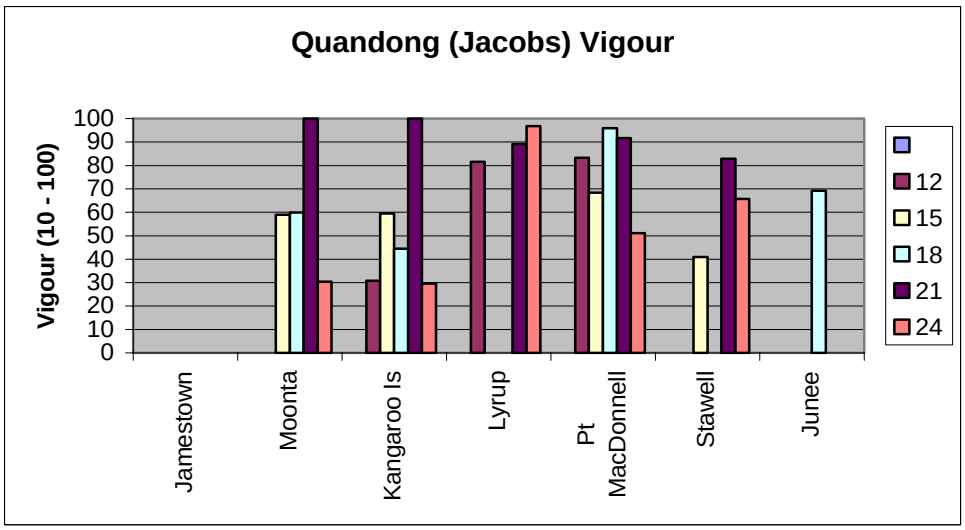
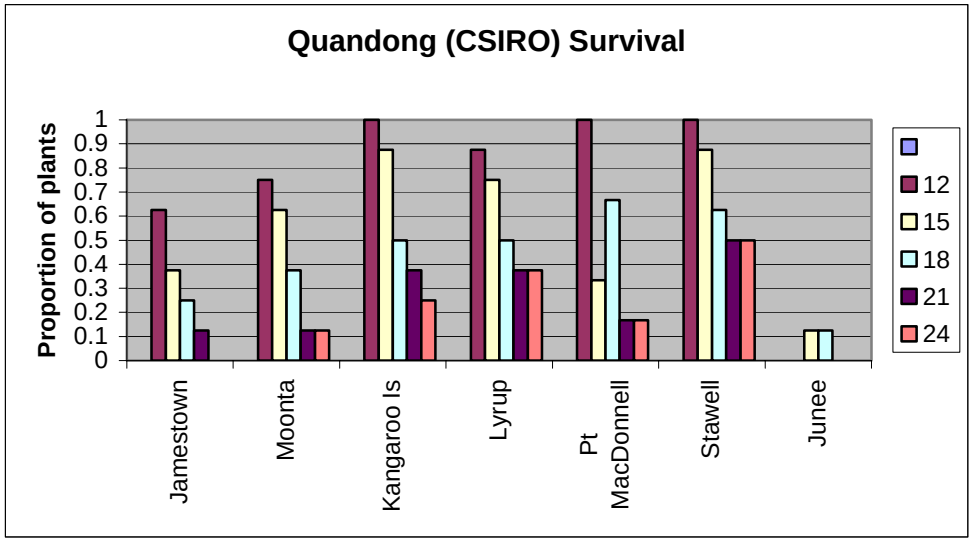
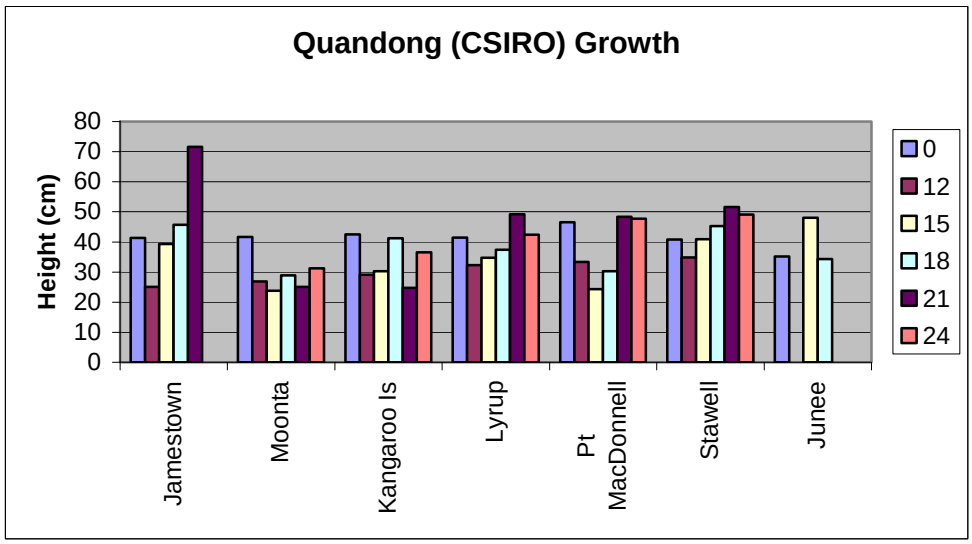


Figure 21 Survival, growth and vigour of Quandong (CSIRO) across trial sites (0 to 24 months after planting, spring 2001)





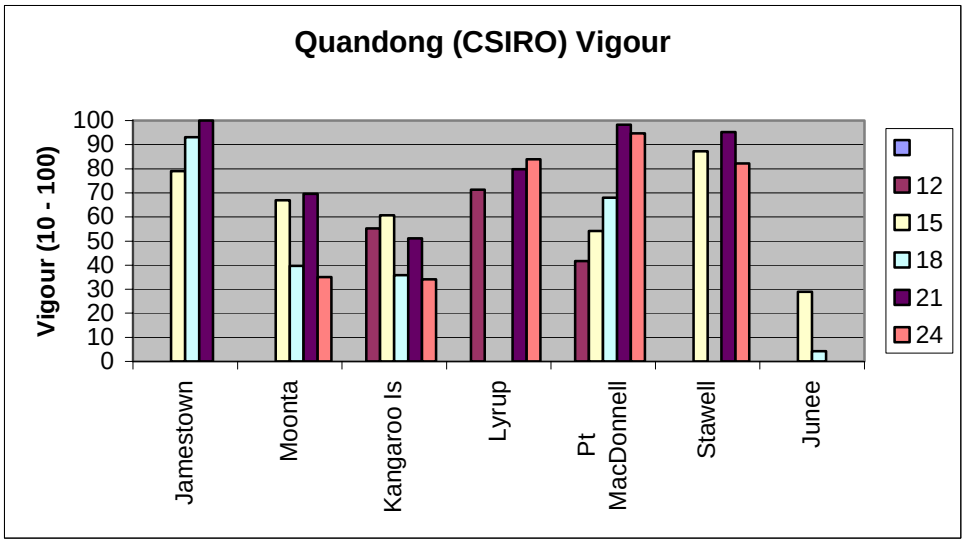
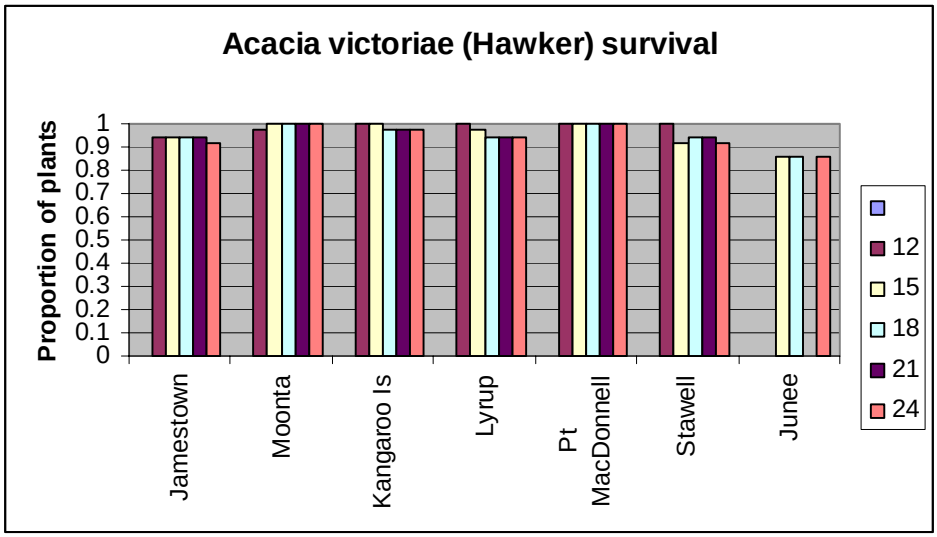
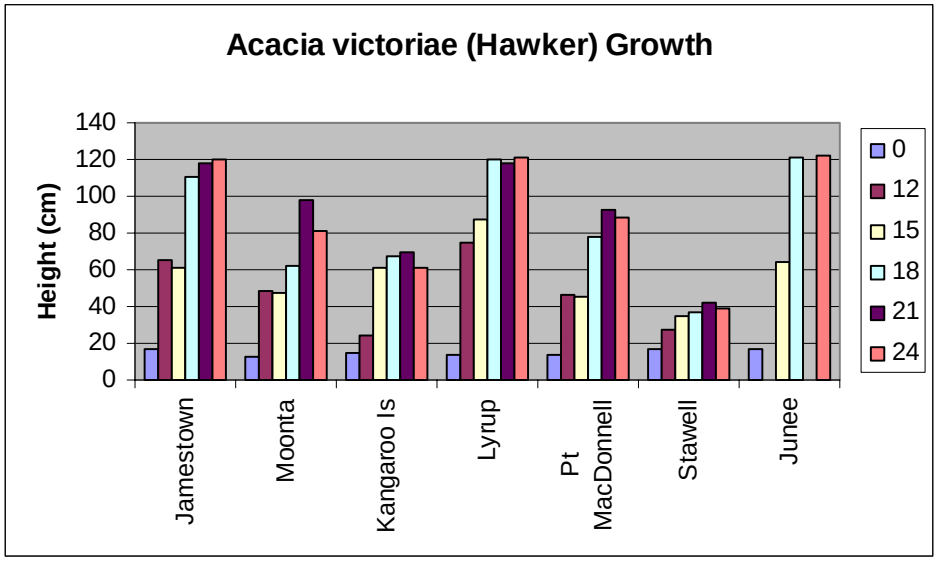


Figure 22 Survival, growth and vigour of Acacia victoriae (Hawker provenance) across trial sites (0 to 24 months after planting, spring 2001)





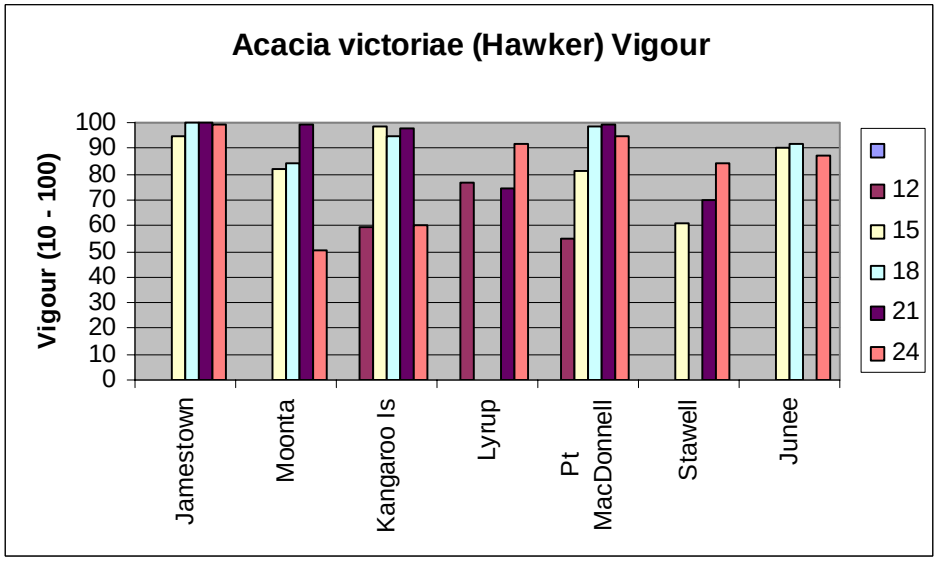
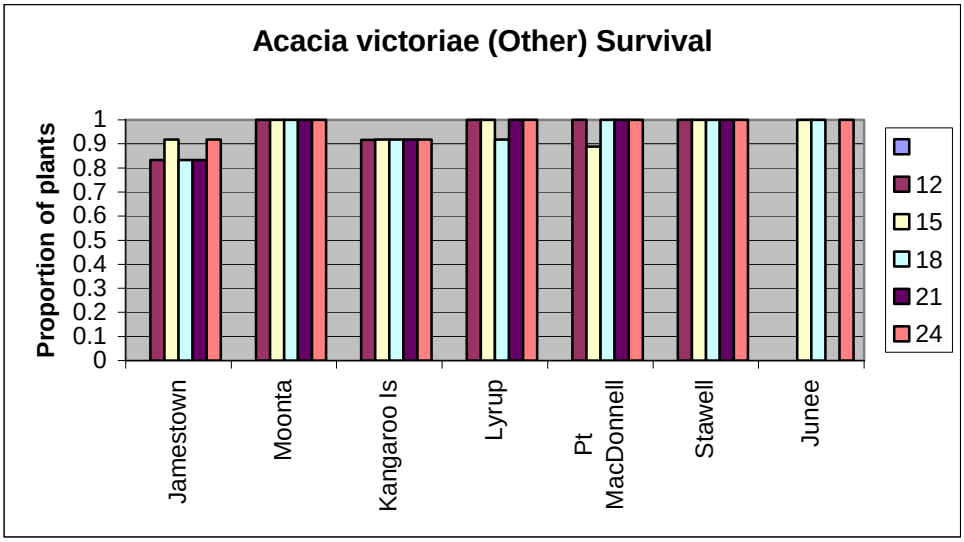
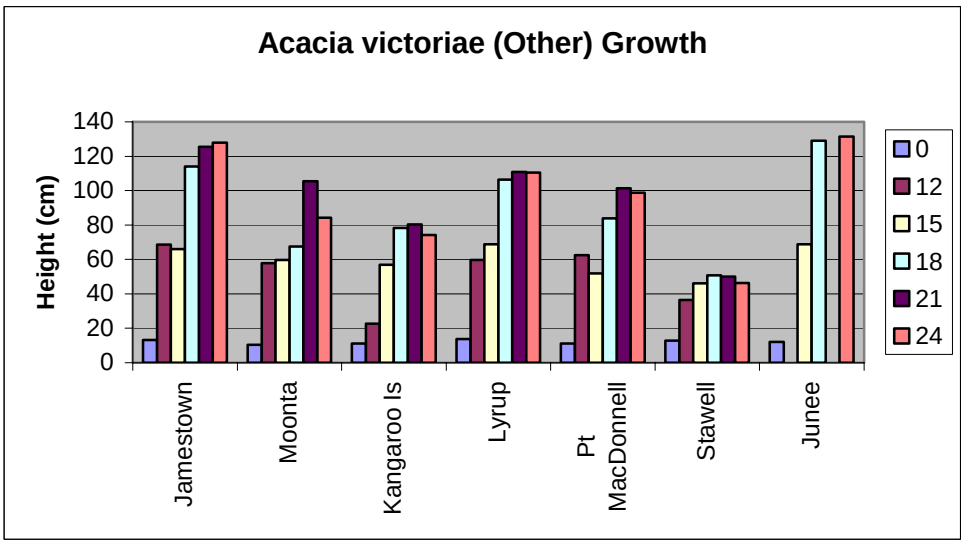


Figure 23 Survival, growth and vigour of Acacia victoriae (other provenances) across trial sites (0 to 24 months after planting, spring 2001)





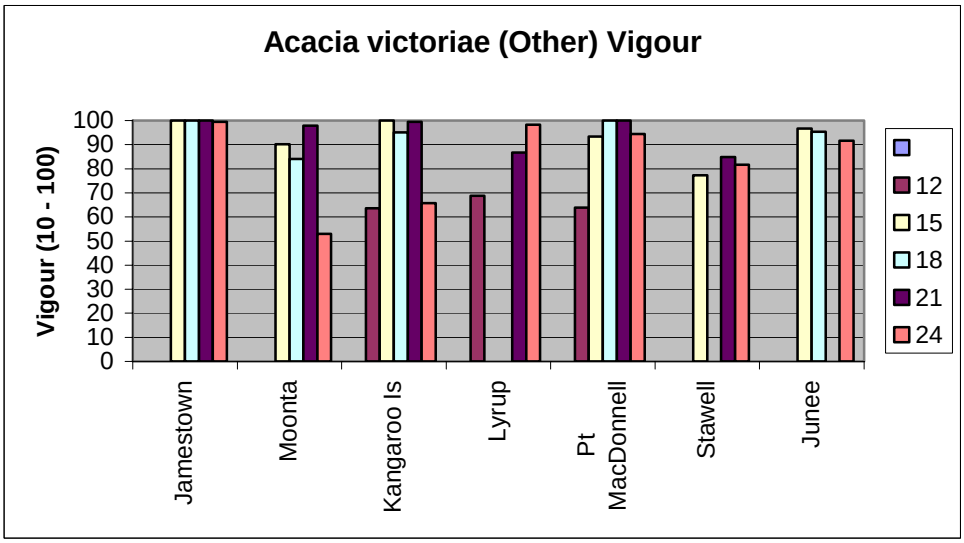
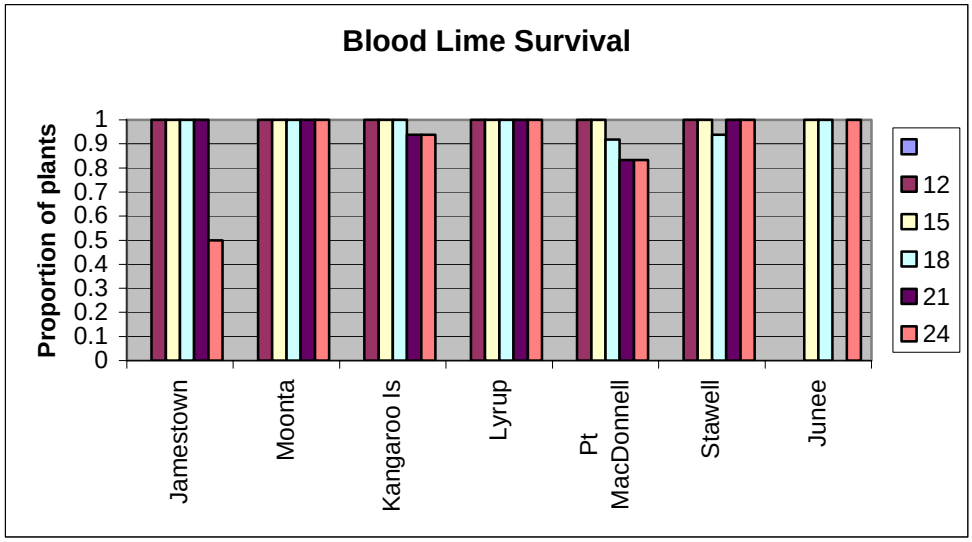
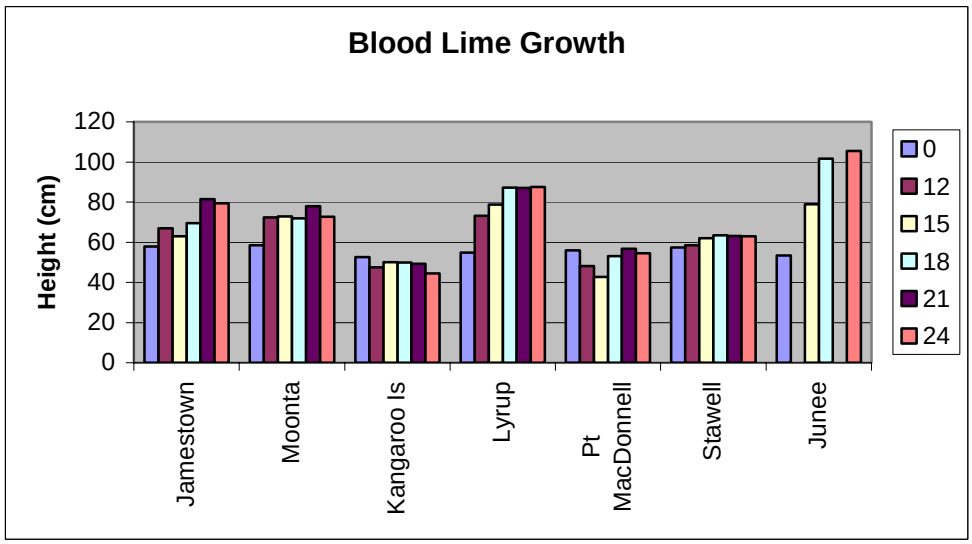


Figure 24 Survival, growth and vigour of Finger Lime Hybrid ('Australian Blood Lime') across trial sites (0 to 24 months after planting, spring 2001)





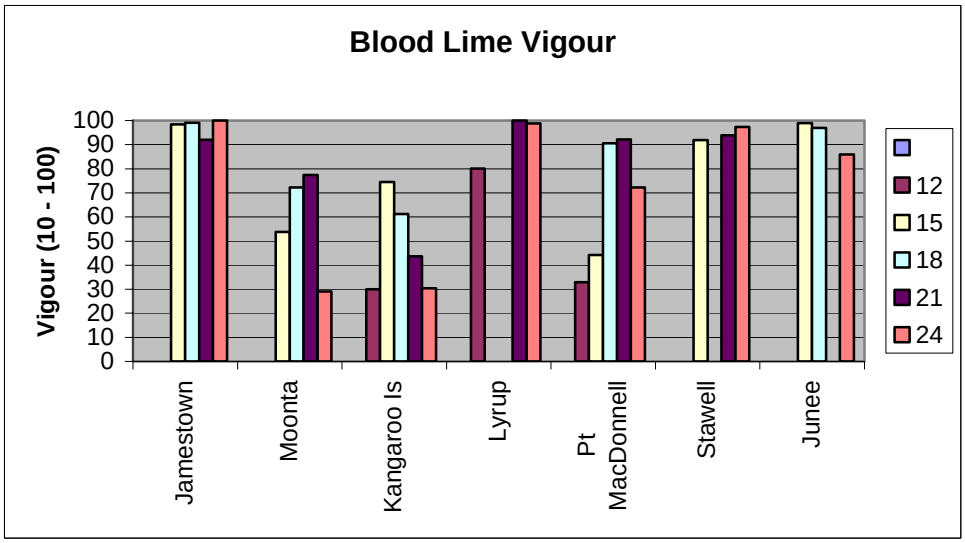
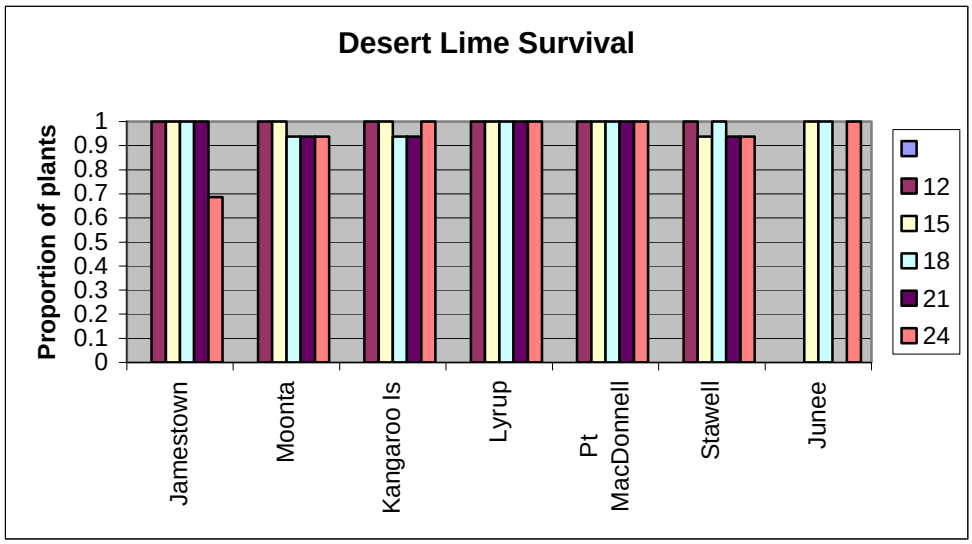
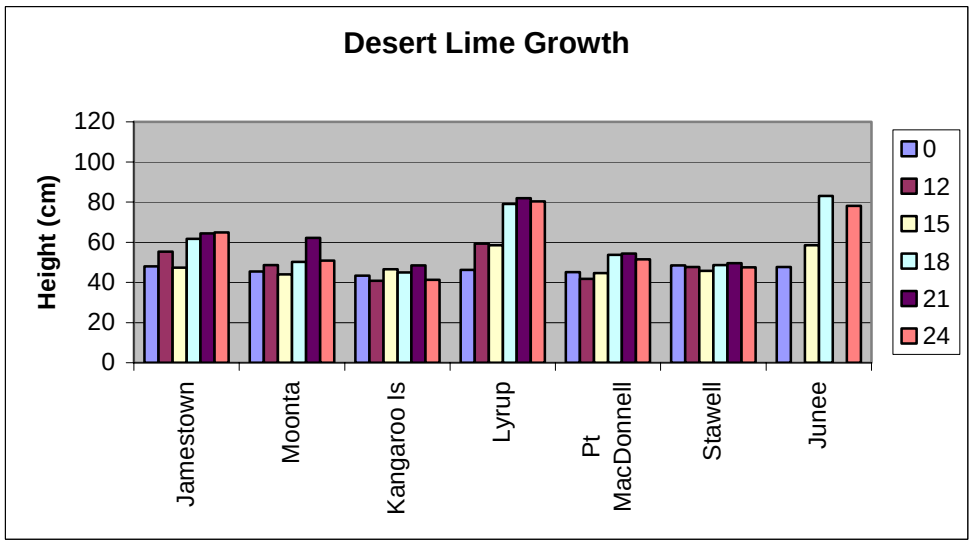


Figure 25 Survival, growth and vigour of Desert Lime (selection CR101-13) across trial sites (0 to 24 months after planting, spring 2001)





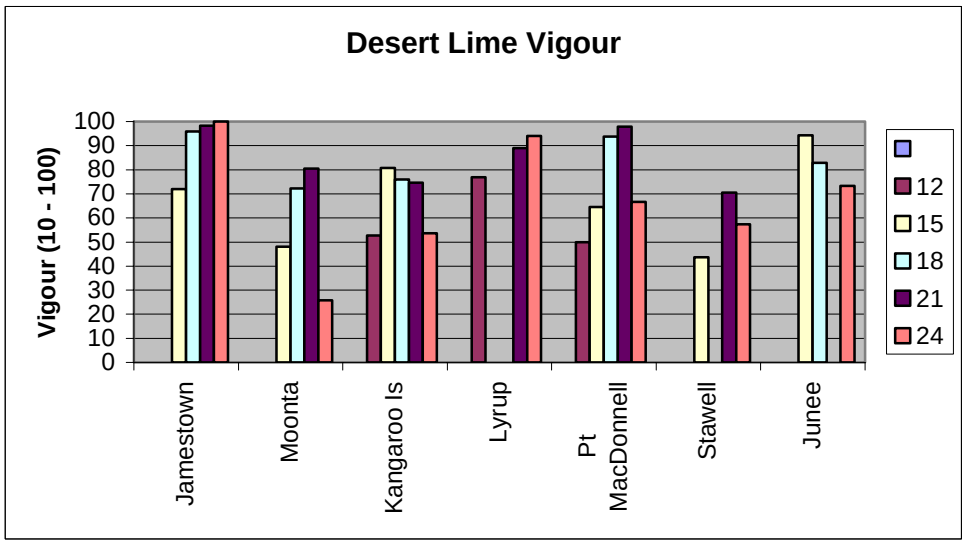
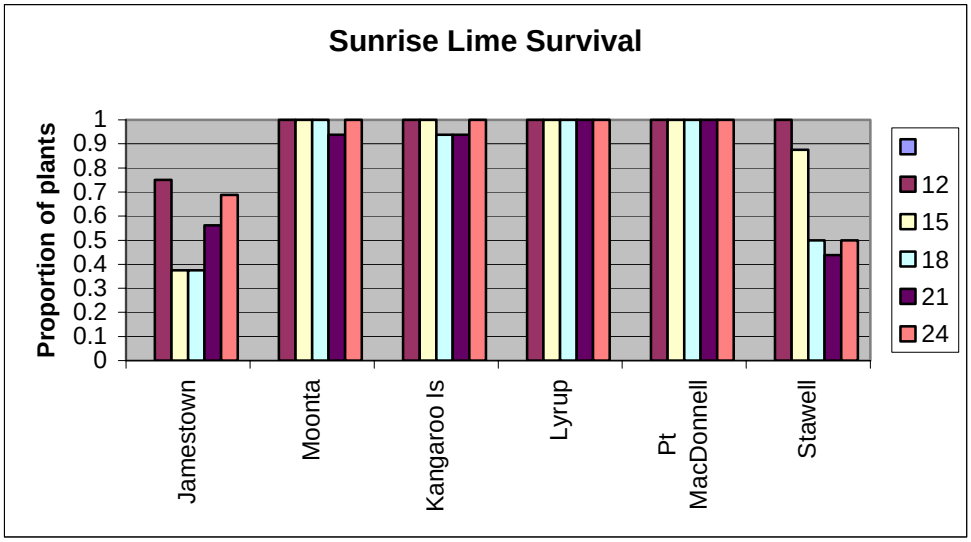
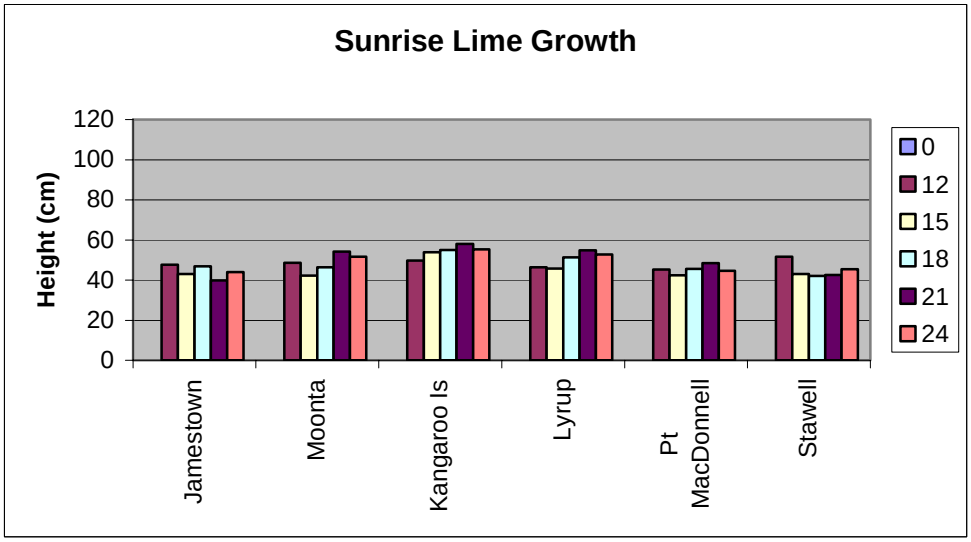


Figure 26 Survival, growth and vigour of Finger Lime Hybrid ('Australian Sunrise Lime') across trial sites (0 to 24 months after planting, spring 2001)





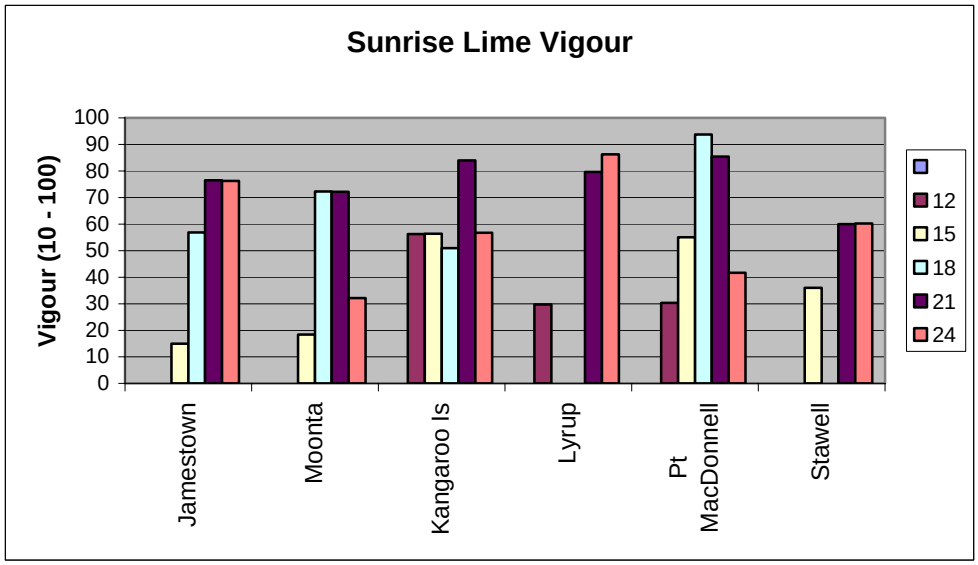
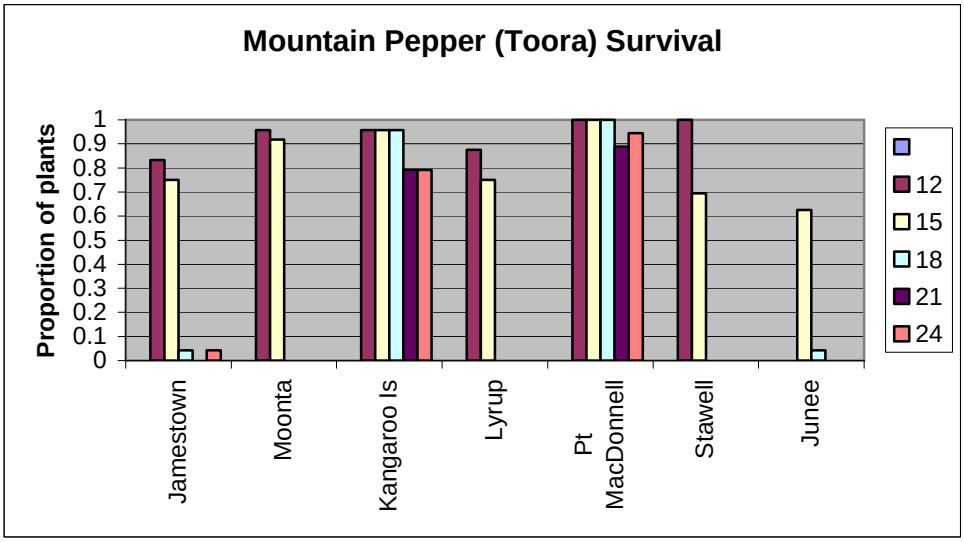
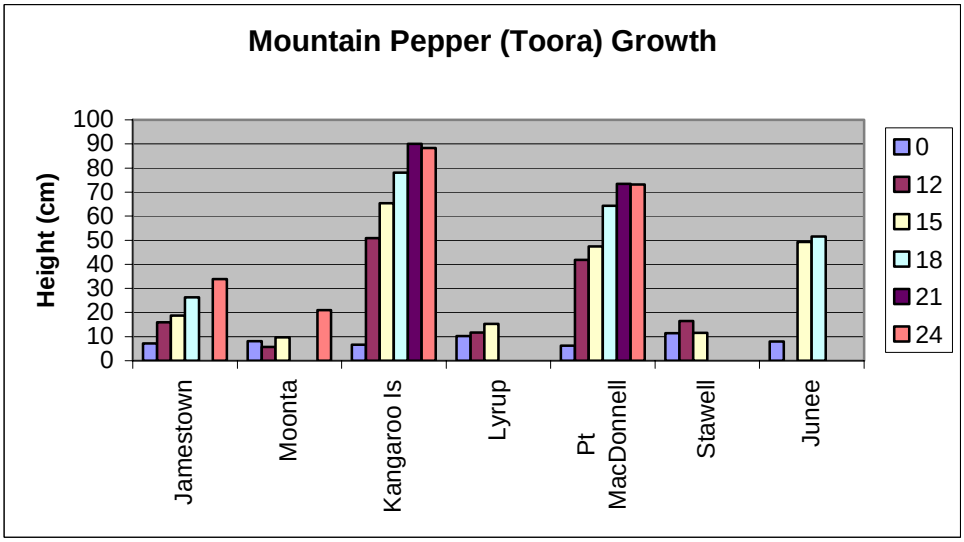


Figure 27 Survival, growth and vigour of Mountain Pepper (Toora provenance) across trial sites (0 to 24 months after planting, spring 2001)





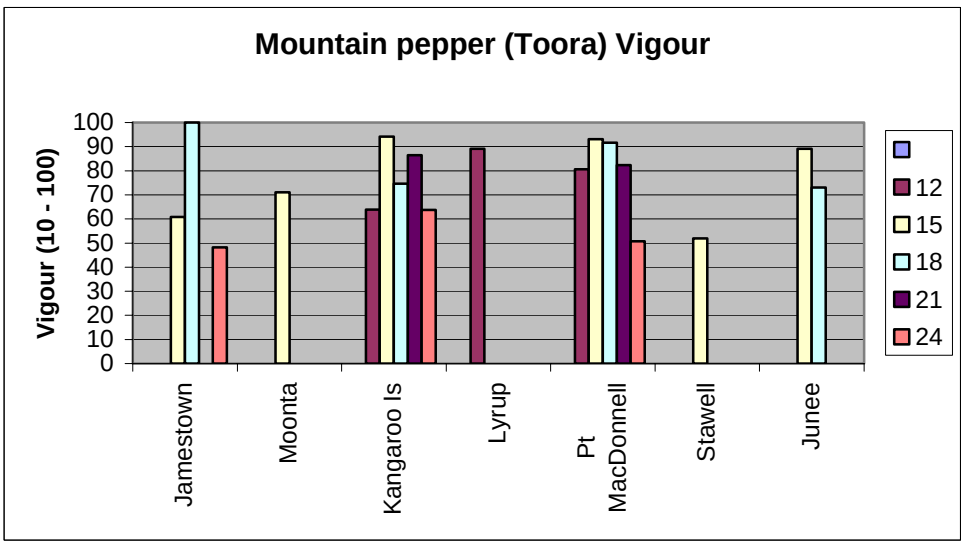
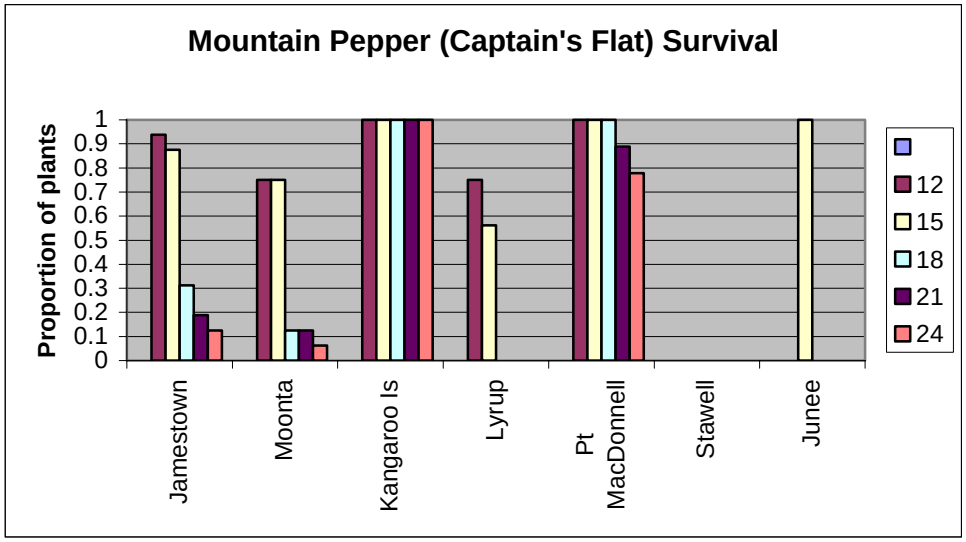
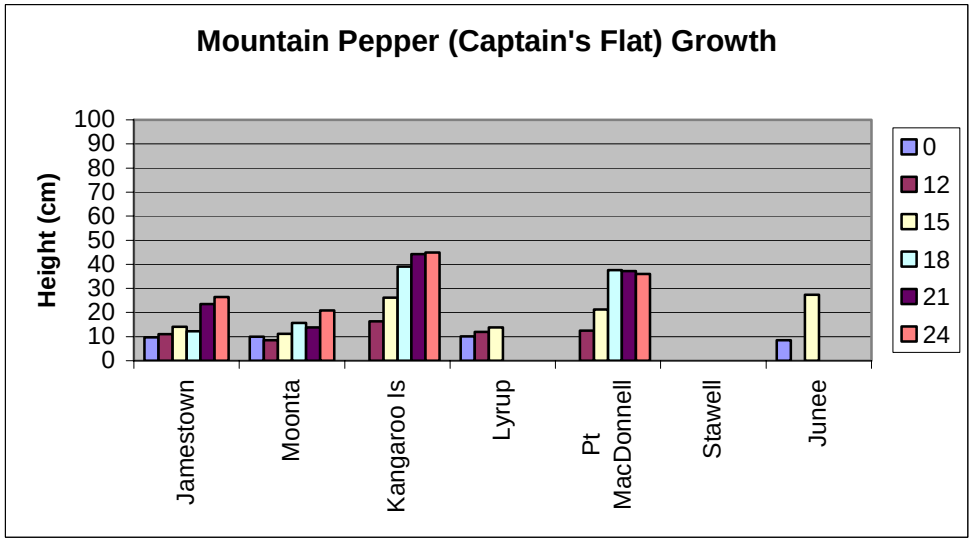


Figure 28 Survival, growth and vigour of Mountain Pepper (Captain's Flat provenance) across trial sites (0 to 24 months after planting, spring 2001)





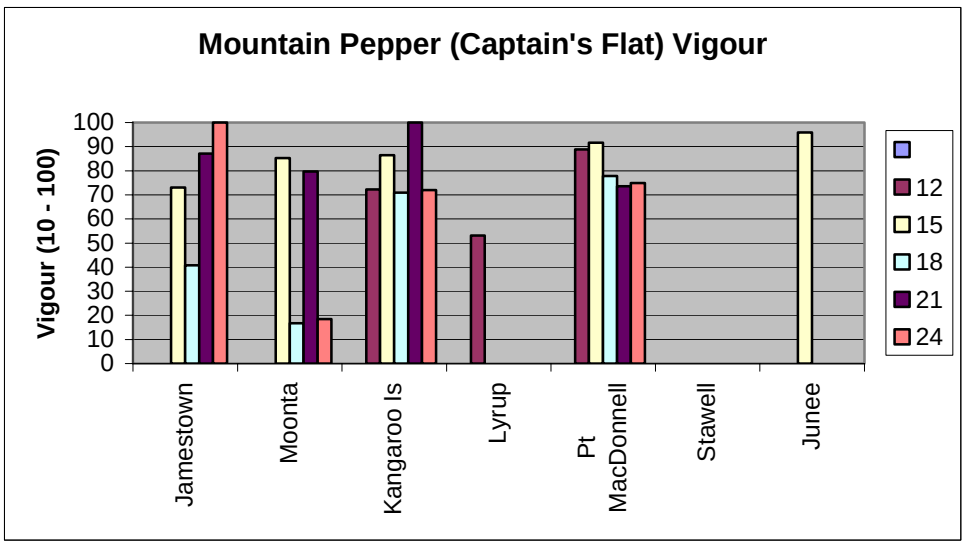
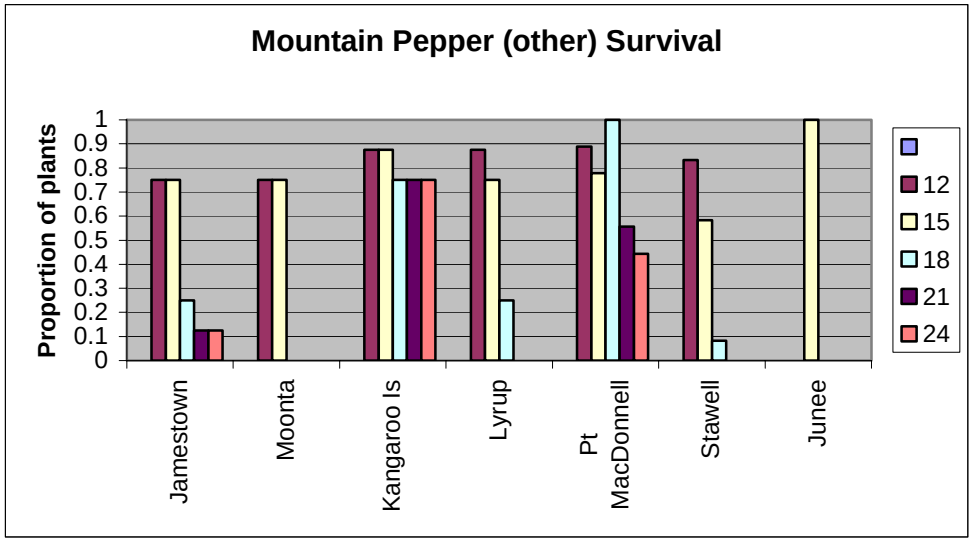
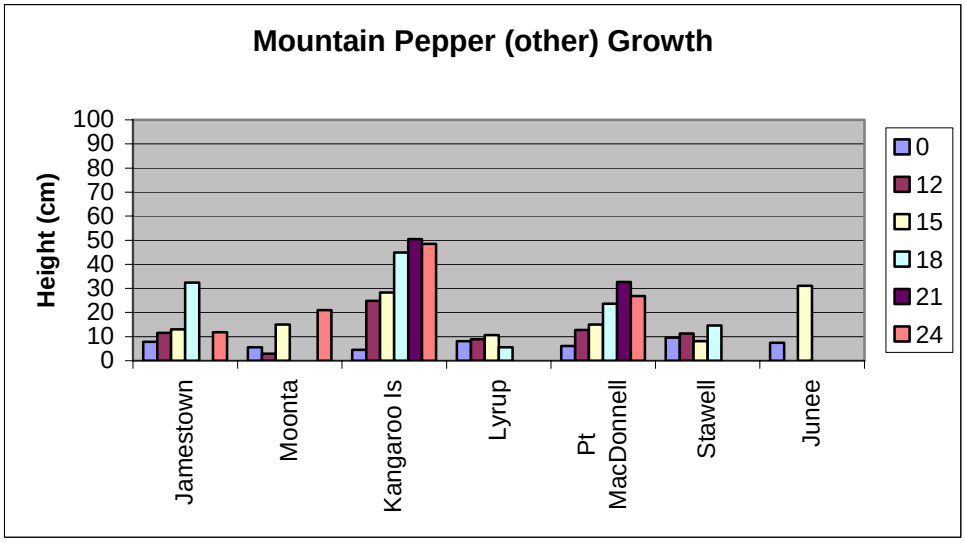


Figure 29 Survival, growth and vigour of Mountain Pepper (other provenances) across trial sites (0 to 24 months after planting, spring 2001)





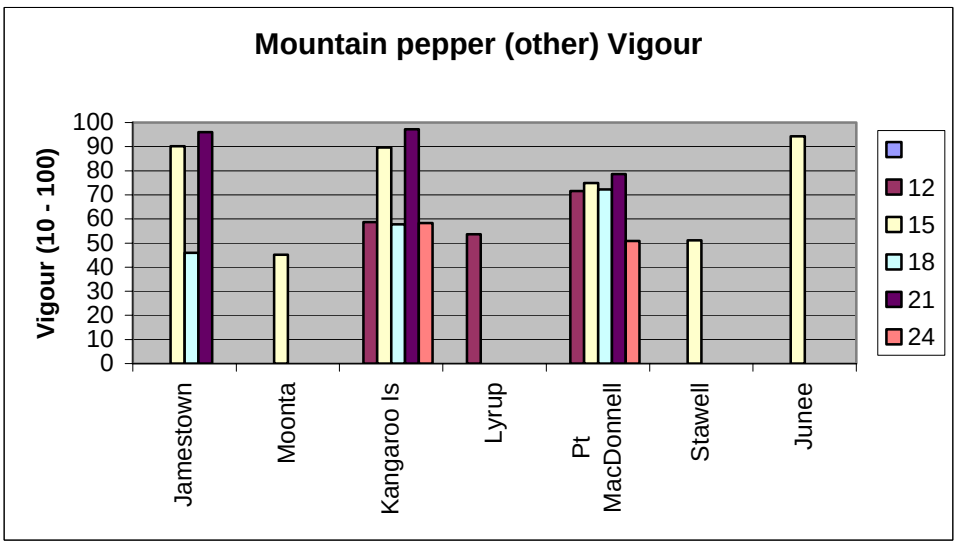
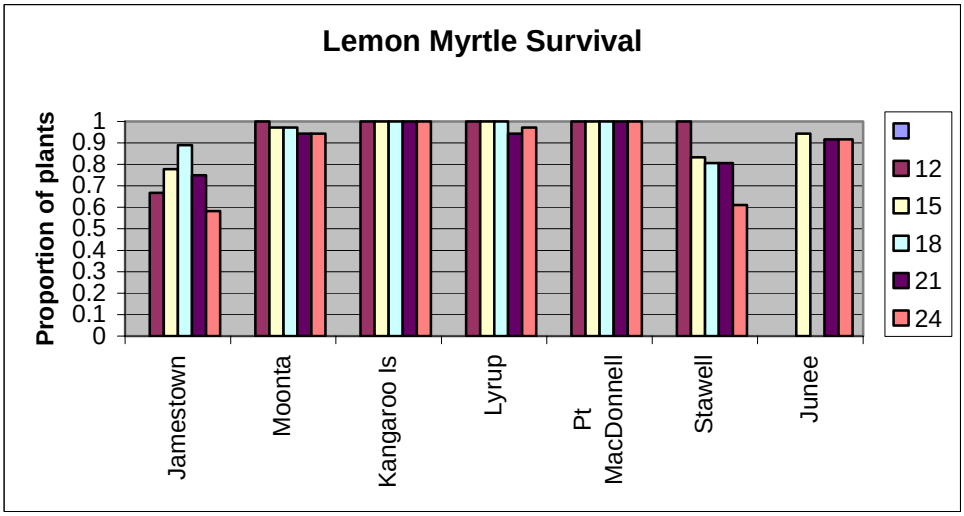
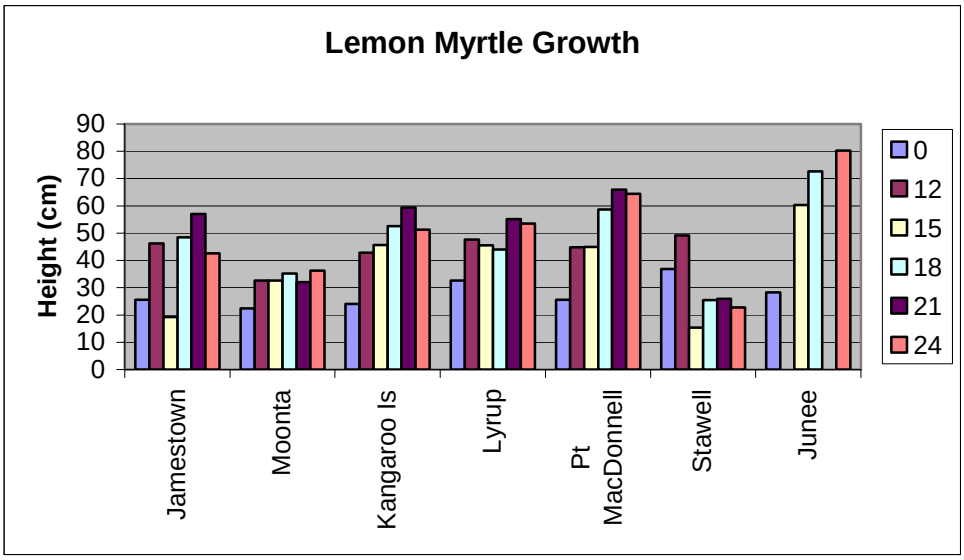


Figure 30 Survival, growth and vigour of Lemon Myrtle (ANPI selection) across trial sites (0 to 24 months after planting, spring 2001)





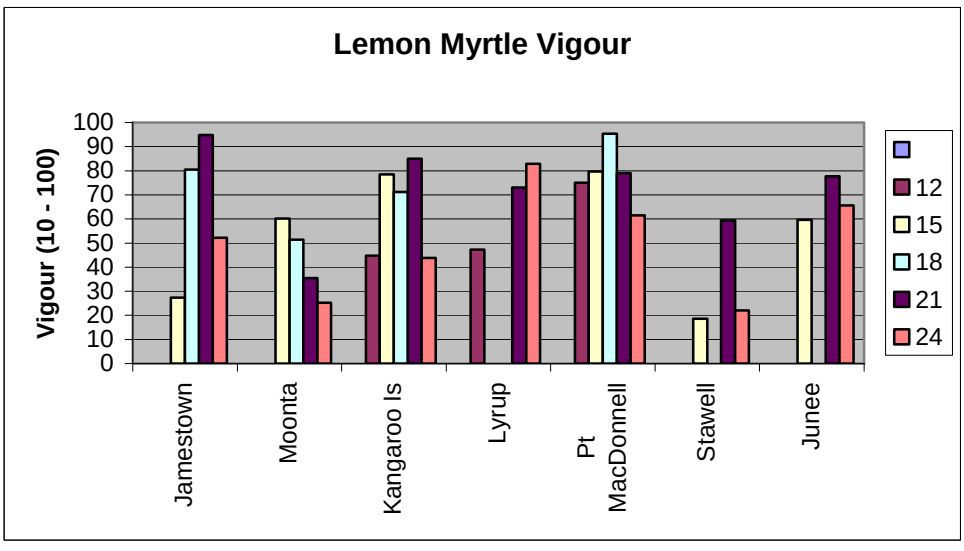
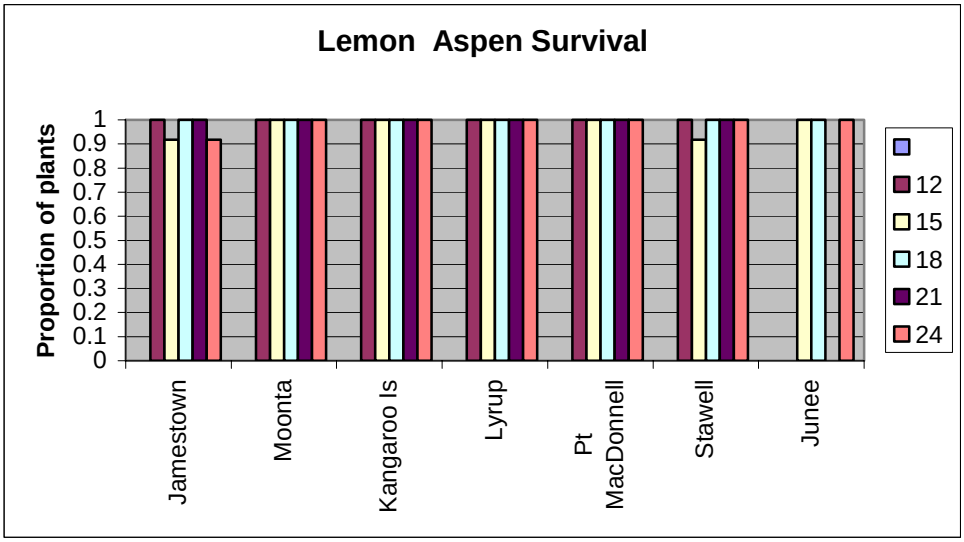
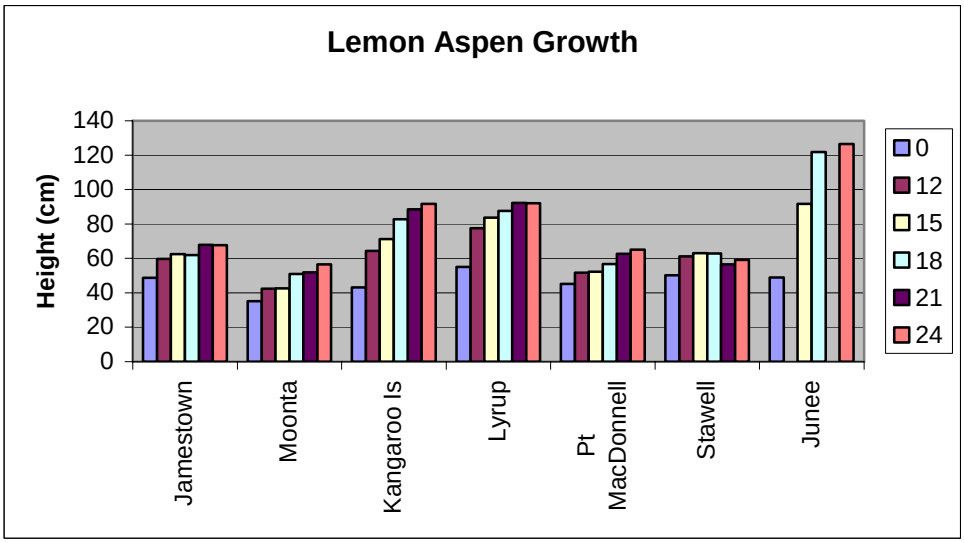


Figure 31 Survival, growth and vigour of Lemon Aspen (ANPI selection) across trial sites (0 to 24 months after planting, spring 2001)





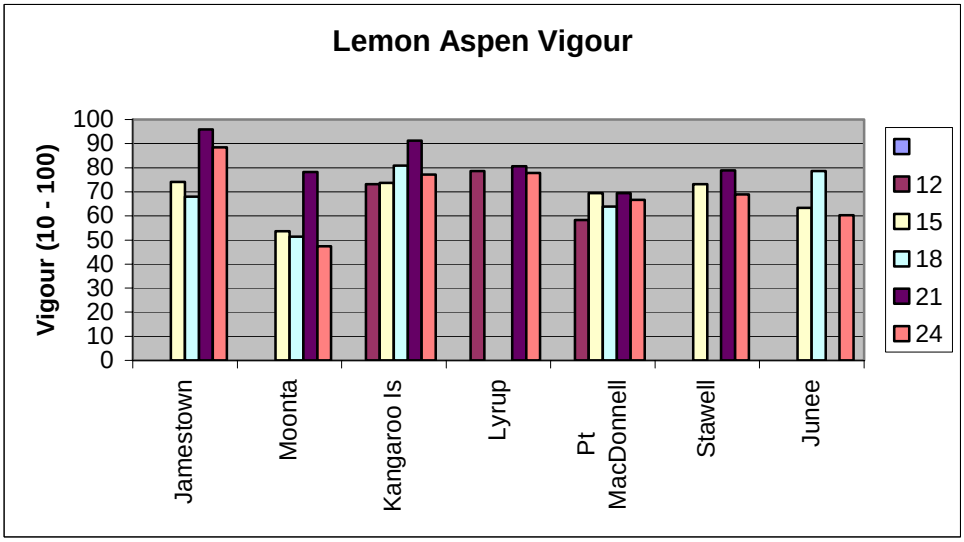
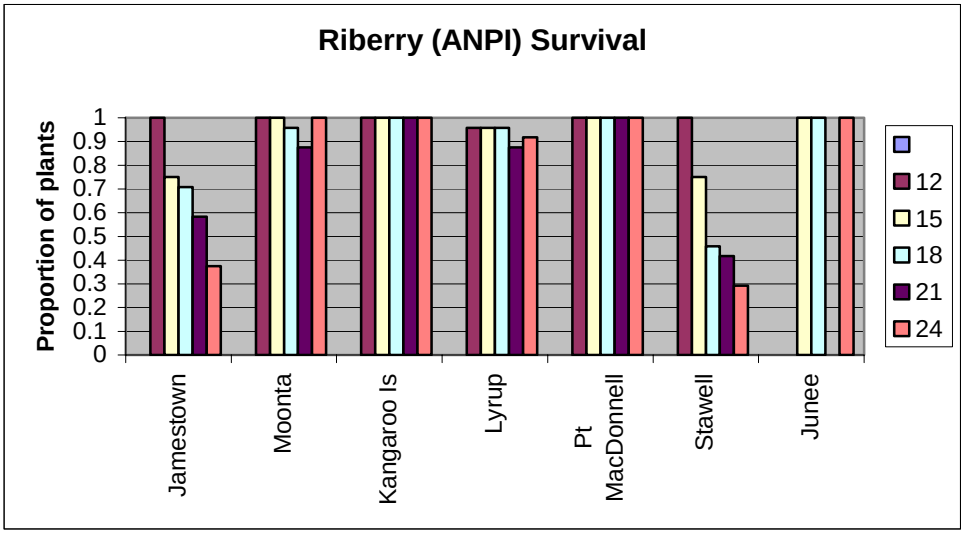
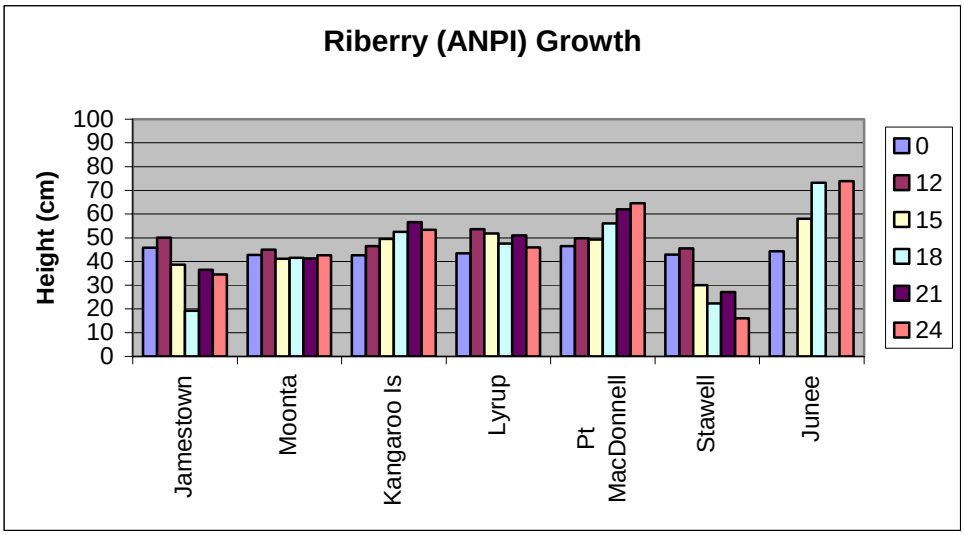


Figure 32 Survival, growth and vigour of Riberry (ANPI selection) across trial sites (0 to 24 months after planting, spring 2001)





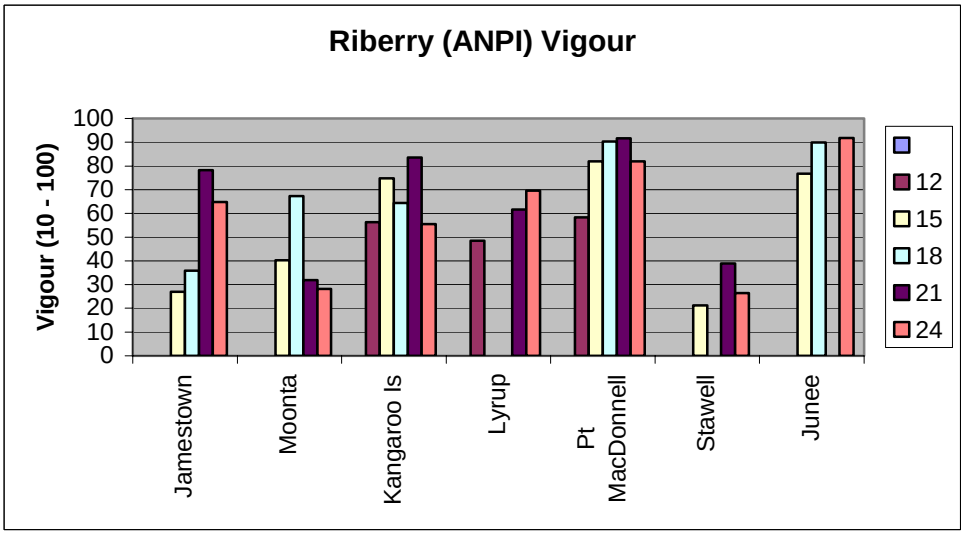
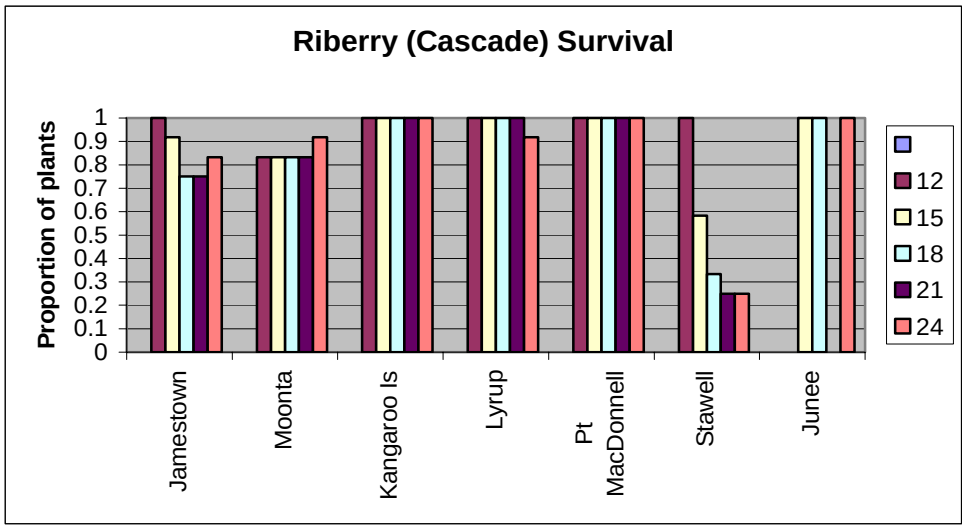
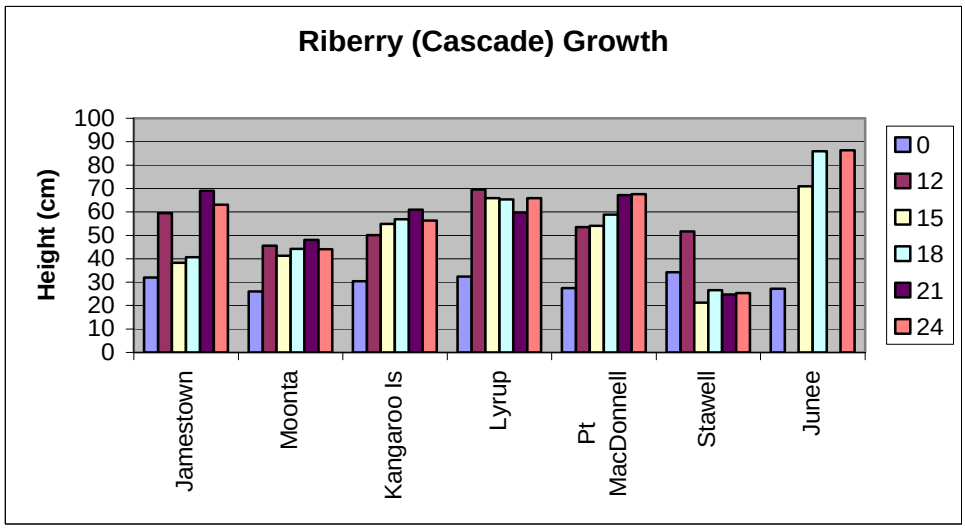


Figure 33 Survival, growth and vigour of Riberry ('Cascade' hybrid) across trial sites (0 to 24 months after planting, spring 2001)





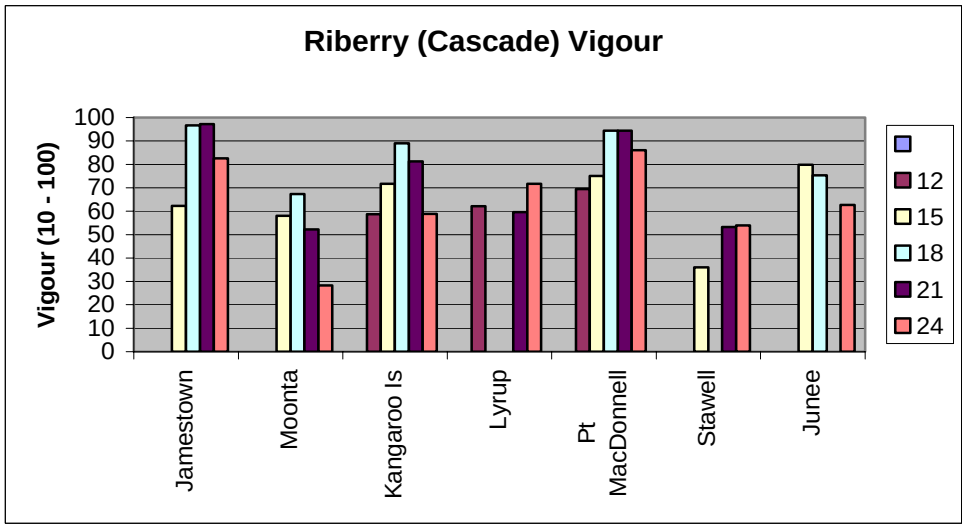
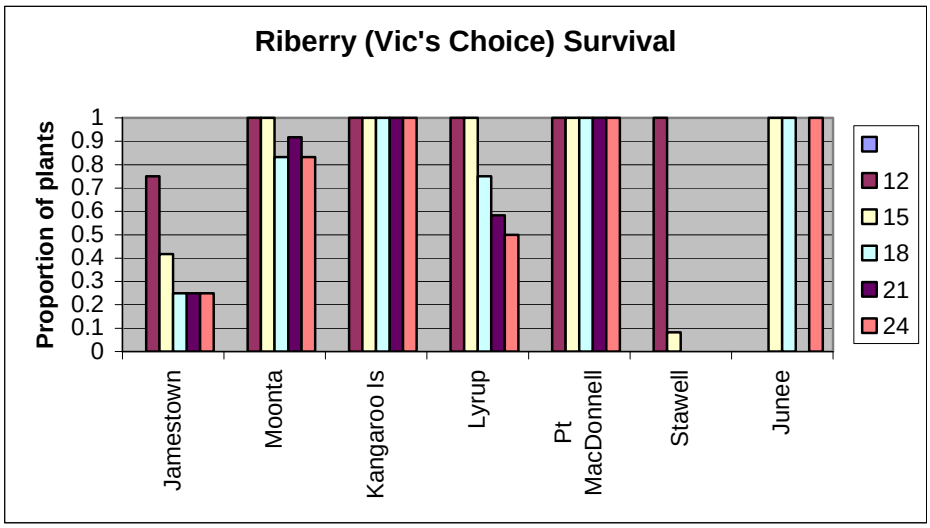
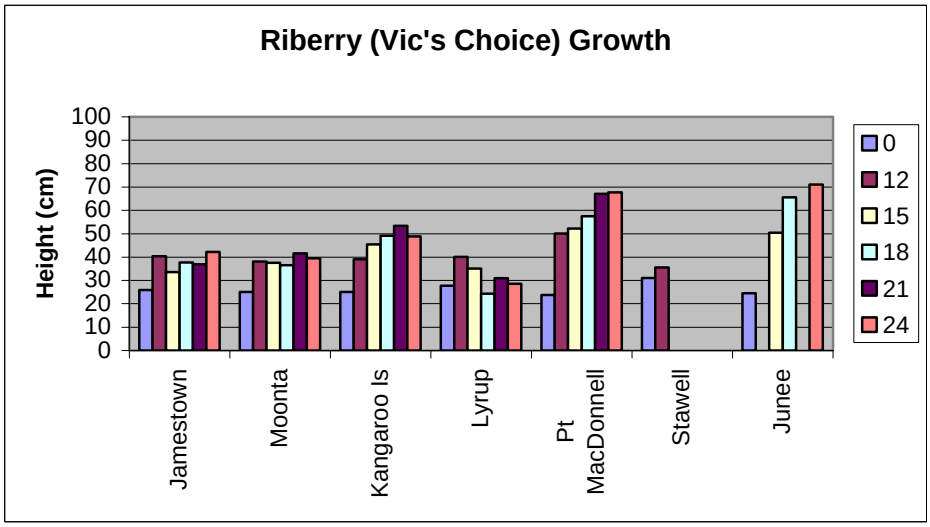


Figure 34 Survival, growth and vigour of Riberry (Vic's Choice selection) across trial sites (0 to 24 months after planting, spring 2001)





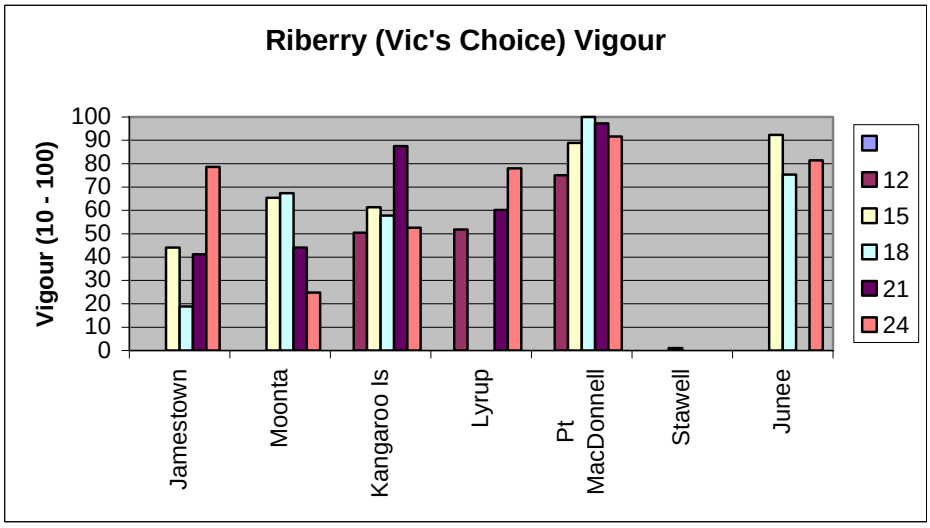
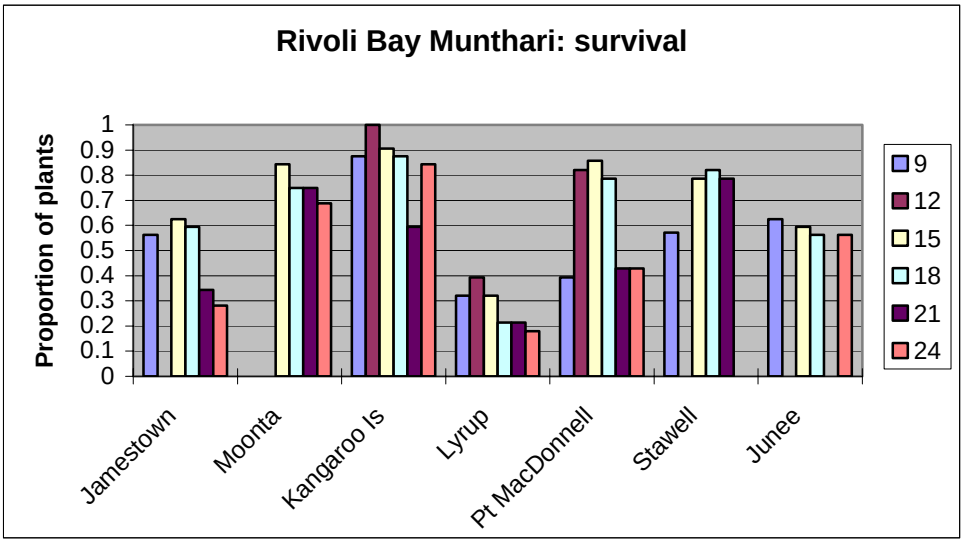


Figure 35 Survival and vigour of Munthari ('Rivoli Bay') across trial sites



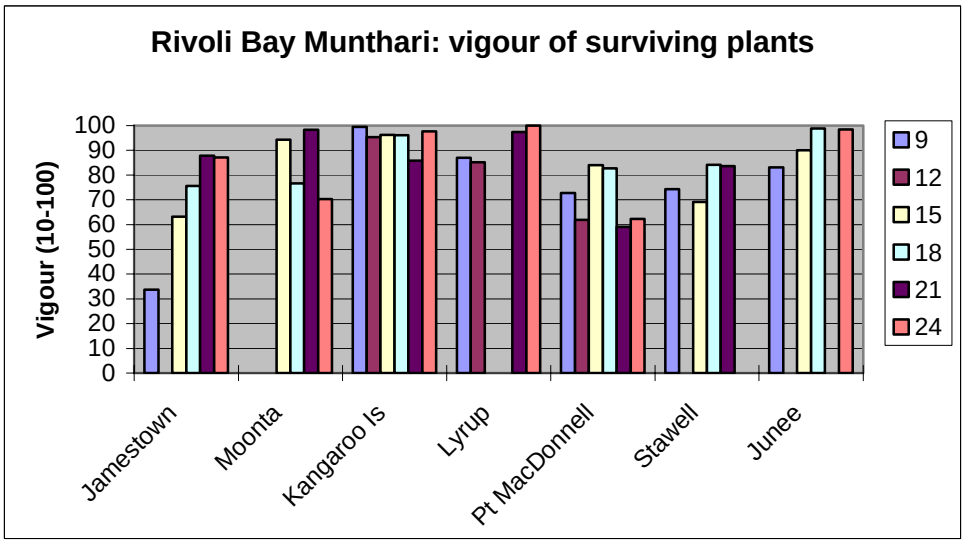
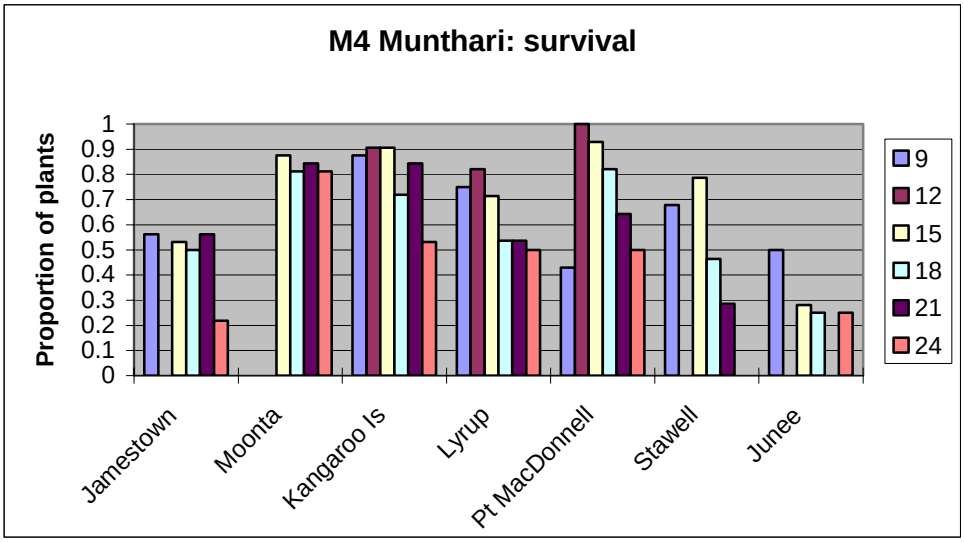


Figure 36 Survival and vigour of Munthari (M4 selection) across trial sites (0 to 24 months after planting, spring 2001)



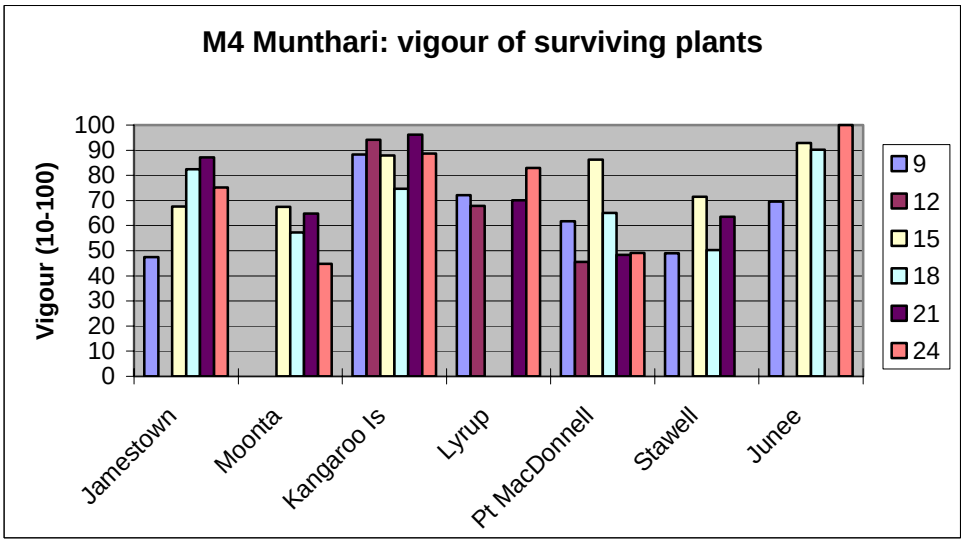
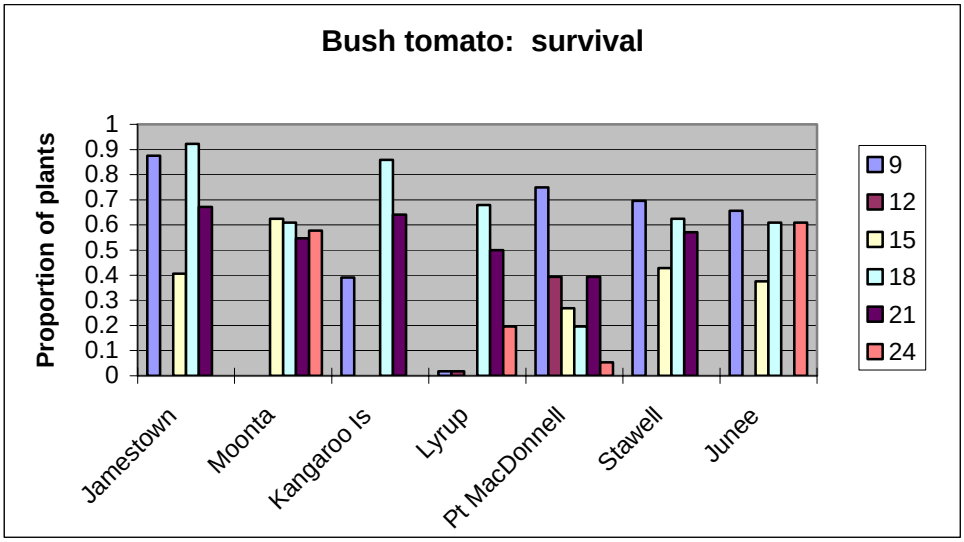
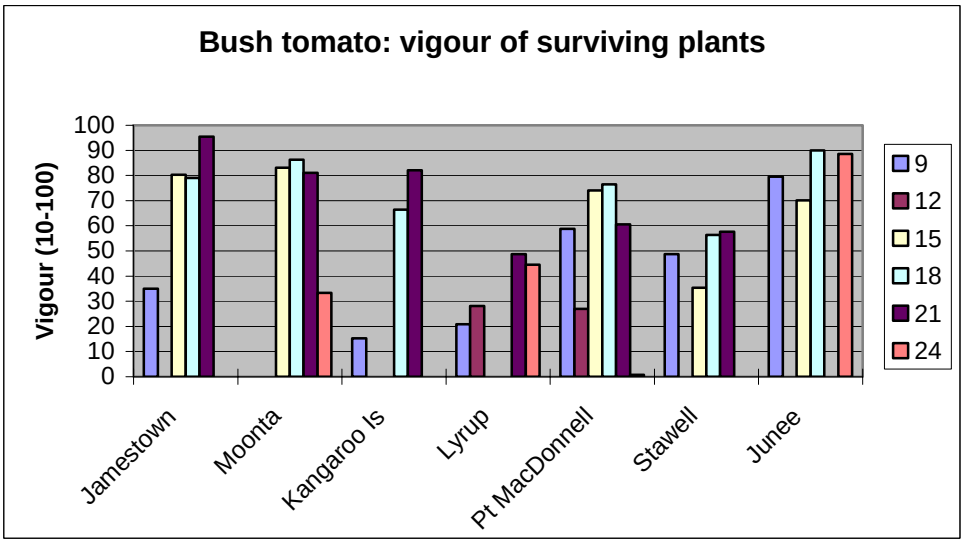


Figure 37 Survival and vigour of Bush Tomato (Solanum centrale) across trial sites (0 to 24 months after planting, spring 2001)





4.2 Plant performance at each trial site

Data and statistics for tree blocks are presented in the following section including Figures 38 to 46. For data on shrubs, please refer to Figures 35 – 37.
Criteria for plants which perform well: **survival > 75% and vigour >75 rating;**
plants which perform poorly: **survival <25% and vigour <50 rating**

Key to Figures 38 to 46

Code	Plant selection
Q FPG	Quandong "Frahn's Paringa Gem" *
Q Wildstuf	Quandong Eyre Peninsula provenance (Wildstuf Nursery)
Q Quarmby	Quandong ex Reedy Creek Nursery
Q Jacobs	Quandong ex R. Jacobs Pt Augusta
Q CSIRO	Quandong CSIRO selections (9-26, 6-16, 11-1)
Avic Hawker	*Acacia victoriae* Hawker provenance
Avic other	*Acacia victoriae* other provenances (Ivanhoe, Wilmington, Copley, Buronga)
Blood lime	Finger Lime hybrid "Australian Blood Lime" *
Desert lime	Desert lime selection CR101-13
Sunrise lime	Finger Lime hybrid "Australian Sunrise Lime" *
MP Toora	Mountain Pepper Toora provenance
MP CaptFlat	Mountain Pepper Captain's Flat Provenance
MP other	Mountain Pepper Other provenances (Mt Macedon, Cape Barren Is, Black Spur)
L Myrtle	Lemon Myrtle ANPI selection
L Aspen	Lemon Aspen ANPI selection
R ANPI	Riberry ANPI selection
R Cascade	Riberry "Cascade" *
R Vic's	Riberry "Vic's Choice"

* PBR – protected

Jamestown (Figure 38)

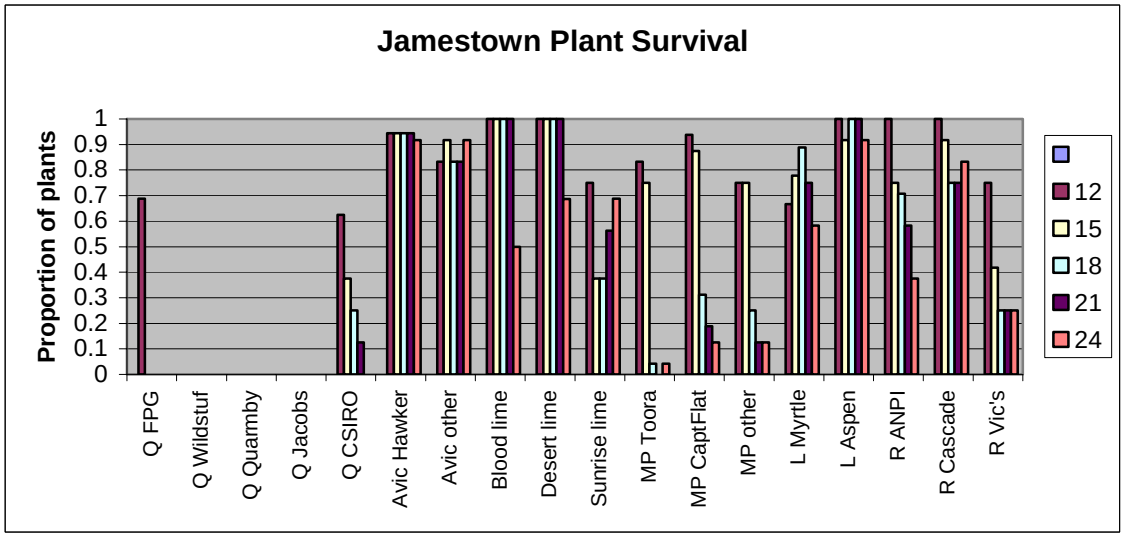
Trees

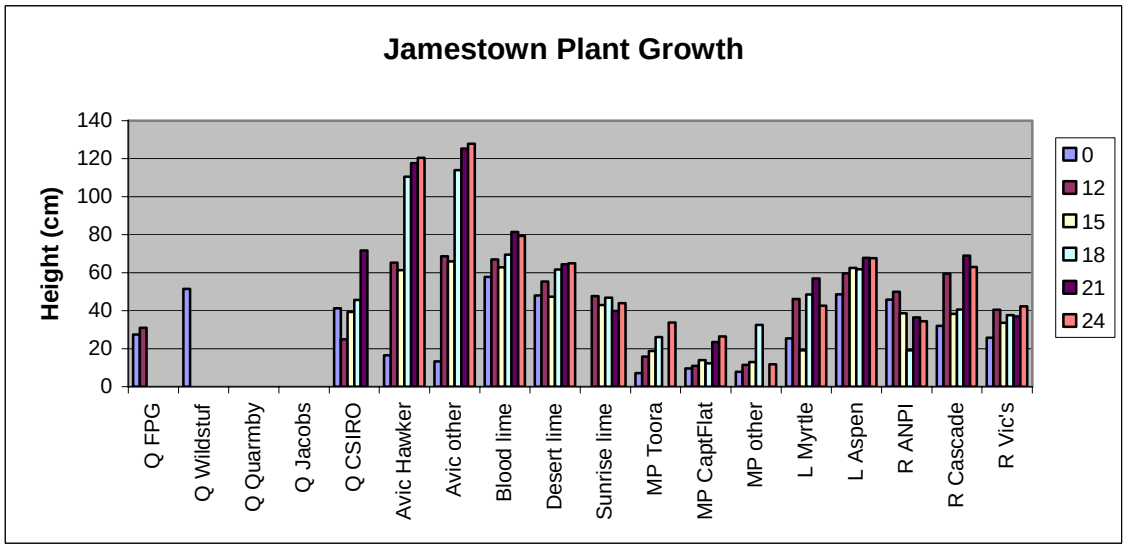
Plants which **performed well (survival > 75% and vigour >75 rating)** – *A. victoriae*, lemon aspen, Blood lime, Desert lime, "Cascade" riberry, lemon myrtle
Plants which showed **moderate success**: Sunrise lime, lemon myrtle, ANPI riberry
Poor performers (survival <25% and vigour <50 rating) – mountain pepper, quandong (though some of the later plantings of vigorous seedlings have performed well), Vic's Choice riberry,

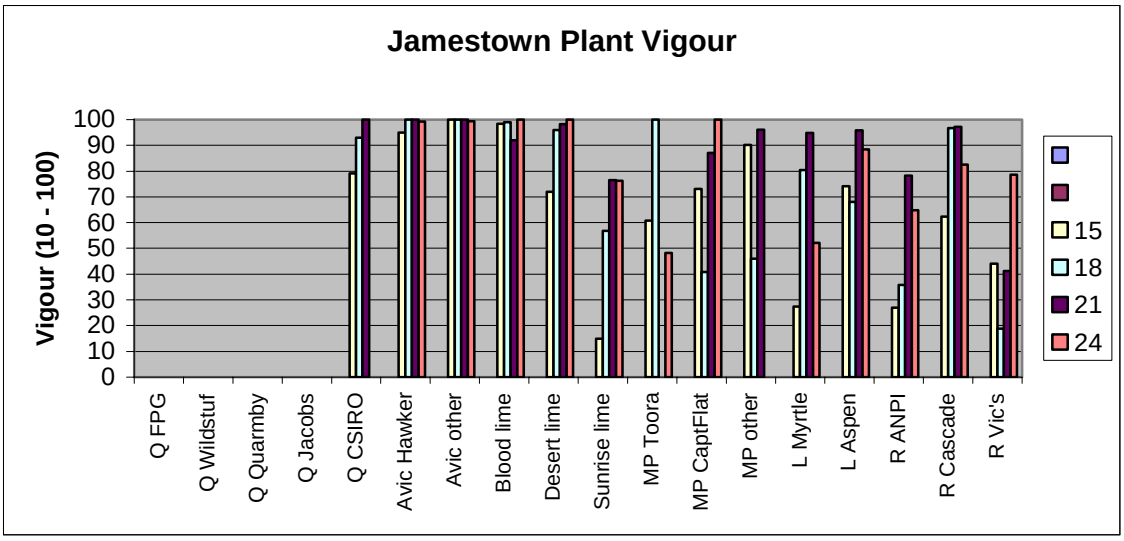
Shrubs

Bush tomato has become established, still flowering and fruiting well in the third season. Munthari were quite variable in establishment between plants along a row 9 (many misses) but the vigour of surviving plants has been good and some have begun yielding fruit. Therefore there does appear to be some prospect of munthari cultivation here.

Figure 38 Plant survival, growth and vigour at Jamestown site (trees)







Moonta (Figure 39)

Trees

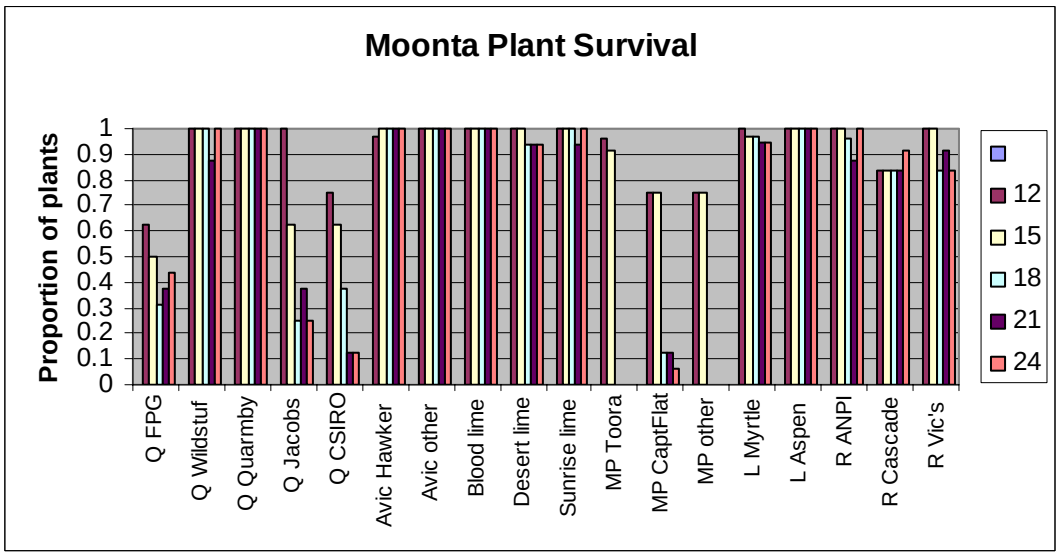
Plant which **performed well (survival > 75% and vigour >75 rating)** – *A. victoriae*, quandong (Eyre Peninsula and Reedy Creek), all three Citrus, lemon aspen
Moderate performers – lemon myrtle, riberry
Poor performers (survival <25% and vigour <50 rating) – mountain pepper, quandong (some selections)

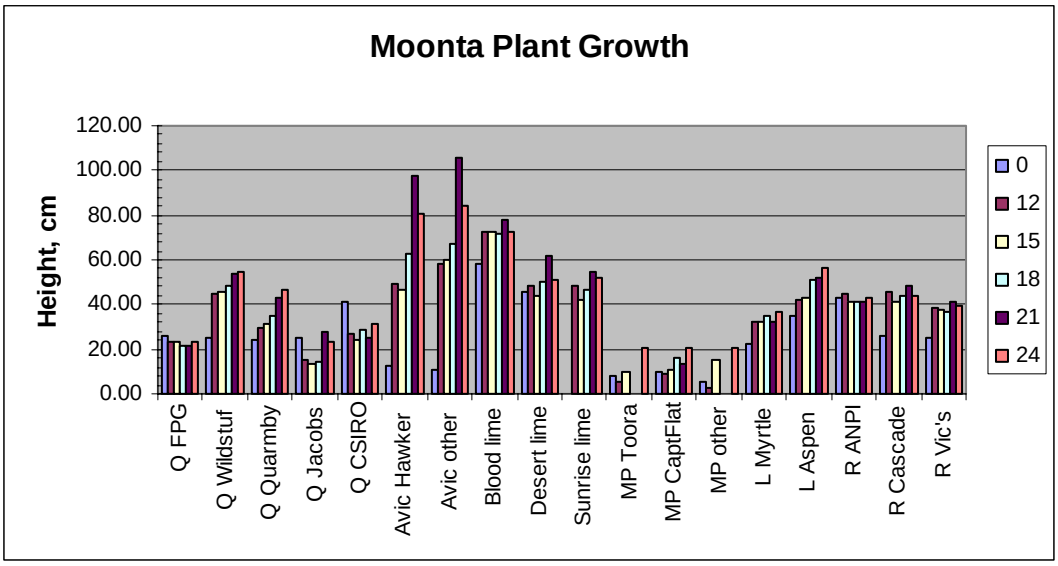
Shrubs

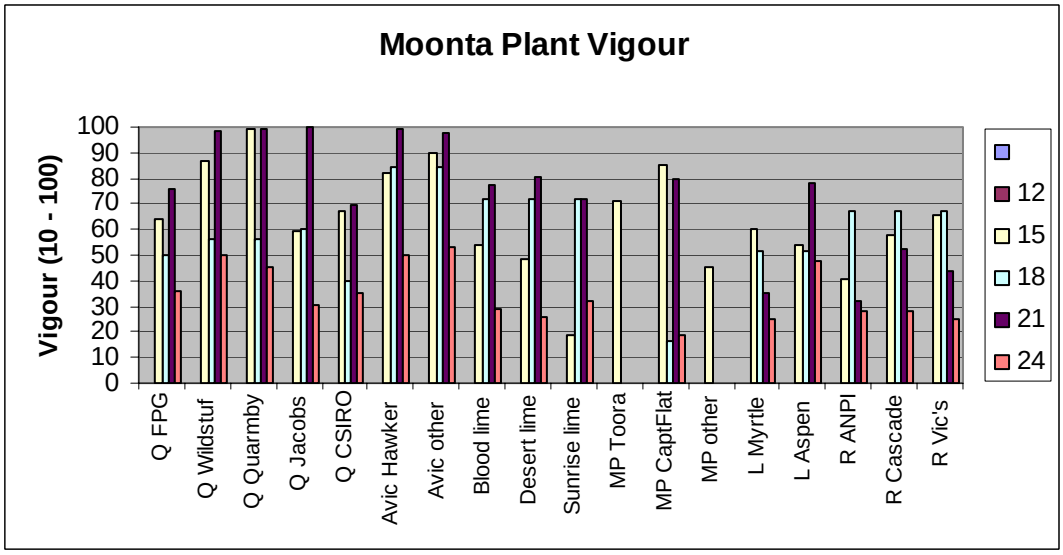
Bush tomato have become established; some are flowering and fruiting in the third season
Munthari were quite variable in establishment between plants along a row 9 (many misses) but the vigour of surviving plants has been good. Where they are growing on a trellis, the wind seems to hamper the growth.

Wind protection is a major factor requiring attention at this site.

Figure 39 Plant survival, growth and vigour at Moonta site (trees)







Kangaroo Island (Figure 40)

After initial success with many plants in establishment and good early vigour, a number of species are now showing decreases in vigour. This appears to be due to a combination of cool and windy conditions. Wind protection is a major factor requiring attention at this site.

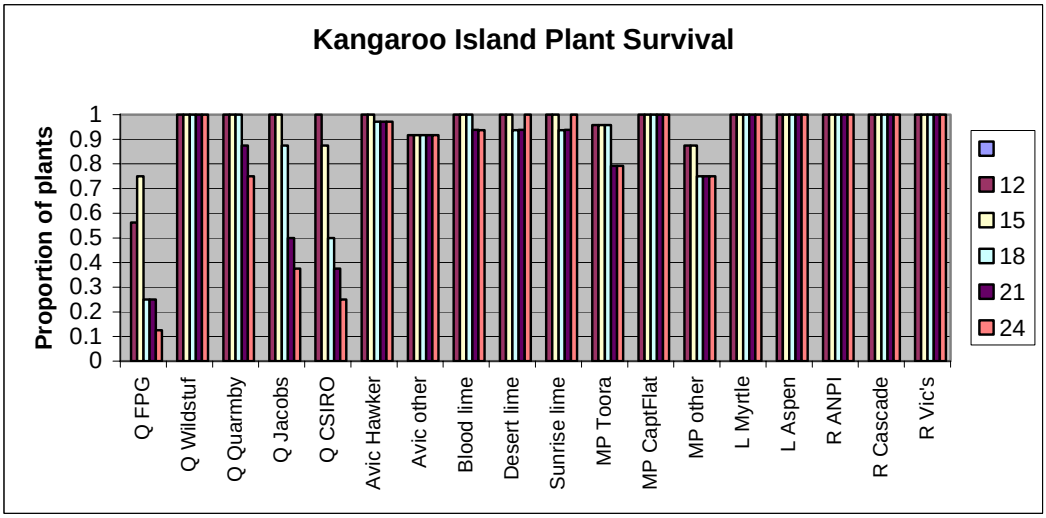
Trees

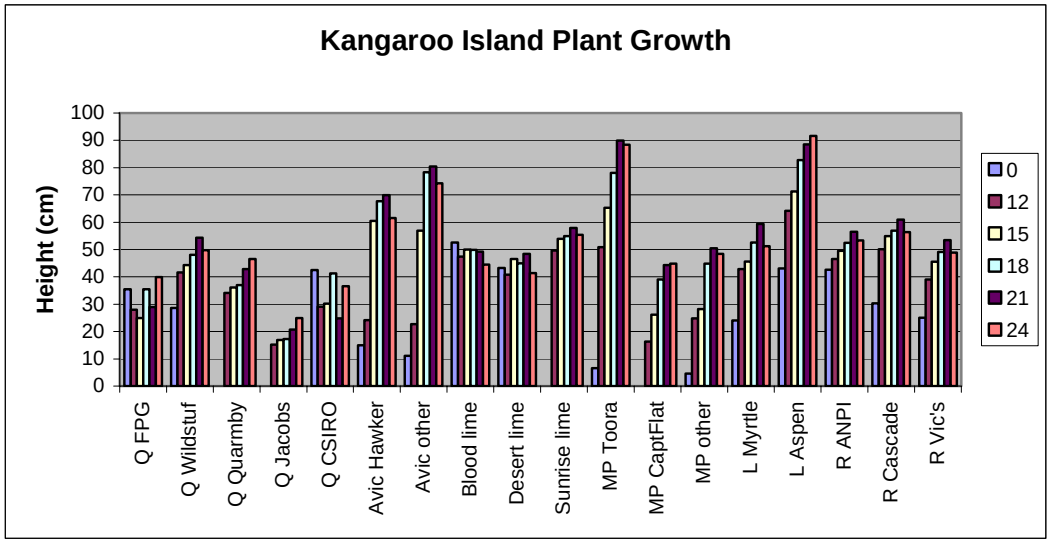
Plant which **performed well (survival > 75% and vigour >75 rating)** – Mountain pepper (Captain's Flat selection at 30 months is clearly better), *A. victoriae*, lemon aspen, riberry (some selections)
Moderate performers – lemon myrtle, some riberry selections, some *Citrus*
Poor performers (survival <25% and vigour <50 rating) – quandong, some *Citrus*

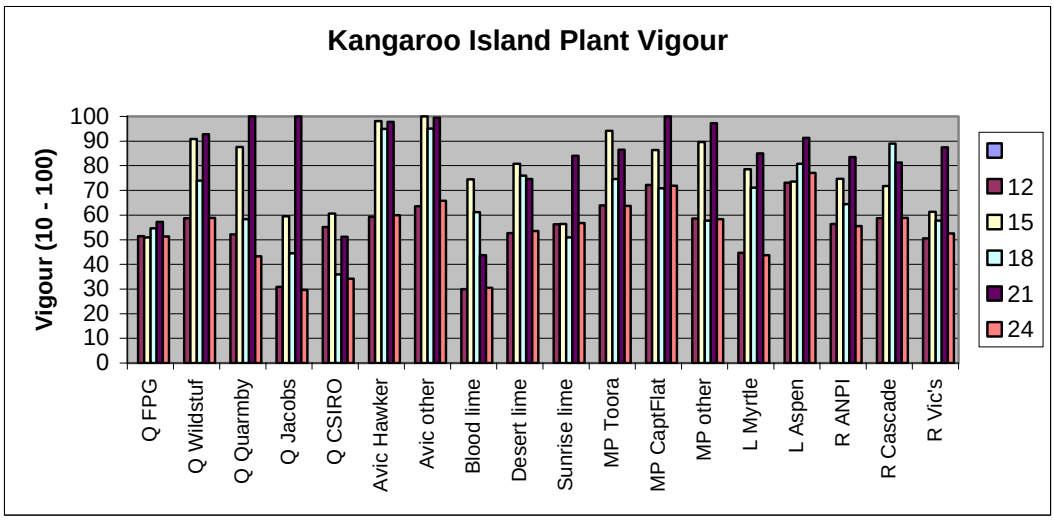
Shrubs

Bush tomato has failed to establish and must be treated as an annual crop in this area, if its cultivation is attempted at all.
Munthari establishment and early growth has been extremely good. However, training on to the trellises has been adversely affected by wind.

Figure 40 Plant survival, growth and vigour at Kangaroo Island site (trees)







Lyrup (Figure 41)

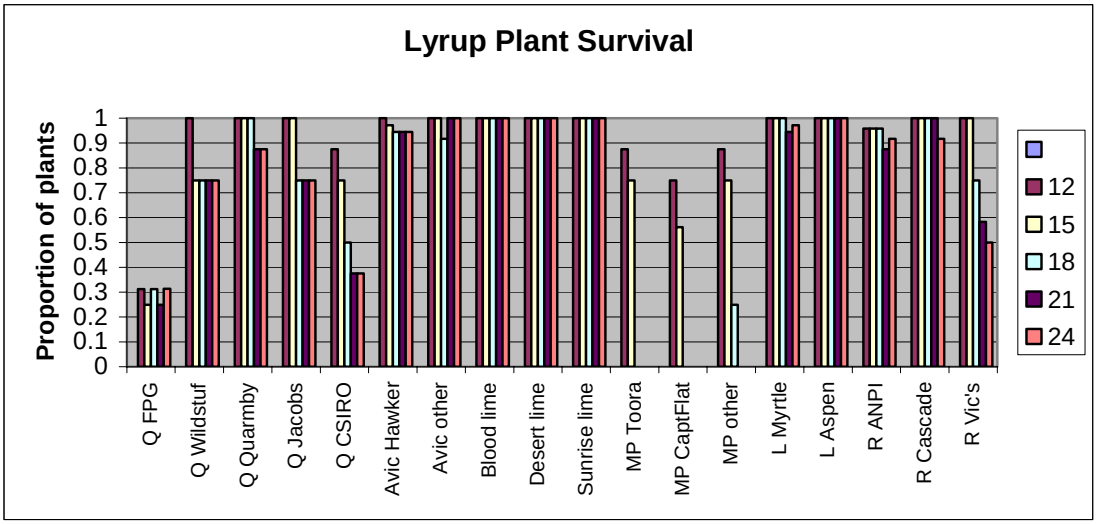
Trees

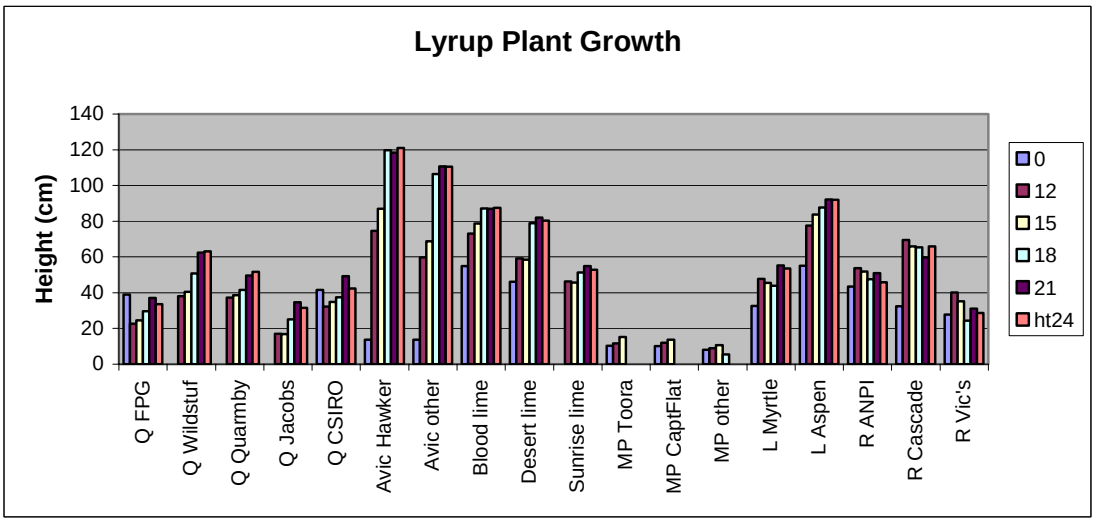
Plant which **performed well (survival > 75% and vigour >75 rating)** – *Citrus*, *A. victoriae*, lemon aspen, quandong (selections which were planted later), Cascade and ANPI riberry
Moderate performers – lemon myrtle, Vic's Choice riberry
Poor performers (survival <25% and vigour <50 rating) – mountain pepper, quandong (early plantings, though survivors are now quite vigorous), Vic's Choice riberry

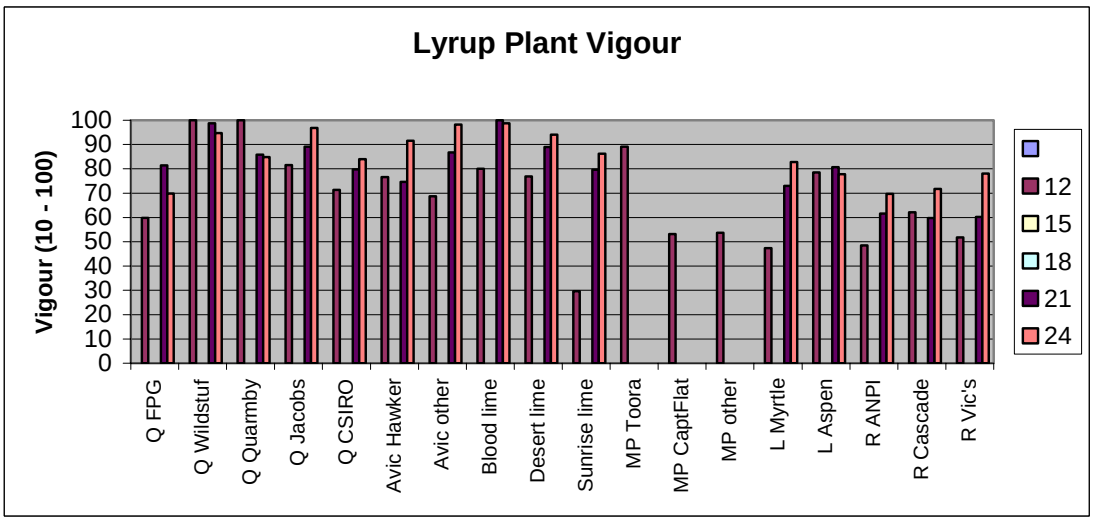
Shrubs

Bush tomato has largely failed to become established: there may have been soil borne pathogen problems (complete failure in first planting).
Munthari establishment was poor, however many of the surviving plants grew quite vigorously. If the early establishment problems can be over come there may be a prospect for this crop in this area, especially if using "inland" selections such as M4.

Figure 41 Plant survival, growth and vigour at Lyrup site (trees)







Pt MacDonnell (Figure 42)

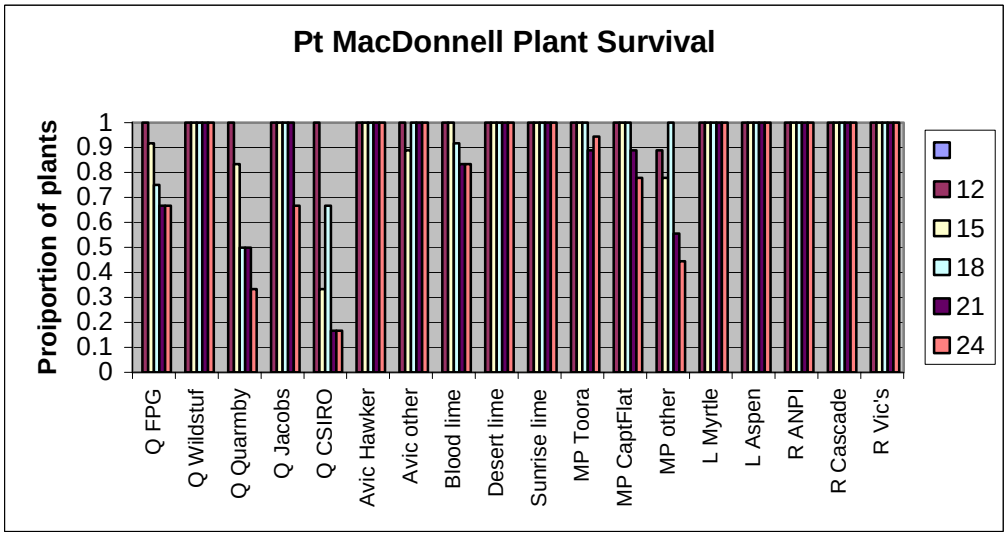
Trees

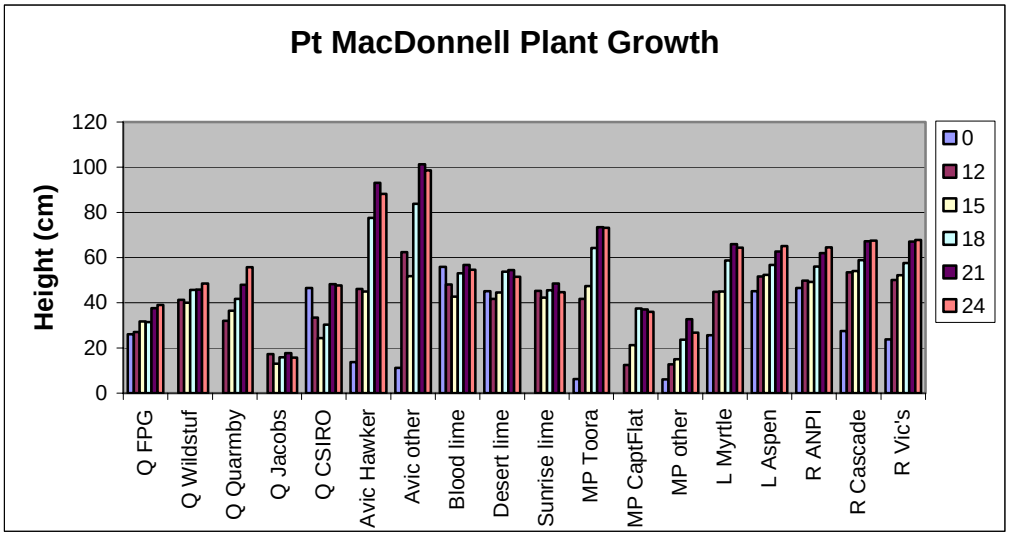
Plant which **performed well (survival > 75% and vigour >75 rating)** – riberry, *A. victoriae*, mountain pepper (Captain's Flat and Toora), quandong (Eyre Peninsula and Jacobs), *Citrus* (Blood lime and Desert lime)
Moderate performers– lemon myrtle, lemon aspen, Sunrise lime, quandong (CSIRO, Frahn's Paringa Gem), mountain pepper ("other" selections)
Poor performers (survival <25% and vigour <50 rating) - none

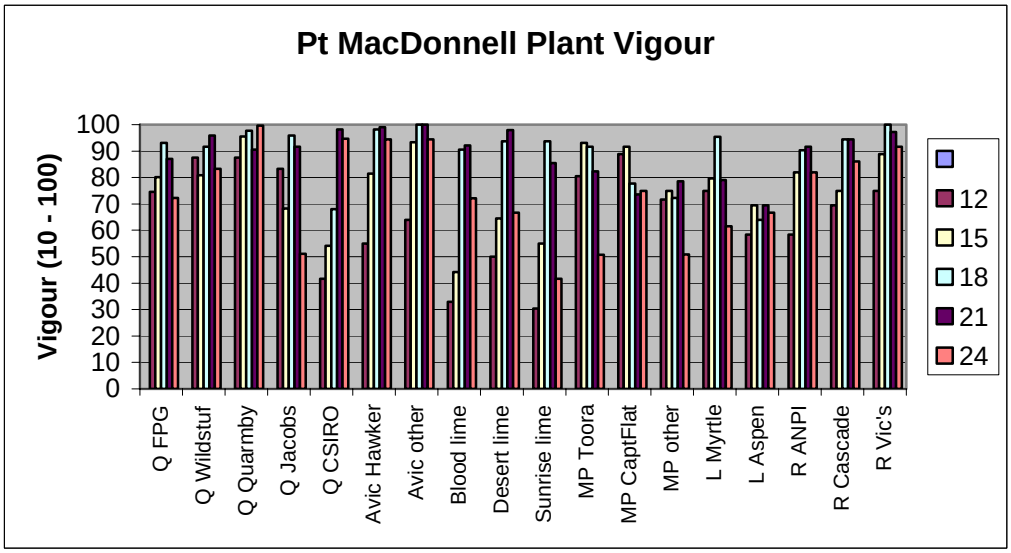
Shrubs

Bush tomato have survived to a small extent but have not really become established and should be grown as an annual crop if it to be grown at all in this region. There were flowers but no fruit in the first summer.
Munthari were very variable in establishment between plants along a row (many misses). Plant survival is declining and vigour is only moderate to good. This plant is native to the region and better results had been expected. A possible reason for lack of success is soil manipulation prior to planting where heavier soil was brought to the surface. This may be ameliorated prior to replanting in future.

Figure 42 Plant survival, growth and vigour at Pt MacDonnell site (trees)







Stawell (Figure 43)

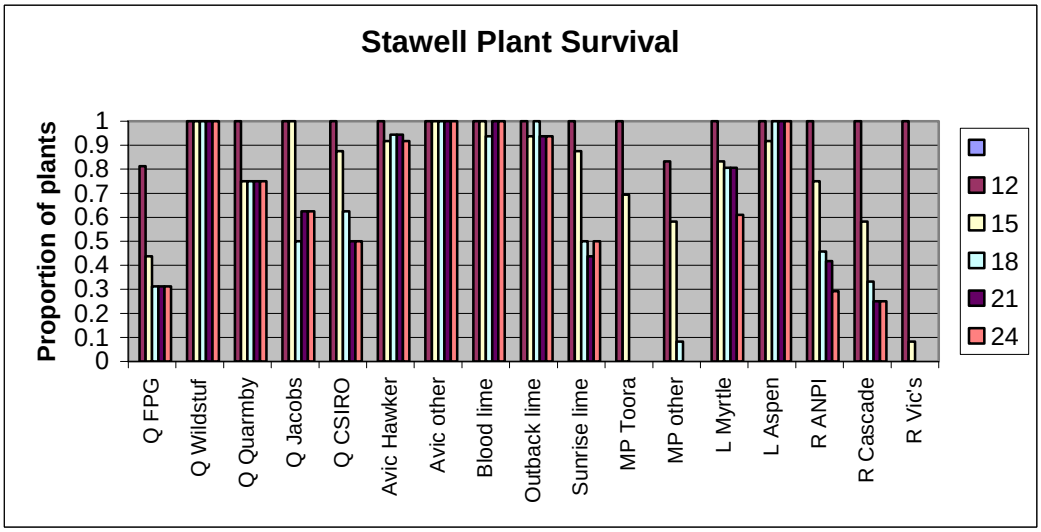
Trees

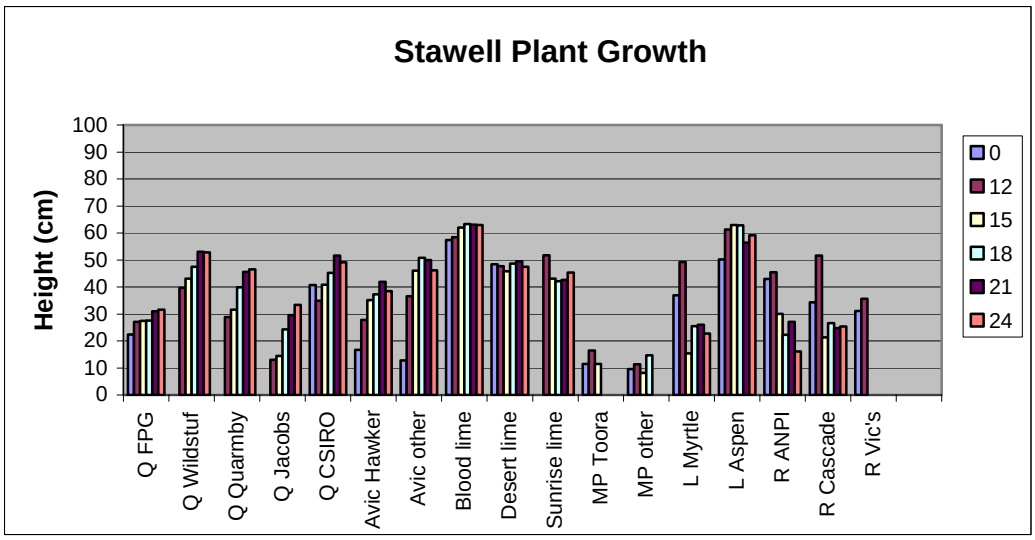
Plant which **performed well (survival > 75% and vigour >75 rating)** – Blood lime, *A. victoriae*, lemon aspen, later plantings of quandong (Eyre Peninsula Wildstuf Nursery, Quarmby's Reedy Creek Nursery)
Moderate performers - Desert lime, Lemon myrtle (good survival, but poor vigour) Sunrise lime
Poor performers (survival <25% and vigour <50 rating) – quandong (Frahn's Paringa Gem), mountain pepper, riberry

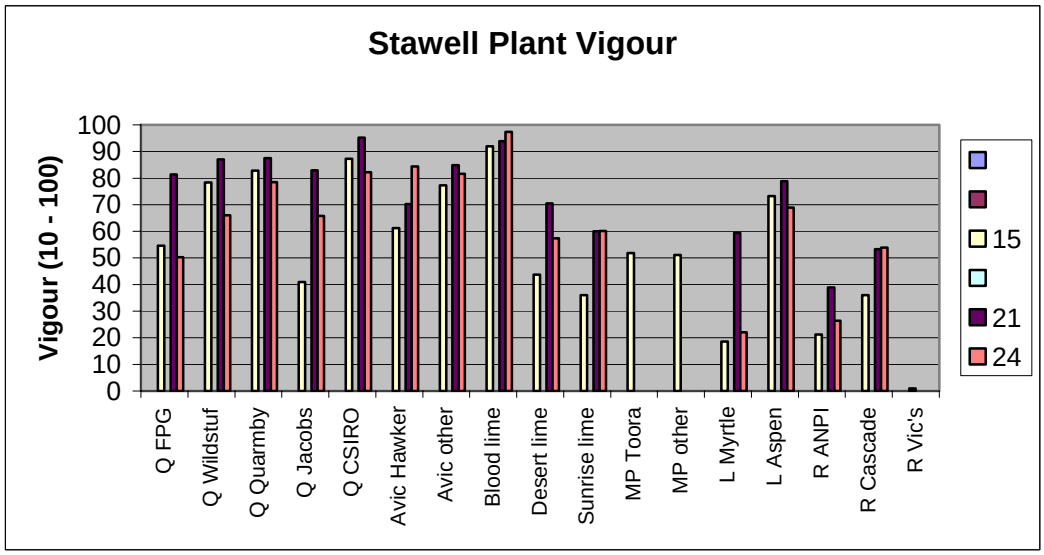
Shrubs

Bush tomato were moderately successful. They flowered and fruited in the first summer. Survival has been low to moderate and the plant has become established through suckers these have not flowered. Vigour has been moderate. Bush tomato needs to be treated as an annual crop in this location.
"Rivoli Bay" munthari has performed quite well in both survival and vigour. Fruit has been produced (500 g in 2004). M4 selection has been considerably less successful, though 3 plants have produced fruit in every summer.

Figure 43 Plant survival, growth and vigour at Stawell site (trees)







Junee (Figure 44)

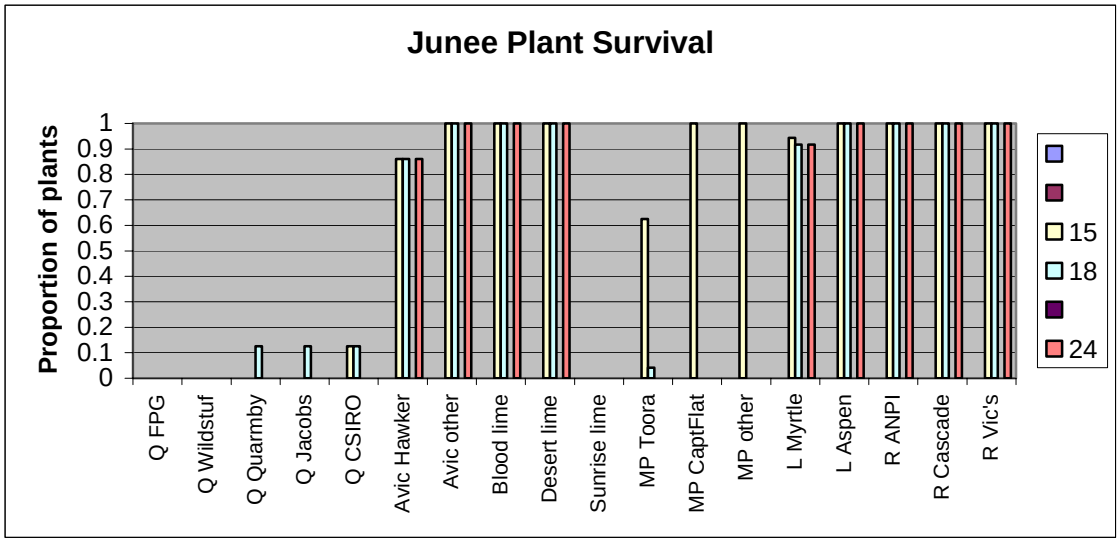
Trees

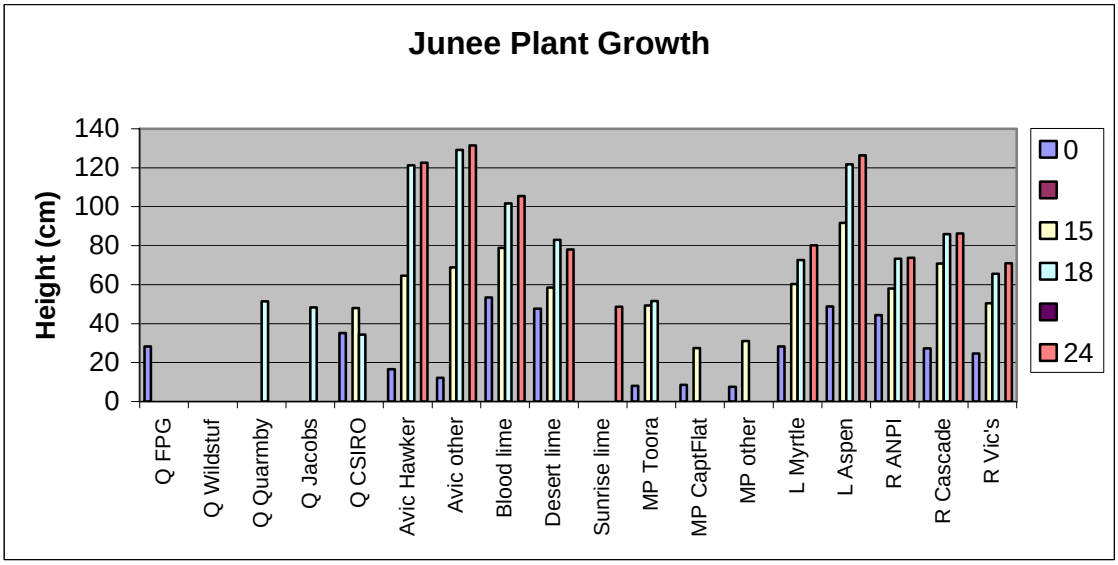
Plant which **performed well (survival > 75% and vigour >75 rating)** – Blood lime, Desert Lime, *A. victoriae*, lemon aspen, lemon myrtle, all riberry selections.
Moderate performers - none
Poor performers (survival <25% and vigour <50 rating) – Sunrise lime, quandong, mountain pepper

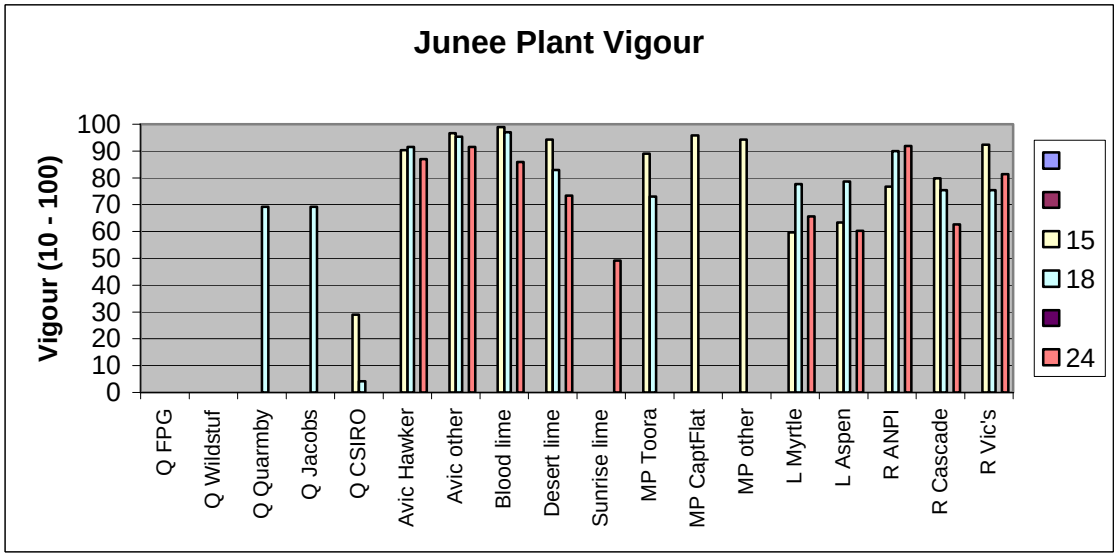
Shrubs

Bush tomato was highly successful although the survival was only moderately good. The plant has become locally established and flowered, fruited and suckered well into the second and third summers
Munthari survival was only moderate (around 50% for “Rivoli Bay” and <50% for M4) but the surviving plants were extremely good in their vigour flowering and fruiting). This shows that there is potential for this crop in this area.

Figure 44 Plant survival, growth and vigour at Junee site (trees)







Mt Gambier (Figure 45)

Trees

Plants that **performed well (survival > 75% and vigour >75 rating) –** *A. victoriae*, all *Citrus*, mountain pepper (some selections), lemon aspen, ANPI and Cascade riberry, some quandong

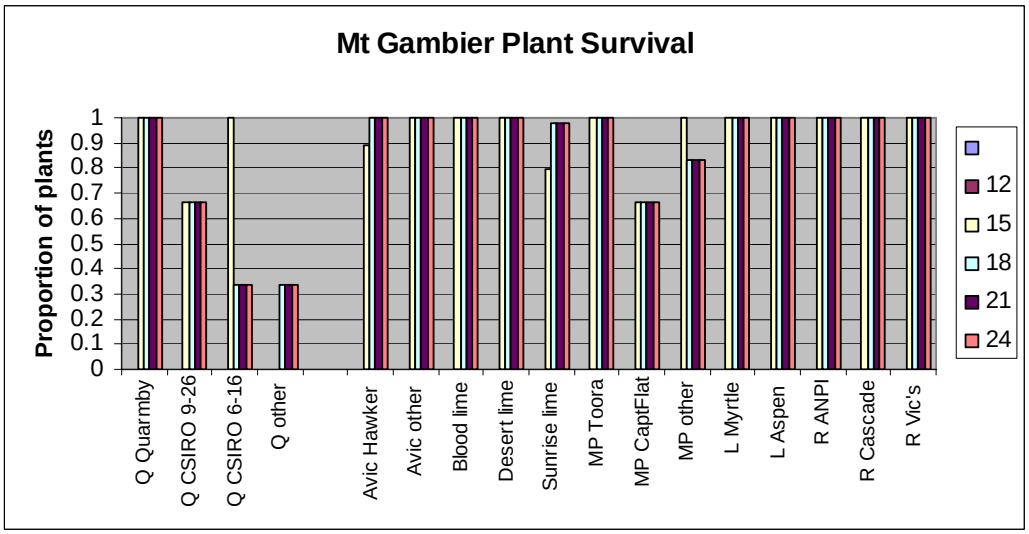
Moderate performers – mountain pepper (Captain's Flat), Vic's Choice riberry, lemon myrtle, some quandong

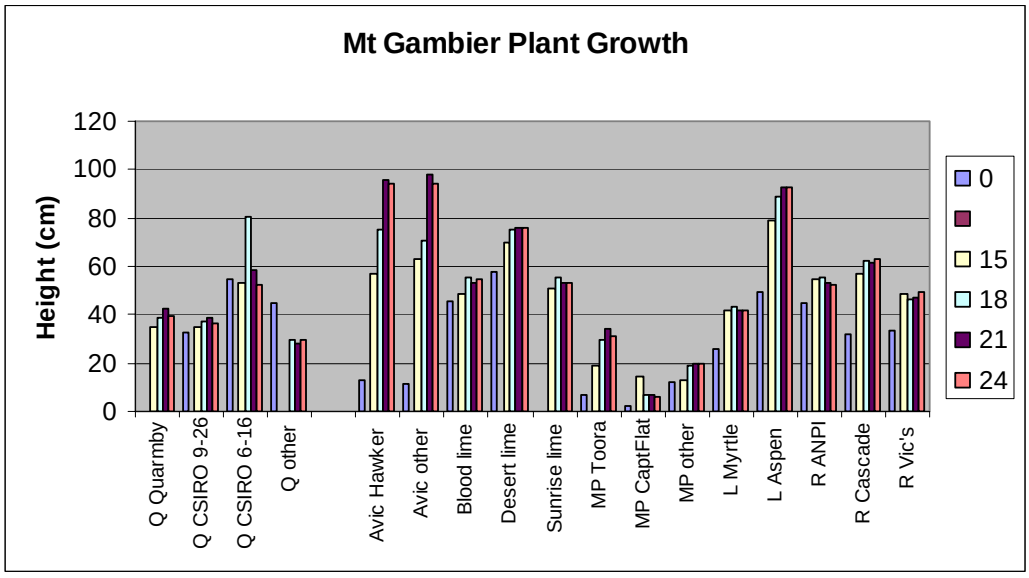
Poor performers (survival <25% and vigour <50 rating) – some quandong

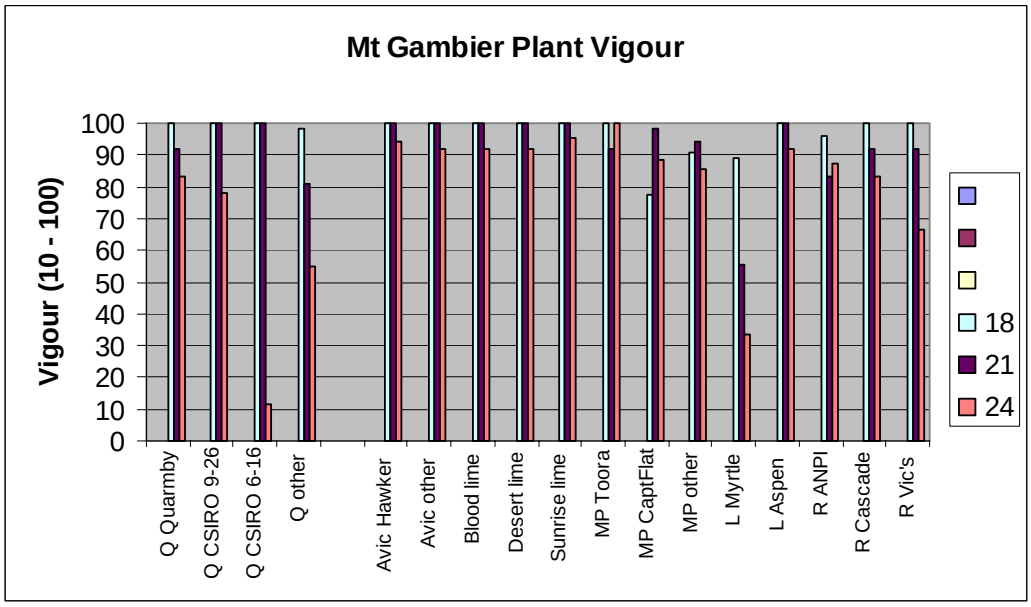
Shrubs

Bush tomato was not successful (data not shown) with almost complete failure to establish. Munthari on the other hand were extremely successful, with over 90% establishment, very good vigour and early flowering and fruit set. In 2004, over 7 kg were harvested from 26 of 31 shrubs.

Figure 45 Plant survival, growth and vigour at Mt Gambier site (trees)







Ceduna (Figure 46)

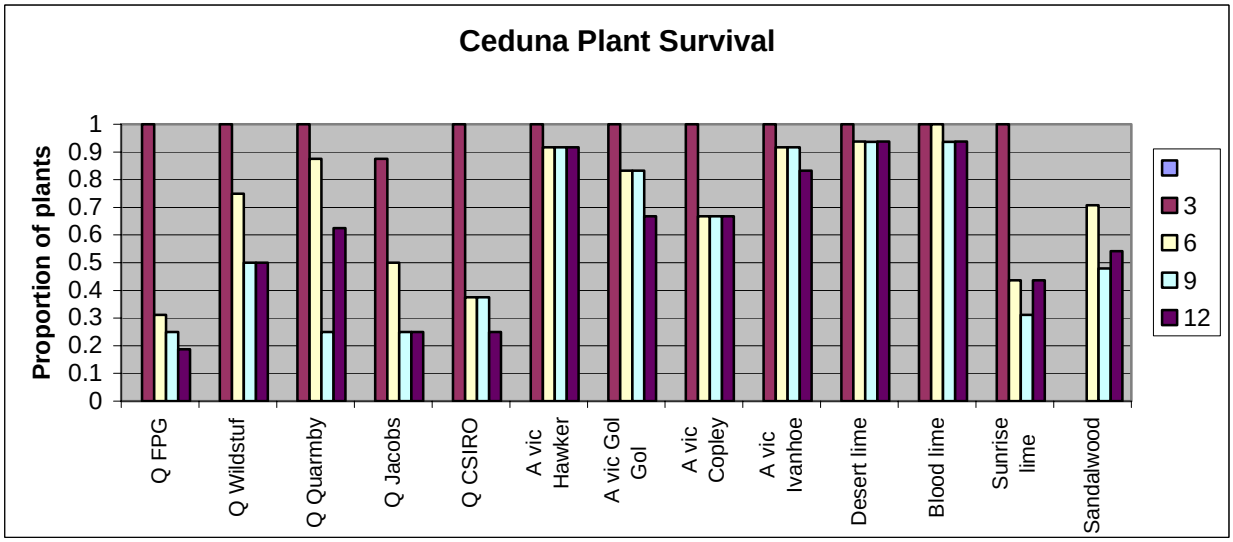
Trees

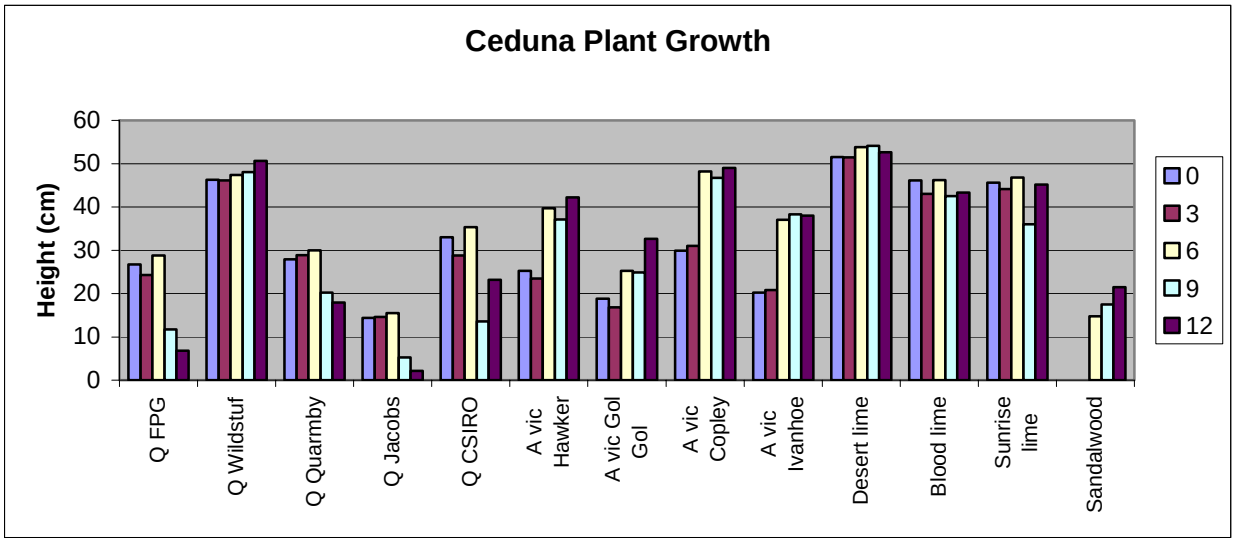
Plants that performed well (survival > 75% and vigour >75 rating) – *A. victoriae* from Hawker and Ivanhoe, Desert lime and Blood lime
Moderate performers – *A. victoriae* from Copley and Gol Gol, Sandalwood, quandong (Eyre Peninsula Wildstuf Nursery and Quarmby's Reedy Creek Nursery)
Poor performers (survival <25% and vigour <50 rating) – quandong (CSIRO and Frahn's Paringa Gem), Sunrise lime

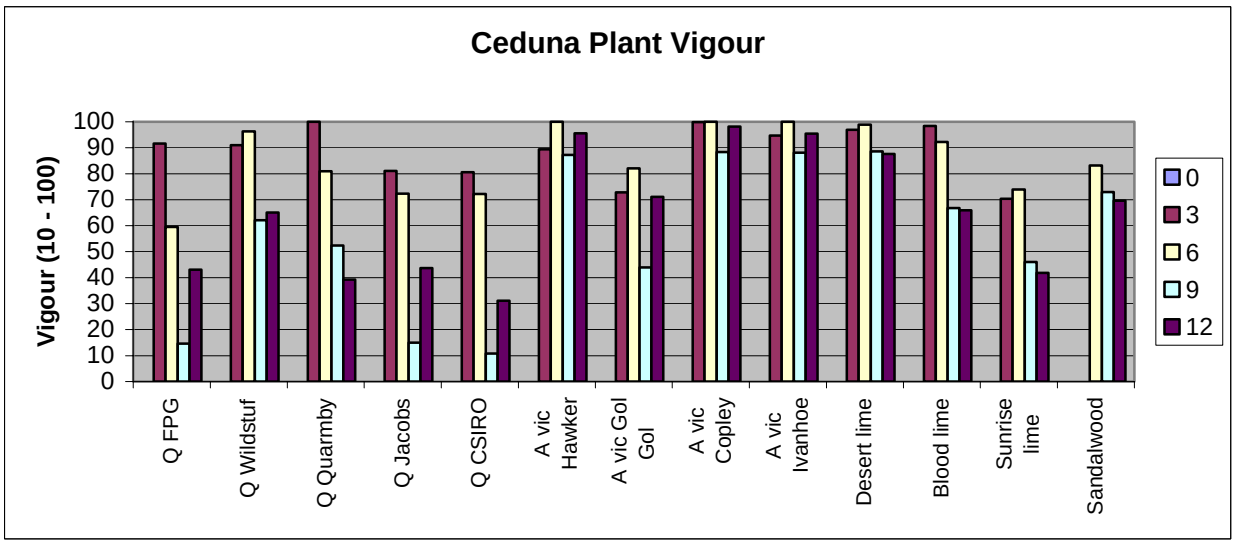
Shrubs and "Climbers"

Data for shrubs (bush tomato and konkerberry) and "climbers" (munthari, bush banana and sweet appleberry) at Ceduna are still being compiled for analysis.

Figure 46 Plant survival, growth and vigour at Ceduna site (trees) (months after planting in Spring 2002)







5. Discussion of research findings

5.1 Quandong

The early establishment of quandong is problematic if treated in the same way as other plants. In our trials, all plants were provided with plastic treeguards held with bamboo stakes. However, there is preliminary evidence from our Kangaroo Island trial and also from other growers, that survival can be increased with extra shading (e.g. shadecloth enclosures). The quandongs which were planted later (1 year after the host plant) tended to survive better, which could be attributed to a combination of better seedling vigour at planting and planting alongside an established host. It was noticeable that in cases where the host plant had grown to fill up the inside of the treeguard, the quandong seedling at the centre was often protected and healthy. This adds further support to the idea that extra protection in the early stages may be beneficial.

We used no chemical fungicides at planting. We may have increased the survival of plants if this type of treatment had been used, as there is a suggestion that soilborne fungal diseases can affect establishment (ANPI / PIRSA online fact sheets).

Those quandong seedlings that survived the first two summers often showed good vigour and growth. This illustrates the importance of assisting the plants in the establishment phase eg by extra shading and wind protection. Sites at which good growth and vigour have occurred in plants which have survived the first 18 months: Lyrup, Jamestown, Moonta, Pt MacDonnell and Stawell.

The quandong seedlings have survived and grown in locations outside the natural range (eg Port MacDonnell and Kangaroo Island). However it remains to be seen whether they are able to flower, set fruit and produce ripe fruit in those locations.

Each quandong plot contained a mixture of plants from different sources because of a need to provide good opportunity for cross-pollination to occur (Lethbridge and Randell, 2003).

Quandong seedlings show a good ability to recover by re-shooting after a major trauma such as loss of all leaves.

5.2 Acacia victoriae

This plant can tolerate and grow well in a very wide range of environmental conditions. It has established well, and has maintained a good to very good vigour in most locations. Growth of this plant is faster than for any other species being tested in the trials.

Flowering and seed set began in the third summer but was very sporadic, with perhaps one tree in any 12-tree plot carrying a small amount of seed (<100 pods). No flowering or seed set has yet been recorded from the southernmost sites (Kangaroo Island, Pt MacDonnell, Mt Gambier – there were some flowers but no seed at the latter two sites).

Because of its shrubby habit, *A. victoriae* needs some pruning and staking to facilitate harvest at later stages, and staking following pruning at windy sites.

From this trial and from other plantings it is clear that there is a great deal of genetic variation between plants, in a range of characteristics, some of which will be important for plant improvement. While we have not yet documented this, there are plants with very atypical foliage, plants lacking spines (a desirable characteristic for cultivation). We can also

anticipate that there will be large variation in seed yield between plants in future. The selection of high yielding plants, of plants with better adaptation to certain areas (soil, climate) and of plants with other useful characteristics is imperative for the future development of *A. victoriae* as a cultivated crop.

Other *Acacia* species can also be cultivated for seed production (Maslin et al., 1998). Some of these other species may have particularly useful agronomic or food characteristics. Similar types of work on selection of plants for greater uniformity and higher yield etc will also be required for these species. The cultivation and use of *Acacia colei* and other arid zone acacias has been investigated scientifically during the past decade (House and Harwood, 1992). The future development of *Acacia* as a food crop at the cultivation end of the value chain will depend on many factors including crop improvement, and the possibility of growing the species as a dryland crop which includes efficient harvest methods.

5.3 Citrus

All three *Citrus* exhibited very good establishment across sites, with the Blood Lime and Desert Lime standing out as the best. The high level of survival across sites is similar to that of *Acacia victoriae*. The Troyer Citrange rootstock probably plays a large role in the adaptability of the *Citrus* to different soils and climates. The vigour of *Citrus* has generally been very good. However many of the plants are reduced in vigour at windy sites (Moonta) and especially a combination of wind and cooler conditions (Kangaroo Is.). Growth in height has been most dramatic at Lyrup and Junee. Future management of the *Citrus* is likely to involve nutrient management.

5.4 Mountain pepper

Although no data has been collected specifically to confirm this, mountain pepper has the greatest water requirement of all the species being trialled or, conversely, is the least tolerant of dry soil conditions. It has only survived through the first two years at two of the sites, i.e. Pt MacDonnell and Kangaroo Is (as well as in the small trial at Mt Gambier). The first summer (2001-02) was relatively mild and this assisted the survival of mountain pepper at many of the other sites, eg Jamestown, Moonta, Lyrup, Stawell, and the plants certainly did grow in the first year, however they did not tolerate the hotter late summer conditions. This indicates that it may be possible to grow mountain pepper in a wider range of environments. However a good, reliable water supply would be needed and the economics of production may not be favourable considering the high water requirement. Alternatively, it may be possible to extend the range by developing a production system where mountain pepper is grown as an understorey plant (as it is in nature). This would be analogous to the cultivation of coffee as a shade (understorey) plant in tropical and sub-tropical areas. On the other hand., production systems have been developed for growing coffee without shade (Drinnan and Peasley, 1997). By identifying paying attention to its particular requirements, the same may be possible with mountain pepper.

The Toora provenance, which has a more upright form, grew the fastest. The other forms being trialled have a more branched, shrubby habit. More recent observation of plant vigour at the Kangaroo Is site (J Melbourne, March 2004) strongly suggests that Captain's Flat provenance is much better suited to those conditions than Toora, even though Toora showed the best growth during the first 2 years. The difference in vigour (appearance) is very clear and, if it continues, demonstrates that it is extremely valuable to test a range of selections or provenances when attempting to grow this crop in a new location.

5.5 Lemon Myrtle

Lemon myrtle can grow in a wide variety of locations. It appears to be tolerant of temporary dry conditions and can often regenerate from the base of the plant after almost complete loss of foliage due to drought. However, losses of plants at Jamestown and Stawell are likely to be due to extended periods without sufficient water. Lemon myrtle does appear to require a consistent water supply to do well. It has performed best at Junee, Jamestown, Pt MacDonnell and in the early stages on Kangaroo Is. More recently wind damage has restricted progress on Kangaroo Is. The plant is also sensitive to frost (e.g. Jamestown) but has recovered well during the 2003-04 summer. Decreases in average height over time are likely to have been due to frost (Jamestown), wind (Kangaroo Is) and low water supply (Stawell).

Despite its ability to grow in a wide variety of locations, lemon myrtle will probably not yield a good quality leaf product across this range. We have not done any detailed investigation of produce quality in this project. Nevertheless it is clear that lemon myrtle does not enjoy alkaline soil conditions and the leaves exhibit nutrient deficiency symptoms typical of acid-loving plants when grown on alkaline soils. Some of these symptoms could possibly be corrected by the application of foliar or other nutrients, if we could identify the primary problems. We have made some chemical analyses of good and poor quality foliage but it is not yet clear what the main problems are. The compost and mulch treatments may be able to alleviate symptoms to some extent. Briefly, an early conclusion is that lemon myrtle is best grown on acid to neutral soils with wind protection.

5.6 Lemon Aspen

Lemon aspen seems well adapted to surviving, growing and having a generally healthy green appearance in a wide range of environments. Despite the limited fertiliser application, these plants are not showing signs of deficiency. Establishment and early growth have been quite reliable.

Flowers have been observed at several sites, but fruit set has only been seen at one trial. Being a fruit crop, we may need to know more about the pollination mechanisms and requirements of this species to be able to ensure reliable cropping.

The average vigour of lemon aspen has been rated moderate to very good. This plant is the most susceptible to insect attack of all the species in these trials. We have not identified what the particular pest/s is/are but these problems have generally not been of great concern to the overall health and vigour of the plant. Lemon aspen also appears to be affected by a hyperplasia (witches' broom) which has developed more obvious symptoms at some locations than others.

5.7 Riberry

"Cascade" hybrid was the hardiest of the three selections tested across sites and seasons. "Vic's Choice" was the least hardy and ANPI selection was intermediate. However it is interesting that at Pt MacDonnell, "Vic's Choice" performed particularly well. At sites with restricted water supply such as Stawell, "Vic's Choice" did not survive and both of the other two selections declined dramatically and showed only poor to moderate vigour. This shows the dependence of riberry on more moist conditions, probably rating in between lemon myrtle and mountain pepper in its water requirements.

Riberry is sensitive to frost but was protected to some extent by the plastic treeguards at Jamestown. It is also sensitive to wind damage. Riberry appeared to be somewhat intolerant of alkaline soil conditions, though less so than lemon myrtle.

The best of the sites for cultivation of riberry at this stage are Pt MacDonnell and Junee, with Kangaroo Is., Jamestown and Mt Gambier rated as reasonable. This could be improved if potential for frost (Jamestown) and wind (Kangaroo Is) damage can be overcome. The hardier selections also show some promise at Lyrup.

5.8 Munthari / muntries

Munthari survival was quite variable between sites and also within sites. Rows of munthari often contained a number of vigorous healthy plants and also a number of failures alongside them. Quite a number of plants were lost, more so at some sites than others, yet the vigour of surviving plants was often very good, especially for “Rivoli Bay”. This suggests that there are problems with seedling establishment that may be caused by soil-borne fungal diseases or soil-borne pests. We can test this by attempting to replant in the same spot to see whether the establishment problem recurs.

If the seedling establishment problem(s) can be identified and overcome, then the munthari can be grown over a wide range of locations. The plant seems to be quite tolerant of a range of soil pH, and is relatively unaffected by frost. It can be susceptible to wind damage, however. This can be seen where plants are being trained on to trellises at Kangaroo Is and Moonta: wind damage occurs when plants reach more than about 30 cm from the ground. The low and decreasing survival at Pt MacDonnell was probably caused by alteration of the soil profile prior to planting. This problem might be solved by some type of soil amelioration (e.g. addition and mixing with lighter soil or sand) prior to replanting.

At all trial sites except Lyrup, trellises have been installed to train the munthari for ease of crop management and picking. Simple, 4- or 5-wire trellises were installed at the end of the second summer. Plants are being trained with the aid of vineyard tying tape. Protection from the wind will be needed in order to successfully train the plants.

M4 munthari, which came from an inland location, in the Upper South East of SA, and “Rivoli Bay” which originated from the south east coast of SA showed some differences in survival that might relate to their origins. For example, while survival and vigour of “Rivoli Bay” was better than that of M4 at several sites, this situation was reversed at Lyrup, a site which is well inland and has an alkaline soil.

Munthari have flowered and fruited at several sites. Fruit were more commonly seen on the M4 selection at this stage. This is because the M4 seedlings were older at planting, and fruit forms on one-year-old wood. The “Rivoli Bay” set fruit at only one site (Mt Gambier) in the second summer. Several more trials have reported fruit set on “Rivoli Bay” in the third summer (2003-04).

5.9 Bush tomato

Growth, flowering and fruit set of bush tomato varied considerably across field trial sites. The ability of the plant to become locally established (i.e. perennial) through suckering in spring and summer also varied a great deal across the sites. There was good local (perennial) establishment only at Junee, Jamestown and Moonta and to a lesser extent at Lyrup and Stawell. These are clearly the warmer, drier sites. At Junee the soil ripping and formation of

large (50 cm) mounds before planting could have assisted perennial establishment of the bush tomato, by ensuring good soil drainage. These mounds may also absorb more heat in the summer, potentially stimulating faster growth and development through to flowering and fruiting.

The development of management strategies for bush tomato, to achieve good yields in both the first year and in subsequent years (at locations where it becomes perennial) requires further attention. Bush tomato is probably best treated as a vegetable crop, for production purposes, rather than as a “perennial shrub” as we have done in these trials. A production system comprising soil ripping (to loosen the soil at depth, for better drainage), mounding, weed control and irrigation, with planting in spring and harvesting at the end of summer appears to be a feasible way to produce this crop.

6. General Conclusions

Overall summary of environmental tolerance of the species tested, referring particularly to establishment and early growth rather than yield and quality which are still to be determined:

Plants which can tolerate a "wide range" of conditions demonstrating good early growth and survival (i.e. showed good early growth and survival at all sites) -
* *Acacia victoriae*
* *Citrus* (but avoid cold + wind)
* Lemon Aspen

Intermediate range:
* Lemon myrtle – avoid alkaline soils if wanting a quality product, needs a reliable water supply.
* Riberry – needs reliable water (eg irrigation).
* Bush tomato - if grown as an annual crop
* Munthari – this could move up to "wide range" as long as we can identify and control the cause of the patchy seedling establishment problem that is sometimes severe
* Quandong - this plant needs special attention (shading and planting some time after establishment of a host, for best early survival, possibly also requires fungicides). If these measures can be applied successfully, this plant could be considered as adapted to a "wide range" of conditions. Quality of planting material will strongly affect establishment.

Restricted range:
* Mountain pepper (high water requirement because it has a shallow root system, and very low tolerance of heat wave conditions)
* Bush tomato (if wanting a perennial crop) – does not become established in cold + wet conditions.

This report presents the results of a trial program that was designed to test what species / selections of native food plants grew well in different locations. Some plants appear to be adapted to a wide range of conditions; others are specific in their requirements and therefore have a restricted range. Several species are intermediate. There are clear differences between selections within species.

When making decisions about what to grow in a particular location, it should be borne in mind that conditions will vary enormously even within a narrow geographic range.

When investigating the potential for native food production in a particular area, it will be worthwhile to consider the following:

- establishment of trial plantings, especially if a plant is taken outside its natural range. This can be done on a quite small scale, at lower cost than has been incurred in this project. For example, a set of six tree species could be trialled using a dozen plants of each, in an area of approx 40 m x 40 m with trees at 4m x 4 m spacings.

- testing different selections if they are available. We have seen clear differences in hardiness among eg riberry and mountain pepper provenances at the one site.

- sourcing improved plant material or plant material of known good quality.

- use of irrigation to aid plant establishment, growth and production. This can be done using various kinds of drip irrigation system, or hand watering if the planting is on a small scale. Although irrigation may not be necessary in the longer term for some arid zone species such as *Acacia victoriae*, faster growth and larger yields are very likely to be achieved by applying irrigation.

- deep ripping of the soil, and also mounding (for better soil drainage) especially in cooler wetter regions. Mounding is likely to assist the growth and production of bush tomato in any location.

- investigation of potential markets for produce, before attempting plantings with a commercial goal.

In addition, we have observed that specific horticultural management is likely to be beneficial to particular plants. Following this discussion, the information is summarized in Table 8.

Quandong

Shading and wind protection in the early stages – eg shade cloth enclosures are likely to be more beneficial than plastic guards. Plant the host plant ahead of time and allow it to become established. May need to use fungicide at planting.

Acacia victoriae

Provenance does not seem to be critical, but it is likely that production will be better when using seed from high-yielding trees. A lot of variability between plants can be expected owing to a lack of improved material. Pruning to remove spreading limbs is recommended for ease of later management and harvest. Staking may be needed after pruning, depending on windiness of location. Weediness of this plant may become an issue in the future, depending on location.

Citrus

If using grafted plants, nutrition and water regimes will most likely be related to standard citrus production methods. Trace element application may be needed on alkaline soils. Removal of shoots from the rootstock is a part of routine maintenance. Cold and windy situations are more difficult.

Mountain pepper

Avoid hot, windy locations, and situations where plentiful water cannot be supplied regularly. Test different provenances if at all possible. Not tolerant of water stress.

Riberry

Treeguards have been beneficial for establishment, especially in situations prone to frost. Test different selections if at all possible. Somewhat tolerant of alkaline soils.

Lemon myrtle

Treeguards have been beneficial for establishment, sensitive to wind damage; avoid alkaline soils.

Lemon aspen

Does not appear to need much in the way of special treatment in early establishment, but pay attention to insect pests – may need to control these if damage is too severe.

Munthari / muntries

There can be establishment problems (good soil drainage is likely to improve establishment) Severity of the problem varied with location; fungicides may be helpful but causes are at present unknown; trellising is helpful for management and harvest, but sensitivity to wind means that wind protection is also necessary if attempting the vertical training of this plant.

Bush tomato

Ripping and mounding (plus weed mat) are likely to be beneficial. Possibly best managed as an annual crop (plant in mid-late spring, harvest in late summer / early autumn) unless conditions are particularly favourable for regrowth from suckers in later years. Perennial establishment may lead to weediness depending on location. A lot of variability between plants can be expected owing to a lack of improved material.

Greenhouse production of some species could be investigated, to extend the range of conditions (e.g. lemon myrtle, bush tomato). This would clearly be a more expensive option but could be considered where there is a local requirement for fresh produce.

Conclusions and future work on production

Further research is required to assist the future production of good, consistent yields of adequate quality in a commercially viable manner in the following areas:

- Plant improvement
- Horticultural production: watering requirements, nutrient requirements, specific requirements for certain species
- Pest and disease control: particularly soilborne diseases of quandong, munthari, bush tomato
- Harvest methods (for some species)

TABLE 8								
Species	**Soil preparation[1,2]**		**Frost tolerance[2]**	**Drought tolerance[2]**	**Wind protection[2]**	**Soil pH[2,3]**	**Test different selections / varieties[4]**	**Special requirements**
	Rip	Mound						
Quandong	✓	C / W	+++	+++	✓ (early)	(A) N C	✓	Shading and wind protection early; host plant (in advance); Cross pollination
A. victoriae	✓	C / W	+++	+++	After pruning	A N C	not available	Pruning of lower lateral branches, then staking
Citrus	✓	C / W	+++	++	C / W	A N C	✓	
Mountain Pepper	✓	C / W	+[5]	-	✓ (hot conditions)	A N (C)	✓	High water requirement; male and female plants for berry production
Lemon Myrtle	✓	C / W	+	+	✓	A N	not tested	Nutrient management on alkaline soils?
Lemon Aspen	✓	C / W	++	++		A N C	not tested	Pollination / fruit set?
Riberry	✓	C / W	(+)	(+)	✓	A N (C)	✓	Frost protection (treeguard)
Bush Tomato	✓	✓	not applicable[6]	++		A N C	not available	Good soil drainage
Munthari / muntries	✓	C / W	+++	++	✓ (on trellis)	A N C	✓	Good soil drainage

1 C / W = cooler wetter areas; 2 based on observation across sites rather than experimental evidence; 3 A = acid, N = neutral, C = calcareous (i.e. alkaline);
4 based on clear differences in performance (establishment, growth, vigour) within and / or between sites; 5 depends on provenance
6 plant dies off in winter
Scale increases in order: - = none, (+) = slight, + = low, ++ = moderate, +++ = high

7. References

Ahmed, AK and Johnson KA (2000) Horticultural development of Australian native edible plants. Australian Journal of Botany **48**: 417-426.

ANPI / PIRSA Online Fact Sheets http://www.anpi.com.au/farmserv/fs_idx.htm (on-line); http://www.pir.sa.gov.au/pages/agriculture/agfactsheets/fs_index.pdf (horticulture / fact sheets) (on line)

Drinnan, J. and Peasley, D. (1997) Coffee in "The New Rural Industries: A handbook for Farmers and Investors" ed. Keith Hyde, RIRDC

House, APN and Harwood, CE (eds) (1992), "Australian Dry-Zone *Acacias* for Human Food". CSIRO Division of Forestry, Australian Tree Seed Centre, Canberra.

Isbell, RF (1996) The Australian Soil Classification. Australian soil and land survey handbook series; v. 4. 143 pp. CSIRO Publishing, Melbourne.

Lethbridge B and Randell B (2003) Genetic and agronomic improvement of quandong. RIRDC Publication No 03/110

Maslin BR, Thomson LAJ, McDonald, MW and Hamilton-Brown S (1998), *Edible Wattle Seeds of Southern Australia. A Review of Species for Use in Semi-arid Regions.* CSIRO Forestry and Forest Products-Western Australia Department of Conservation and Land Management (CALM), CSIRO Publishing, Melbourne.

Sykes SR (2002) 'Australian Outback', 'Australian Blood' and 'Australian Sunrise' *Plant Varieties J.* **15**(4): 18-21.

Williams ER, Matheson AC and Harwood CE (2002) Experimental Design and Analysis for Tree Improvement Second Edition, 220 pp, CSIRO Publishing, Melbourne.