

**1999/2000**

**HORTICULTURE  
TECHNICAL ANNUAL  
REPORT**



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## PREFACE

The purpose of this report is to present all the work done in the past year by the Horticulture Division and other Divisions that worked on horticulture industry related projects.

The Horticulture Division provides research, development and extension services to horticulture industries in the Darwin, Katherine and Alice Springs regions of the NT. Activities of the Division cover most of the fruits, vegetables, nursery and cut-flower crops.

Work reported in this report is organised into the structure as detailed below:

## FRUITS PROGRAM

**Objective:** *To improve the sustainability and expansion of commercial fruit production.*

<u>Sub-Program</u>	<u>Coordinator</u>
Mango	Dr Vinod Kulkarni
Table Grape	Mr Geoff Kenna
Banana	Mr Kevin Blackburn
Exotic Fruit	Mr Matt Darcey
Sub-tropical	Mr Geoff Kenna
Citrus	Mr John Mansfield

## VEGETABLES AND ORNAMENTALS PROGRAM

**Objective:** *To enhance the profitability and sustainability of vegetable and ornamental production in the horticulture industry.*

<u>Sub-Program</u>	<u>Coordinator</u>
Annuals/Vegetables	Mr Kevin Blackburn
Cut-Flower	Mr Mark Houtt
Nursery	Mrs Megan Connelly

**Table 1.** Trends in production, value and price of mango, banana and table grapes in the last five years

	1995	1996	1997	1998	1999
<b>MANGO</b>					
Production (tonnes)	5,598	5,472	8,253	5,841	11,749
Value (\$m)	19.67	19.41	26.75	19.3	36.4
Average Price (\$/kg)	3.51	3.55	3.27	3.33	3.11
<b>BANANA</b>					
Production (tonnes)	2,957	3,798	4,137	4,633	6,466
Value (\$m)	2.97	4.35	7.27	7.12	13.05
Average Price (\$/kg)	1.01	1.15	1.76	1.54	2.02
<b>TABLE GRAPES</b>					
Production (tonnes)	1,600	1,326	1,800	2,500	2,400
Value (\$m)	6.40	6.10	8.1	10.2	14.5
Average Price (\$/kg)	4.00	4.60	4.5	4.1	6.04

**Table 2.** Production and value of fruit and vegetables for 1998 and 1999

	Crop Production (tonnes)		Increase/Decrease %	Value (\$m)		Increase/Decrease %
	1998	1999		1998	1999	
<b>FRUITS</b>						
• Mangoes	5,841	11,749	101%	19.3	36.4	89%
• Melons	2,496	2,120	-15%	2.3	2.2	-4%
• Table Grapes	2,500	2,400	-4%	10.2	14.5	42%
• Bananas	4,633	6,466	40%	7.1	13.1	84%
• Citrus	506	488	-4%	.76	.74	-3%
• Other	592	842	42%	3.5	1.6	-54%
Sub-total	<b>16,568</b>	<b>23,577</b>	<b>42%</b>	<b>43.1</b>	<b>68.5</b>	<b>59%</b>
<b>VEGETABLES</b>						
• Asian vegetables	1,692	2,123	25%	4.2	5.5	31%
• Traditional vegetables	2,772	2,198	-21%	5.6	3.5	-38%
Sub-total	<b>4,464</b>	<b>4,321</b>	<b>-3%</b>	<b>9.8</b>	<b>9.8</b>	<b>0%</b>
<b>TOTAL FRUITS &amp; VEGETABLES</b>	<b>21,032</b>	<b>27,898</b>	<b>33%</b>	<b>52.9</b>	<b>78.3</b>	<b>48%</b>

## HIGHLIGHTS FOR THE YEAR

- In collaboration with CSIRO, Queensland and WA Departments, 1,800 mango hybrids were planted in order to select improved hybrids of the current commercial variety Kensington pride. From the first year's flowering and fruiting six promising lines have been selected for further testing at other sites.
- A joint research project into the feasibility of commercial cocoa production in northern Australia is being carried out in conjunction with Queensland, Western Australia, Rural Industry Research and Development Corporation and Cadbury Schweppes.
- In collaboration with CSIRO and growers, a number of treatments are being trialled to reduce uncertainty of flowering and promote early flowering in mangoes. Again, early trials show promise.
- Bilateral agreements have been developed with Sarawak, the Malaysian National institute, Vietnam, and are being negotiated with Sabah for collaboration and exchange of scientific information, scientists and plant material.
- The Department identified and registered a mango variety named 'Celebration'. This variety was identified on a private property and has a number of characteristics more attractive than the current commercial variety Kensington Pride.
- Foliar and soil analysis conducted on some 40 growers' properties are being used to improve productivity in mangoes. A similar study is progressing with bananas.
- Demonstration of improved production practices of Asian vegetables was undertaken at a number of sites to improve efficiency. Growth in this industry is very high and a long-term viability is very important. Assistance is being provided to this industry to improve their post harvest practices, particularly the cool chain.
- Research was focused on defining the water and nutrient requirements for the Ti-Tree/Pine Hill region for table grapes. Issues included high nitrates in the ground water and possible deleterious effects of salinity. In addition work also included the refinement of the use of very expensive growth regulators for uniformity of bud break.
- A number of breeding programs were initiated in Zingiber and Etlingera in addition to the program already in an advanced stage with Alpinia gingers. A new Alpinia ginger, 'Federation lady' was released this year as a contribution of the NT towards the Centenary Federation celebration.
- Work was initiated to start the screening facility for Panama Tropical Race 4 disease. The Queensland DPI and the national and local banana industry were consulted extensively in developing a protocol for the screening facility and proposals are being developed to attract external funding from Horticulture Research and Development Corporation to match industry funding to undertake this project in the NT.
- The Department in conjunction with the Office of Resource Development and Queensland and WA completed a study of overseas markets for mangoes. The report on the study will assist the industry to focus on overseas markets and to develop strategies for marketing of increased production from the NT in the near future. This document also provides some information on preferences in these markets for varieties and a number of other characteristics.
- Land releases in the Lambells Lagoon area have substantially increased the land planted to bananas (200 hectares), mangoes (1,000 hectares), durians (30 hectares) and other crops. Similar spectacular developments have also taken place in the Venn area in Katherine, where resolution of native title issues has allowed for the release of some 1000 hectares of land. Most of this is under planting to citrus, mangoes, asparagus and other vegetable crops.
- In Central Australia, 300 hectares have been planted to table grapes in the Pine Hill / Ti-Tree area. Water resource investigations have demonstrated capacity for an additional 1,000

hectares of development. Negotiations are continuing in relation to the release of horticulture blocks at Woodgreen and Pine Hill. Utopia offers opportunities for development of horticultural projects on Aboriginal land.

- DPIF, the Northern Territory University (NTU) and the industry association have jointly developed horticulture industry training packages. The packages include quality assurance, post-harvest treatment, irrigation, nutrition and canopy management. Extension workshops and specialist consulting services (including interstate consultants) are provided in support of the training packages.
- The Department assisted in developing proposals to both the Rural Industries R&D Corporation and the Horticulture R&D Corporation to obtain funds to appoint a full time communication officer to work with NTHA. The communication officer was appointed towards the end of the year and will be a major asset in developing the Asian vegetable industry.
- Some support has been provided for industry plant collection trips to Thailand, Hawaii and other countries to introduce new ornamental plants to the NT nursery industry. A number of varieties of new fruit crops have been introduced including longan and pitaya. The Department's Post Entry Quarantine (PEQ) facility provides the only opportunity in northern Australia for the introduction of new varieties of fruit, vegetables and ornamental plants.
- The Department has provided the Northern Territory Horticulture Association (NTHA), \$120,000 per annum for a three-year program for the development and implementation of market quality assurance programs, market development and industry development strategies.
- The Department assisted the nursery industry in the organisation of the "2000 Annual Conference" in Darwin in April 2000. Some 300 delegates from all over Australia and some overseas countries attended this conference. It presented an opportunity to showcase not only the nursery industry but the whole NT horticulture industry.
- Workshops have been conducted with various government and non-government agencies and Aboriginal landholder representatives to identify and prioritise horticulture development opportunities in the Tennant/Barkly and Alice Springs regions. Progress is being made with documenting ground water, soil types and infrastructure on Aboriginal properties in the southern part of the Territory to identify horticulture development opportunities.

## **ACKNOWLEDGEMENTS**

We are most grateful for the assistance provided by a number of growers in all regions who allowed Departmental staff to conduct research and monitor plant growth and related observations on their properties. This collaboration has enhanced the effectiveness of conducted research and optimised our resource utilisation.

Financial assistance provided by the Rural Industries Research and Development Corporation and the Horticulture Research and Development Corporation is most appreciated.

We are also grateful for the collaborative assistance provided by CSIRO, QDPI, Agriculture WA and Cadbury-Schweppes.

Dr Niranjan Dasari

Assistant Secretary, Horticulture Division

## HORTICULTURE DIVISION STAFF

NAME	DESIGNATION	LOCATION
DASARI Niranjan Rao B.Agr.Sc., M.Agr.Sc., Ph.D. Assoc. Dip. (Computing)	Assistant Secretary Horticulture	BARC
MITCHELL, Lynette <sup>1</sup>	Personal Assistant (AO3)	BARC
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HAMILTON, David Trade Cert.Hort., B.Hort. Sc. (Hons)	Technical Officer (T3) Perennial Crops	BARC
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FORD, Chris <sup>9</sup> Cert. Trop. Hort., Level 2 Rural Skills.	Technical Officer (T2) Post-Entry Quarantine	BARC
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HOSKING, Andrew B.Sci.(Hons), Cert. 2 Hort.	Technical Officer (T2) Irrigation	BARC

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SALTER, Dean	Technical Officer (T2)	TTRF

1. Lynette Mitchell transferred July 2000
2. Debbie Halprin transferred June 2000
3. Francene Brown resigned
4. Matt Darcey commenced 29/11/99
5. Kevin Blackburn retired 30/6/00
6. Susan Marte resigned 10/3/00
7. Megan Connelly commenced 29/12/99
8. Mike Poffley retired 30/6/00
9. Chris Ford commenced 3/10/99
10. Warwick Clape retired 4/4/00

11. Peter Slinger resigned 22/12/99
12. John Orchard 18/8/99
13. Sean Tory commenced 6/5/99
14. Terri Tighe commenced 16/12/99 – deceased 25/8/00
15. Stuart McAlister deceased 14/2/00
16. Tony Maddern commenced 1/3/99
17. Chris Kinnaird commenced 24/10/99
18. Richie Renfree commenced 19/5/00
19. Daryl King commenced 27/2/00
20. Andrew Nesbitt commenced 14/4/99

## LOCATION DETAILS

### **Berrimah Agricultural Research Centre (BARC)**

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## ABBREVIATIONS USED THROUGHOUT REPORT

<b>AZRI</b>	Arid Zone Research Institute
<b>BARC</b>	Berrimah Agriculture Research Centre
<b>CPHRF</b>	Coastal Plains Horticulture Research Farm
<b>CSIRO</b>	Commonwealth Scientific Industrial Research Organisation
<b>DDRS</b>	Douglas Daly Research Station
<b>DPIF</b>	Department of Primary Industry & Fisheries
<b>DM</b>	Dry Matter
<b>ESP</b>	Exchangeable Sodium Percentage
<b>GA</b>	Gibberellic Acid
<b>HRDC</b>	Horticultural Research and Development Corporation
<b>IPM</b>	Integrated Pest Management
<b>KP</b>	Kensington Pride
<b>KRS</b>	Katherine Research Station
<b>MFT</b>	Mango Flowering Treatment
<b>NIANT</b>	Nursery Industry Association of Northern Territory
<b>NTCGA</b>	Northern Territory Citrus Growers' Association
<b>NTHA</b>	Northern Territory Horticulture Association
<b>PBZ</b>	Paclobutrazol
<b>PBR</b>	Plant Breeders' Rights
<b>QDPI</b>	Queensland Department of Primary Industries
<b>R&amp;D</b>	Research and Development
<b>RIRDC</b>	Rural Industries Research and Development Corporation
<b>TTRF</b>	Ti Tree Research Farm

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**PROJECT: Mango Productivity Survey in the NT**

**Project Officers: V Kulkarni, G Owens, D Hamilton and V Kawaljenko**

**Location: Commercial Orchards in the Darwin Rural Area.**

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**Objective:**

***Over five years (1997-2001) assess the productivity and nutrient levels of different orchards against management practices, to determine what factors contribute to increased productivity.***

**Background:**

Average yields of Kensington Pride are approximately 8 t/ha in the NT. That is less than half of what is being achieved with other cultivars in other countries. Although breeding an improved Kensington cultivar offers much in the long-term, we are still faced with the day to day problems in the short term. Key factors that are important to increased productivity need to be explored.

**Method:**

This project commenced in 1997 with 62 farms participating in locations throughout Acacia Hills, Bees Creek, Berry Springs, Elizabeth Valley, Humpty Doo, Howard Springs, Lambells Lagoon and Virginia. During the second year of the project only 38 of the original 62 farms continued with the project. On each farm three trees were selected, and each tree was subjected to leaf and soil analysis pre-flowering and post-harvest. Yield was also rated subjectively on a scale from 1–10 based on the density and number of fruits on the tree. The growers were asked to supply information about their management inputs i.e. fertilisers applied, irrigation and so on.

In the second year of the program, seven of the 38 farms were selected for more intensive studies on nutrient levels and fruitset. Leaf and soil samples were collected bi-monthly, and fruit set observations started from flowering through to harvest. This work is still continuing and will finish in 2001.

**Results:**

Nutrition in relation to yield – results did not show any clear relationship between either soil or leaf nutrient levels and yield.

Paclobutrazol (plant growth regulator ) effects on yield - an assessment of orchards in Berry Springs generally showed that paclobutrazol application significantly increased yield. Nutrient levels, in particular calcium, tended to be higher in treated trees.

Soil pH - virgin soils in the study area are generally acidic, well below the optimum level of pH 6.0-6.5 required in orchards. Over the last two years an average of 39.5% of orchards had a pH greater than 6.0, and 60.5% a pH less than 6.0. The stability of soil pH is also important to ensure uniform availability of nutrients throughout the season. We defined stability as a change in pH of no greater than a five-fold increase or decrease. To date 45% of orchards recorded stable pH levels, while 55% recorded unstable levels. Nevertheless, we have seen a general increase in pH, as a result of increased lime application.

Soil pH effects on yield – soil pH did not appear to have any clear effect on yield. High and low yields were recorded against similar pH levels, and pH levels varied significantly in both high and low yield categories.

Yield assessment in relation to minimum temperatures (dry season) – in 1997, 21 orchards averaged a yield rating of greater than five. In 1998, only four orchards achieved a yield rating of greater than five. In 1998 temperatures to induce flowering for the most part were above 20°C. Flower initiation in mango requires a base temperature of 18°C, so the warmer temperatures during 1998 inhibited optimal flowering, and therefore productivity.

Micronutrient levels (zinc and boron) - zinc and boron play an important role in fruit set and formation. Poor fruit set limits yields, and is considered a major issue for growers. Unless added, these nutrients are in short supply in our soils. In 1997, pre-harvest, approximately 37% of orchards had zinc leaf below the minimum level of 20 parts per million (ppm). In 1998, approximately 24% of orchards recorded minimum levels. Boron levels were generally too low in most orchards. Further, the levels of leaf boron varied considerably from time to time. Approximately 45% of the orchards recorded unstable boron leaf levels throughout the seasons. Boron leaf levels appeared to be closely related to seasonal rainfall and irrigation inputs.

Seven orchards (intensive studies) – developing a picture of seasonal patterns of nutrient levels in the soil and the tree. Fruit set data to be collated and analysed. Project concludes in 2001.

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**PROJECT:           The National Mango Breeding Program**

**Project Officers:   V. Kulkarni and D. Hamilton**

**Location:           Mareeba's South Edge Research Station (SERS) and Coastal  
Plains Horticulture Research Farm (CPHRF).**

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***Objective:***

- ***Develop improved mango cultivars for the domestic and international markets.***
- ***Generate quantifiable data on the heritability characteristics of mango.***

**Background:**

The National Mango Breeding Program is a collaborative project between the Queensland Department of Primary Industries, CSIRO, NT DPIF and Agriculture WA. The program was initiated in 1994, and is expected to be completed in 2010.

**Method:**

Controlled crossing using hand pollination techniques produced progeny. A total of 33 parental combinations were crossed to generate hybrids. In all but a few cases Kensington pollen was used as the male parent. Each hybrid seedling was replicated once by means of grafting onto a KP seedling. All of the grafted hybrids were planted at SERS and all of the original seedlings were planted at CPHRS for screening. Initial screening and selection of promising hybrids will be done at both sites. Further evaluation of the selected trees will be carried out in the major growing regions in larger field trials to determine their commercial suitability.

## Results:

In the first phase of the program, from 1994 to 1997 approximately 1851 progenies were produced between the four agencies. All of the hybrids have been field planted with seedlings located at CPHRS, and a grafted replicate of each located at SERS.

The second phase of the program, the initial selection, and characterisation of the hybrids, commenced in 1999-2000. At SERS some 350 hybrids fruited, while only 30 fruited at CPHRS. Approximately 30 of the hybrids appeared to have some promising features, and were displayed at a presentation of fruits to industry representatives in both Queensland and the Northern Territory. These presentations were very warmly received.

Six hybrids were selected out of the 350 evaluated at SERS in the 1999-2000 season. These hybrids will be further evaluated on research station sites at Darwin, Kununurra and Mareeba. Growers located throughout the various mango districts will further evaluate a selection of the best of these hybrids at a later date.

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## **PROJECT: Improvement of Mango Flowering Through the Manipulation of Flowering**

**Project Officers: V. Kulkarni and D. Hamilton**

**Location: CPHRF, Commercial Orchards**

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### **Objective:**

- ***To induce early and regular flowering to ensure early and consistent yields.***
- ***To reduce and minimise any adverse effects of untimely and excessive vegetative growth.***
- ***To develop a cost-effective high density planting system and a management strategy on a scientific basis.***

**EXPERIMENT 1.** - Trials on the use of paclobutrazol (PBZ) and pruning (hedging) in a high density planting system.

### **Background:**

One factor adversely affecting the efficacy of paclobutrazol is delayed flushing at flowering time. A combination approach with paclobutrazol and pre-flower tip pruning by hand was very effective in previous trials. A number of growers are now adopting this method. Observation trials of mechanical pruning were not very successful. Mechanical pruning, in combination with paclobutrazol, however, does appear to be somewhat effective if applied early after harvest. It allows for vigour control with some renewal of growth and reasonable flowering. This opens real opportunities for higher density planting systems to be employed. High-density systems offer the main advantages of reduced land use and higher yields/hectare in the initial years of production.

### **Methods:**

A density-planting site of Kensington Pride mango was established at CPHRF in 1995 with blocks of trees spaced at either 7 x 5, 7 x 7, or 10 x 10 m (conventional). Tree numbers per block are 285/ha, 240/ha and 100/ha respectively. Orchard management is based on standard industry recommendations. Paclobutrazol was applied to the 7 x 5 and 7 x 7 planting densities as a collar

trench in December at a rate based on tree canopy size. Pruning treatments were not applied, as the trees had not reached their required size. Yield and average fruit weights were recorded.

### **Results:**

A considerable number of trees started flowering early in May across the 7 x 7 and 7 x 5 planting densities. In the untreated 10 x 10 density block flowering was significantly less and was also delayed. As a result, final yields/hectare for each of the planting densities were 8.4 t/ha, 6.2 t/ha and 3.0 t/ha for the 7 x 5, 7 x 7 and 10 x 10 density blocks respectively. Average tree yields and fruit weights were similar for both the 7 x 7 and 7 x 5 planted blocks.

These results show that the yields produced from trees at different densities progressively increased with and increase in number of trees/hectare. We would expect this to happen for a number of years, after which yields would be expected to plateau.

## **EXPERIMENT 2** – Mango Flowering Project

### **Background:**

This is a joint project with CSIRO and is being funded by the industry and HRDC. It is based on two treatments being developed to manipulate flowering in Kensington Pride. Firstly, the mango flowering treatment (MFT) initiated by CSIRO, involves applying a cincture around the tree trunk and tying it with string soaked in a plant growth retardant (pgr) called morphactin. DPIF is developing the other treatment to suit local conditions, the plant growth retardant paclobutrazol (P) application.

### **Method:**

Nine commercial farms were selected throughout the Darwin and Katherine region. Each site consists of three treatments, MFT, P and C (control). The MFT was applied at the start of the trial, and does not need to be applied every year. The P treatment is applied every year of the trial in December at a rate determined for each tree depending on the size of the canopy surface area. Each treatment was applied to 50 trees, so 150 trees in total are part of the trial. Measurements consist of leaf nutrient levels measured monthly, soil analysis twice per year – pre-harvest and post-harvest; leaf chlorophyll; percentage vegetative growth; percentage flowering; and total yield – average fruit weight and numbers, fruit quality parameters. In addition the growers are supplying up to date information about their management inputs.

### **Results:**

In 1999 the first year of the project, it was a very strong year for flowering, as flowering was generally good in all treatments. Nevertheless, flowering was significantly earlier and more intense on trees treated with MFT and P compared with the controls. Flowering was more synchronised on trees treated with MFT.

Earlier flowering also translated into earlier harvest of the MFT and P treated trees compared with the controls. Fruit from the P and C treatments appeared to be larger than fruit from the M treatments. It appears that the increased fruit numbers per panicle in the MFT treated trees could be related to fruit size. Fruit set and retention will be measured in the year 2000.

The MFT treatment generally imposed considerable stress on the treated trees causing yellowing of leaves, and in some cases death of trees. Younger trees appeared to be more susceptible to the stress. The stress factor could also have contributed significantly to the general reduction in fruit size across the treatment.

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**PROJECT:           Mango Cultivar Trials****Project Officers:   V.Kulkarni and   D.Hamilton**Location:            Berrimah Farm (BARC), Coastal Plains Horticulture Research Farm (CPHRF) and Growers' Farms

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**Objective:**

- ***Introduction, testing and identification of new cultivars and species for commercial and research purposes.***
- ***Develop and release new cultivars with potential in domestic and export markets.***
- ***Expand the harvest season with cultivars maturing earlier and later than Kensington Pride.***

**Method:**

Promising new cultivars are propagated and multiplied, and planted at either BARC or CPHRF. After establishment the cultivars are ready for multi-location testing throughout the Top End. Volunteer growers are selected, and become part of a special agreement in certain cases to preserve the rights of plant breeders (PBR).

**Results:**

Two cultivars, Baneshan and Kesar were introduced from India. Baneshan is a late-maturing cultivar being exported to Malaysia and Singapore, and is expected to be better suited to the Katherine region. Kesar is a very good quality fruit with a slight external red blush. After initial establishment in Darwin both cultivars will be planted in Katherine also. Of the four species of *Mangifera* introduced earlier, *M.torquenda* flowered and has set fruit. The introduction of species will continue in collaboration with QDPI.

The new mango cultivar ' Celebration ' has been registered with PBR and is now available to growers. Kulkarni in 1994 identified it in a private orchard (Australian Tropical Produce Ltd) for its very attractive appearance, regular bearing and quality attributes. Celebration is late-maturing compared to KP. There is considerable demand for it in Katherine and Queensland where growers wish to extend the season. Fruit quality is expected to be superior in the Katherine region.

Cultivars introduced earlier from India and Thailand were established at CPHRF in 1996, and were expected to produce commercial quantities in the year 2000. A few cultivars are particularly suitable for processing and will be evaluated in conjunction with an external collaborator. One cultivar that has potential as a dwarfing rootstock is being used clonally for tree vigour control.

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**PROJECT: Evaluation of Drip Irrigation for Mangoes in the Top End**

**Project Officers: C. Wicks and A. Hosking**

**Location: Commercial Mango Orchard at Lambells Lagoon**

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***Objective:***

- ***Proof drip technology for mango irrigation in the Top End.***
- ***Develop irrigation strategies utilising drip irrigation.***

Over the last few years, growers have been asking the Irrigation Section for our opinion on using drip irrigation on mangoes. While there has been some work overseas, there is little clear information on the pros and cons of drip irrigation in mango.

With an ever-increasing number of mangoes being planted, the demand upon water resources is climbing rapidly. This may mean that in a few short years mango growers may be operating in an environment of water shortages. Using drip irrigation is one way growers can reduce water inputs in the early years.

In the NT, there are a number of growers who have used drip irrigation with seeming success. However most of the data is anecdotal and the irrigation systems involved have problems not apparent in a cursory investigation. It appears that most growers who use drip irrigation think that they do not need to apply as much water as a sprinkler system does.

While it is true that drip irrigation systems are more efficient than sprinkler systems, the degree of efficiency is only 5-20%. The water requirements of a fully mature tree do not change because the method of application has changed. The level of reduction in irrigation has to be determined, as does the effect of wetting a smaller portion of the root zone.

In 1997 (at planting), the Irrigation Section started a small trial on a grower's property. In that trial we are comparing the growth, yield and water usage of trees grown on drip (single emitter per tree) with trees grown on sprinkler irrigation. The trial will have to last for at least five years to allow the trees to reach early maturity.

The data collected to date shows no significant differences in tree growth even though the sprinkler-irrigated trees received approximately 20% more water than the drip-irrigated trees. Though the trees flowered and fruited in the 1999 season, no yield data was taken as there was too much variation.

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**PROJECT: MCD007 Mango Productivity Project in Darwin and Katherine - Katherine Component**

**Project Officers: J. Mansfield, T. Maddern, R. Renfree, C. Kinnaird, M. Gosbee, G. Kyle, V. Kawaljenko**

**Location: Co-operators' properties in the Katherine Region**

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***Objective:***

***To determine the relations between tree performance and climatic and management factors.***

There are large variations in yield and fruit quality between two different mango farms in the same year, between trees on the same farm in the same year, and on the same tree in two consecutive years. To try to understand this variation, a previous study in the Katherine Region investigated 12 groups of three trees in orchards on three different soil types over three years. These orchards varied in management practices and in the bearing age of the trees. Information was collected on the nutrient status of the leaves at flowering, after harvest, fruit yield, and fruit quality. However, few relationships between yield and the concentration of nutrients were observed. This possibly was because soil type, climate, microclimate, rootstock and management practices may have had a greater impact on yield than individual nutrient levels. Therefore, a further study measuring a greater number of factors was initiated.

**Materials and Methods:**

In a joint study between staff in the Darwin and Katherine regions, six sites in both regions have been selected for evaluation. At the Katherine sites the tree performance, climatic and management parameters are being measured. The tree performance is being assessed by determining their growth patterns (recording at what time of the year the trees are producing new leaves, flowers or fruit), the yield of the tree and the fruit quality. Climate is being studied by recording temperature and relative humidity using dataloggers. The management of the tree is being assessed by taking soil samples to monitor soil nutritional status, taking leaf samples to monitor leaf nutritional status, and measuring irrigation inputs using water meters. In addition, the growers are recording when and how much fertilizer they apply and when they carry out other management operations. From this information, the relations between tree performance and climatic and management factors will be assessed. The trial started in Katherine region in July 1998. The sites were visited on a weekly basis to take readings and samples in 1998 and 1999 seasons. In 2000, these visits were changed to a fortnightly basis.

**Results and Discussion:**

This project involves looking at patterns and trends and therefore a complete analysis of the results cannot occur until three complete years of data is collected (December 2001). However, there have been some observations made which quantify what is occurring on mango properties in the Pine Creek/Katherine region.

In 2000, the flushing patterns at the six monitored sites were different to those in 1999. In 1999, the flushing at most properties, based on monthly tree ratings, appeared to be almost continuous from 1 January to at least early July. During this period, there was always some flush on the trees at all the properties and at some properties it was consistently above 50% of total terminals on the tree flushing and in some was 80% of total terminals. In contrast, in 2000, the flushing from 1 January to 30 June was a lot less, with a lot more distinct peaks of flushing. The maximum amount of flushing was 40% and at all properties during the time, no or almost no flushing was recorded at some monitoring periods.

The yield of fruit from the monitored trees at the various sites ranged from 3 kg per tree to 125 kg per tree. Four of the monitored sites showed fairly consistent yields between the three monitored trees on these sites, while the other two sites showed variation from almost no yield per tree to yields above 50 kg per tree from the three trees on these sites. The results also showed that most of the fruit drop (not including flower drop) occurred at pea size (10 mm diameter) and marble size (17 mm diameter).

The results of the soil tests tend to show that during the wet season, the levels of soil nutrient drop. In addition, the soil and leaf nutrient analyses show that micro-nutrients (Iron, Zinc, Copper and Boron) appear to be at below optimum at most of orchards at all times of the year.

Initially, the results from each site were only given to the owner of the monitored property. However, several growers involved expressed an interest in sharing the results from their property with the owners of the other monitored properties so that they could compare information. A discussion group has been established so that this can occur. The growers intend to meet on a regular basis to share information in relation to the research project but also in relation to other issues. It is intended that as part of this project, that the members of the discussion group may continue to collect some of the information, which is currently collected by departmental staff, once the project be terminated at the end of 2001. This information would be of assistance in monitoring their management practices.

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**PROJECT: MCK004 Evaluation of Mango Selections and Lines in the Katherine Region**

**Project Officers: J. Bright, S. McAlister, R. Renfree**

**Location: Katherine Research Station**

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***Objectives:***

- ***To select mango cultivars and selections suitable to the Katherine region.***
- ***To determine the optimum density of planting on the evaluation of breeding selections.***
- ***To determine if whether cultivars that are quick to come into bearing as grafted trees pass on this characteristic to their progeny.***

Although Kensington Pride is the preferred mango eaten by most Australians that have had mangoes, it exhibits a number of attributes that might be improved on through breeding and selection.

In May 1994 a population of 550 seedlings of the cultivar Glenn, were planted from seed collected in December 1993. Seeds were collected from Glenn trees growing at six different pollination distances from Kensington Pride trees. An explanation of this project has been published in previous Horticulture Division Technical Annual Reports under the project "Monoembryonic Seedling Selection".

In January 1998, a number of mango trees were planted at Katherine Research Station as part of a number of sub-projects. These projects were looking at:

1. Breeding sub-project - crossing Kensington Pride with other mango cultivars including Irwin and Julie and evaluating the performance of the seedlings. Measurements are being taken to identify trees that produce fruit that have Kensington Pride flavour with less fibre but they must also have marketable size, colour and shape.

2. Optimum Tree Density sub-project - determining the optimum tree density for evaluating breeding trials by examining how close mango seedlings can be planted without affecting seedling performance and assessment.
3. Juvenility sub-project - examine whether cultivars that are quick to come into bearing as grafted trees pass on this characteristic to their progeny.

An explanation of each of these sub projects was presented in the Horticulture Division Technical Annual Report 1997/98 under the titles:

- Use of the bouquet-method in mango breeding.
- High density planting for mango seedling evaluation.
- Use of Kensington Pride as a seed parent in mango breeding.
- Variation in the length of the juvenile period for mangoes derived from different seed parents.

In 1998/9 several of the rootstock trees in the juvenility sub-project were grafted. Replants were carried out where plants had died. These sites will be treated as missing sites.

**Progress report:**

***Monoembryonic Seedling Selection Sub-project***

Of the 550 original Glenn/Kensington Pride trees planted at Katherine Research Station as part of the project "Monoembryonic Seedling Selection", six have been chosen for further evaluation. These six trees are currently being grafted on to Red Cross common rootstocks and shall be compared against numerous cultivars that may have potential in the region. Planting out of the trial is due in late 2000. Selections include N10E10 (treatment E), N10E56 (treatment C), N8E54 (treatment C), N6E35(treatment C), N3E4(treatment E), N1E18(treatment A) where:

Treatment A is Ballongilly1<sup>st</sup> Glenn tree beside Kensington Pride

Treatment C is Manbulloo 1<sup>st</sup> Glenn tree beside Kensington Pride

Treatment E is Manbulloo 1<sup>st</sup> Glenn tree beside Kensington Pride from Kensington Pride side only.

The other cultivars to be planted with them for comparison are: Kensington Pride (as the "Standard"), Celebration, Chene, Joa, Neldica, E10-5/3 Heidii, S113, S52, Alphonso selections and B74 (Tango).

***Breeding sub-project***

Plants in the trial are yet to flower.

***Optimum high density planting sub-project***

Measurements of trunk circumferences at 20cm above ground reveal a trend for larger circumferences for the tree at wider spacings (see Table 1).

**Table 1.** Girths circumferences at different spacings

Spacing (metres)	Circumferences (mm)
1	30.2
2	34.5
3	34.9
3.5	35

Further results will be reported on in 2000/2001.

***Juvenility sub-project***

Flowering was reported on some Willard and Willard grafted plants. No other flowering was reported.

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**PROJECT: MCK005 Rootstock Effects on Mango Productivity**

**Project Officers: J. Bright, S. McAlister and R. Renfree**

**Location: Co-operator properties in the Katherine Region**

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***Objective:***

***To select rootstocks suitable for growing Kensington Pride mangoes in the Katherine region.***

In response to the promising results obtained over past seasons with just a few rootstocks, it was decided to evaluate a far greater range of polyembryonic genotypes that may prove useful as rootstocks for Kensington Pride. The influence of soil type and salinity on rootstock performance also requires evaluation.

This project combines projects, which were published in previous Horticulture Division Technical Annual Reports under the projects "Rootstocks for saline soil conditions" and "Rootstock effects on mango productivity".

**Materials and Methods:**

***Rootstocks for saline soil conditions sub-project***

Rootstocks were included primarily based on their performance in past experiments in Central Australia in which the uptake of Na and Cl, and the development of leaf symptoms were used to screen polyembryonic cultivars. It was considered necessary to evaluate the effectiveness of this screening procedure by examining how selected cultivars performed as rootstocks for Kensington Pride, under a range of "stressful" soil conditions.

Rootstocks included in the trial were:

- Treatment 15      KRS watertank
- Treatment 16      Kensington Pride
- Treatment 18      Sg. Siput
- Treatment 35      Banana Callo
- Treatment 52      13-1 (selected in Israel, good tolerance)

Kensington pride was used as the scion on all rootstocks at all sites.

At each site, treatments are replicated five times in single tree plots.

The experiment sites, approximate conductivity, and planting dates are shown in Table 2.

**Table 2.** Experiment location, conductivity and planting dates

Site	Conductivity $\mu\text{S/cm}$	Planting Date
Broome (W.A.)	3900	May 1998
Mataranka (N.T.)	1500	August 1997
Bowen (QLD)	3000	Not Planted
Rockhampton (QLD)	Unknown	Not planted

***Rootstock Evaluation on Blain and Tippera soil types sub-project***

An experiment with 64 different rootstocks was planted in mid 1996 on a Tippera clay loam, while the second experiment with 104 different rootstocks was planted in late November/early December 1997 on a Blain sandy loam. These treatments consist of polyembryonic genotypes from DPIF arboreta; trees identified by local nurserymen; polyembryonic types bred at KRS; seed supplied by overseas mango workers; and a limited range of other *Mangifera* species. In both experiments, each treatment is replicated five times with individual tree plots. Nearest-neighbour designs have been employed in an attempt to account for spatial variation.

**Results and Discussion (progress report):**

***Rootstocks for saline soil conditions sub-project***

The Broome site (WA) has been abandoned as trees were neglected and died. The Bowen and Rockhampton sites (QLD) were not planted. The only site where trees are still growing is the Mataranka site and this was due to be harvested for the first time in the 2000 season.

***Rootstock Evaluation on Blain and Tippera soil types sub-project***

The Blain site will be harvested for the first time in 2000

The Tippera site was harvested in 1999. As this is the first year of harvest the interpretation of the results is made difficult as young trees give variable data ie from the analysis cv was very high >40%. As the trees get older, the variation is expected to reduce.

Future work shall analyse tree height and trunk circumference in an attempt to analyse yield efficiencies.

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**PROJECT: MCK011 Foliar Nitrogen Nutrition**

**Project Officers: J. Bright, S. McAlister and R. Renfree**

**Location: Katherine Research Station**

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***Objective:***

***To determine the effects of rate and timing of foliar nitrogen applications on the yield and quality of mangoes.***

The nitrogen nutrition of mango remains an area of much debate and confusion. Over the last decade in the NT, there have been major swings in the quantity of nitrogen recommended for

commercial orchards. Current rates range from zero up to 300 g N per tree per year. Foliar application of nitrogen has received limited attention.

### **Materials and Methods:**

The experiment was established on four year old trees at Katherine Research Station, in January 1996, with three different rates of nitrogen (80, 40, 20 and 0 g N/tree). The rates of N applied for each treatment were increased in 1998 as they appeared to show no detrimental /positive effects on tree growth and production. Current rates of N grams /tree /year are 140, 90, 60 and 0 applied at four different phenological stages (post-harvest flush, pre-flowering, fruit at golf-ball size, and split between all 3 of these stages). These treatments were arranged in a factorial design with five replicates and individual tree plots.

### **Results:**

The harvest in 2000 will be the final harvest for this trial. An analysis for each of years from 1996 to 1999 and over all years using Bonferroni's inequalities shows no significant differences between different foliar nitrogen treatments with respect to:

- Control versus nitrogen treatments for weight and number of fruit and average weight of fruit (in each year) and yield quantity and quality (LSD=4.0) (over all years).
- Timing of nitrogen for average weight of fruit (in each year) and yield quantity and quality (LSD=4.0) (over all years).
- Nitrogen rates for weight and number of fruit (in each year) and yield quantity and quality (LSD=4.0) (over all years).
- Interaction between timing and nitrogen rates for average weight of fruit (in each year) and yield quantity and quality (LSD=4.0) (over all years).

Leaf analysis revealed no excess or deficient nitrogen levels for any of the treatments for the years 1996-2000.

### **Discussion:**

From a statistical point of view, the data gives us no indication of a difference between rates of nitrogen applied and timing of nitrogen applications. Even when we compare nitrogen applied versus no nitrogen applied (control) there is no statistical difference in yields. This is due to the enormous variability from tree to tree that seems to be so characteristic of Kensington Pride. Some of the treatment means differ by more than 100% and yet the probability values are too high to be considered significant. In layman terms the potential to double yield is not "non significant". It could be argued that perhaps we should have replicated more, but there is an obvious limit to how many trees we could have included given all of the treatments. At this point, it is probably a good time to be asking how do we account for this enormous variability in Kensington Pride when we are performing trials on the crop and trying to analyse data.

From a purely horticultural point of view, the data indicates that N is increasing fruit numbers and yield, but that some applications (pre flowering) are having a deleterious effect. The pre flowering appears to be promoting excessive vegetative flushing just prior to or during flowering and this is competing with fruit set and development. Conversely the golf stage application looks to be promising as it appeared to give good numbers of fruit and weight of fruit for each year when compared to the other treatments. It is interesting to note that the nitrogen rate effect is strongest in the two highest yielding seasons i.e. 1997 and 1999. Also of interest is that the highest nitrogen level generally has the highest weight. We increased the rate of nitrogen in 1998 in the hope that it would be excessive but it appears we should have used a lot more. The 1999 samples were sent for post harvest assessment to see if the rates or timing had an effect on fruit quality. These results are being analysed and will be reported on in late 2000. The fact that there are no large differences

between leaf levels of nitrogen could mean it is not a reliable source for determining yield potential. It would appear from this trial that there are definitely other sources of nitrogen available to the plant as the control trees leaf analysis show N as being within the optimal range.

The results of post harvest assessment and the final harvest will be presented in the 2000/2001 Technical Annual Report.

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**PROJECT:           Mango Research at Ti Tree - Cultivar Evaluation**

**Project Officers:   D. Salter, G. Kenna and A. Nesbitt**

**Location:           Ti Tree Research Farm**

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***Objective:***

***Evaluate the commercial potential for late season production of mangoes in the southern region of the northern territory.***

**Introduction:**

The maturity period for mangoes in the southern region of the Northern Territory is relatively late compared with the early season production in the Top End. The majority of production areas in Queensland have also completed harvest before late varieties mature in the Ti Tree area. The purpose of this trial is to evaluate the suitability of a number of late maturing mango selections for their suitability to supply domestic markets.

**Material and methods:**

At present the mango plantings at Ti Tree Research Farm consist of eight cultivars planted in a single row running north to south at a spacing of three metres between trees. All cultivars except Keitt have two trees of that variety planted adjacent to each other. For Keitt there is only the one tree. All trees are on Kensington Pride rootstock. Fruit was harvested and recorded as it matured to compare the cultivars for differences in fruit maturity, fruit numbers, size and total yield (kg. fruit/ per tree).

**Results:**

Harvest of the earliest maturing varieties R2E2, Irwin, Lippens and Springfels commenced from the 6-8th of December 1999 with the harvest of the latest varieties Kent, Keitt, Sensation, Palmer and Isis being completed by the 20th of April 2000. The harvest period varied significantly. The cultivars that picked for the more extended periods tended to have the best combined average yield per tree and average fruit weight except for Sensation which had an acceptable average yield per tree in terms of fruit numbers but a poor average fruit weight. The cultivars that produced the best average fruit weight were R2E2 (779 g), Isis (346 g), Kent (343 g), Keitt (313 g) and Palmer (293 g). The cultivars that produced the highest average yield per tree (kg) were: Isis (51 kg), Sensation (36 kg), Kent (35 kg) and Keitt (31 kg).

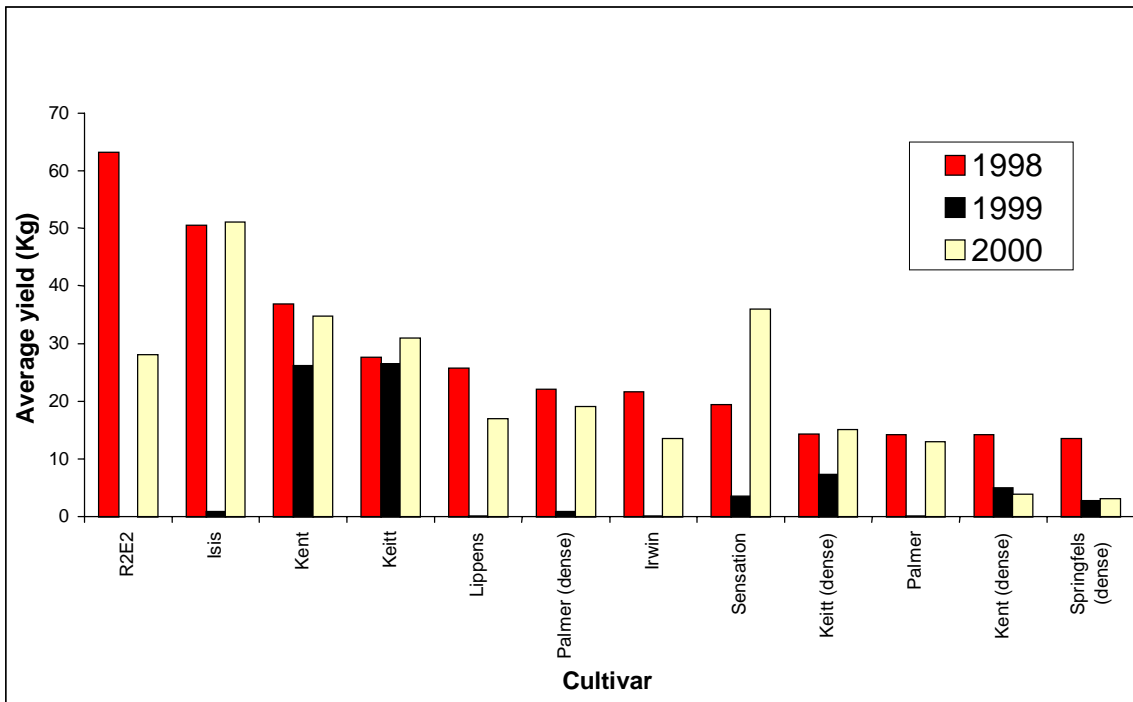
**Discussion:**

Due to exceptionally heavy rain throughout February and early March 2000 the fruit piercing moth was again a problem in the later maturing varieties. This was partially overcome by harvesting the fruit at a less mature stage and allowed to ripen fully mature away from the tree. However as the

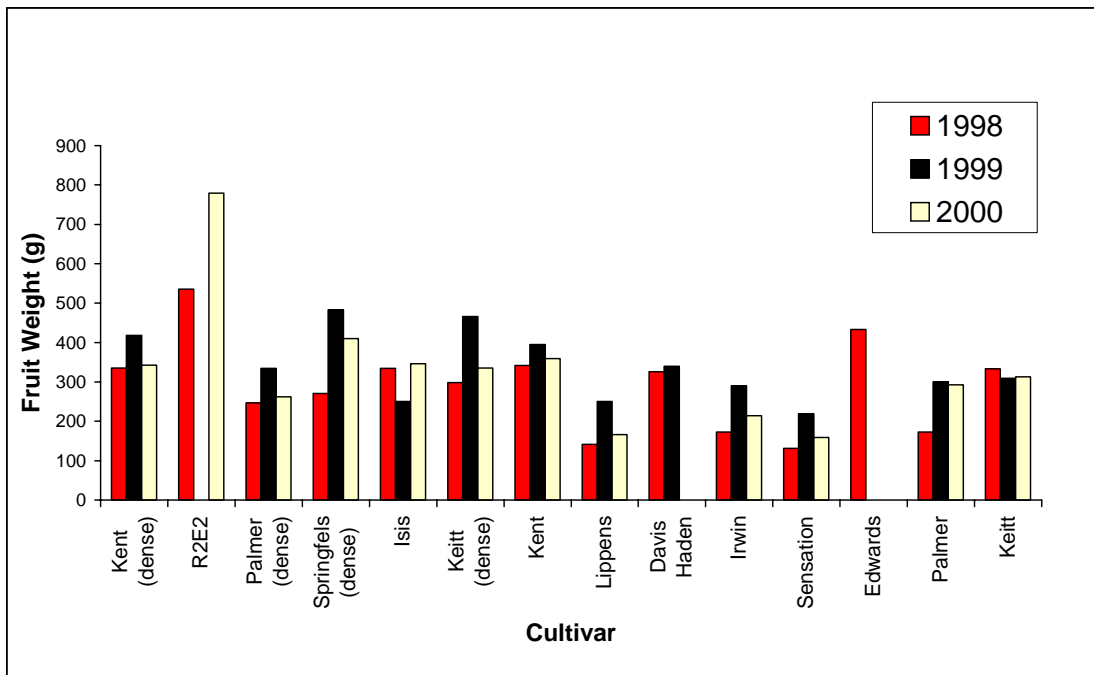
moth became more prevalent after the February rains fruit was attacked at the immature stage while still on the tree.

**Summary:**

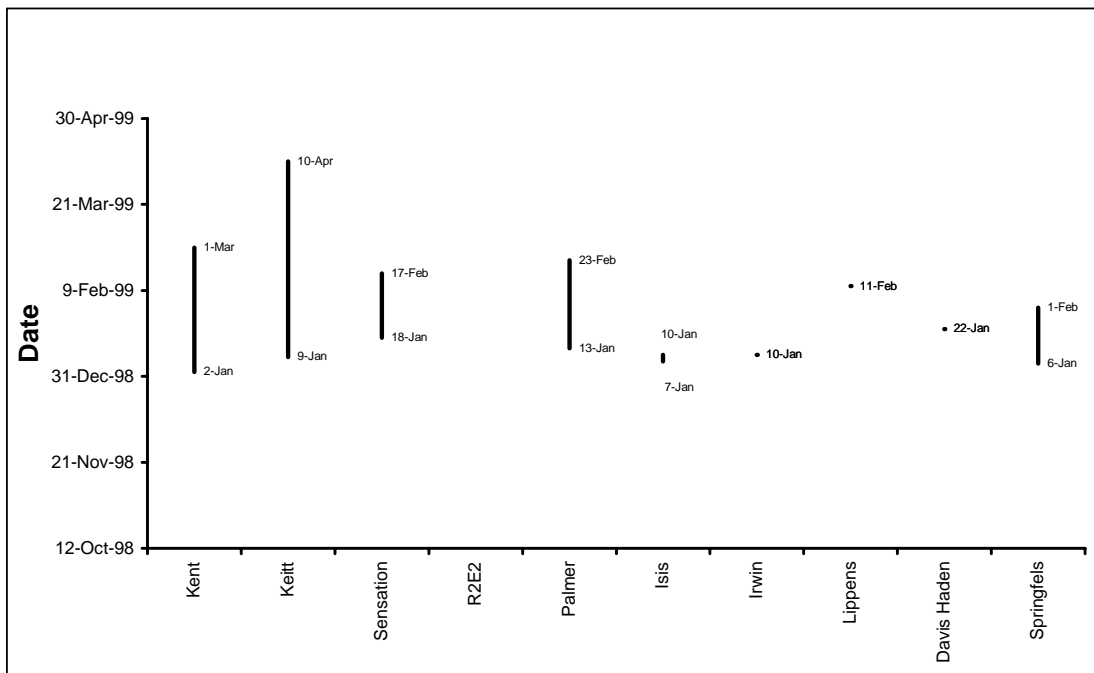
In summary the average yield were markedly up on last season, particularly Sensation, R2E2, Isis and Palmer. It should be noted however that these varieties produced poor yields in the 1999 season. The average fruit weights were slightly down on last season however fruit size was still acceptable and met market standards except Sensation, Irwin and Lippens which were significantly lower due to the much higher average yield per tree. The cultivars with the best combined average fruit size/ average yield per tree were Isis, Kent and Keitt. The latest maturing cultivars were Kent, Keitt, Isis and Palmer. While Sensation had a very acceptable average yield per tree the fruit size was below market standards.



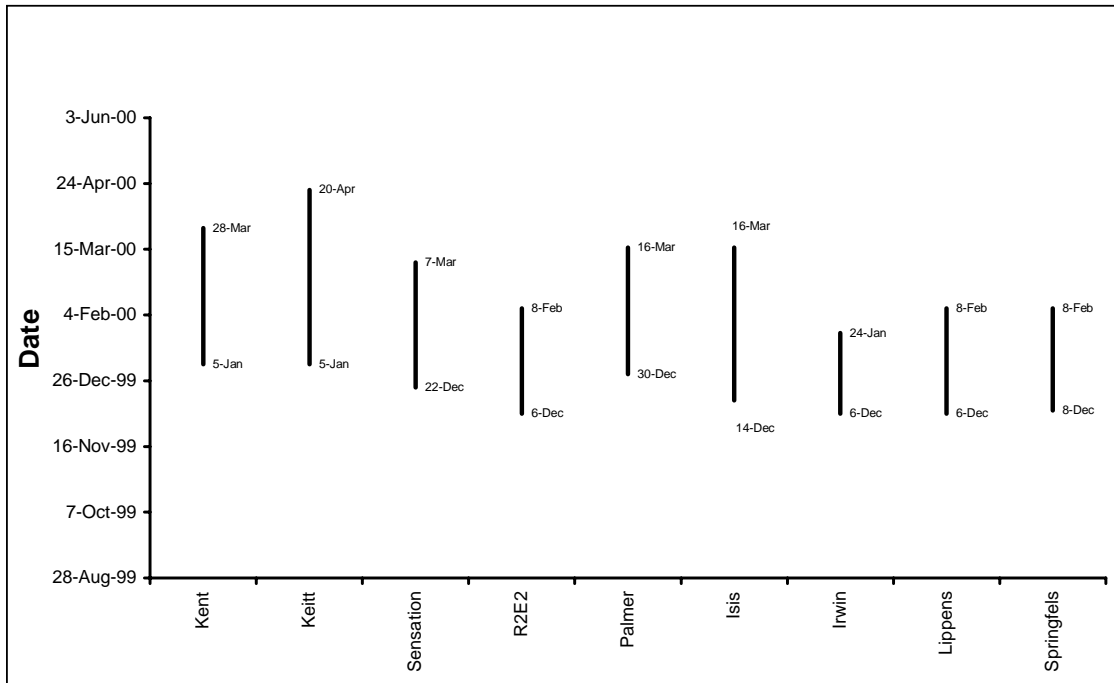
**Figure 1.** Average yield per tree comparison for 1998, 1999 and 2000



**Figure 2.** Average fruit weight comparison between 1998, 1999 and 2000 for each cultivar



**Figure 3.** 1999 harvest range for each cultivar



**Figure 4.** 2000 harvest range for each cultivar

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**PROJECT:           The Use of Dormancy Breaking Agents for Early  
Tablegrape Production in the Northern Territory  
Season 1999**

**Project Officers:   G.Kenna, D. Salter, A. Nesbitt, N. Isgro, D. McDonald**

**Location:           Ti Tree/Territory Grapes**

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***Objective:***

***Improve the productivity, quality and profitability of the tablegrape industry in the NT.***

**Introduction:**

The development of a tablegrape industry in Central Australia has been based upon the ability to produce an early maturing, high quality product for domestic markets. Tablegrape varieties grown in the Ti Tree/Pine Hill area, 200 kms north of Alice Springs, begin to mature fruit from the last week of October through to mid January.

Grapevines grown in this area often receive inadequate winter chill which leads to an uneven and erratic budburst. The number of fruit clusters and shoots can also be reduced and the timing of various management practices made difficult. The result can be a reduced yield and poor quality crop. The application of a dormancy breaking agent such as Dormex (hydrogen cyanimide) to vines is an essential management tool in Central Australia. Dormex enhances and accelerates budburst and assists in reducing the effects of a lack of winter chill.

An enhanced, early budburst results in fruit maturing for early markets. Tablegrape production in this area incurs high costs of production. Higher returns for early market fruit helps to ensure the viability of the industry.

Calcium cyanimide ( $\text{CaCN}_2$ ) was originally identified as having dormancy breaking properties when used on glasshouse grapes in Japan. It was later found that it was a soluble hydrolysis product of calcium cyanimide which had dormancy breaking properties. This compound was hydrogen cyanimide ( $\text{H}_2\text{CN}_2$ ) which is marketed commercially under the trade name Dormex. This chemical breaks down in soil to various nitrogenous compounds including Urea.

In Central Australia Dormex is usually applied to grapevines at the maximum recommended rate of 5% v/v (2.5% active ingredient). Past research has indicated that one of the factors determining the vines response in terms of an early, even budburst is how effectively the chemical can be applied to the vine. A thorough and even wetting of canes/spurs, buds and the crown of the plant with minimal runoff is essential.

The spray application rate required to achieve this is around 400 mL per vine (500 L/ha). The cost of chemical per hectare of vines sprayed is significant (see Table 1) Industry has identified a need to investigate methods to reduce Dormex costs and improve spray efficacy.

Work to investigate the efficacy of various Dormex concentrations in combination with surfactants and a possible replacement for Dormex commenced in Central Australia in July 1995. The Northern Territory Department of Primary Industry and Fisheries in cooperation with researchers from the University of California (Dr Nick Dokoozlian and Mr Don Luvisi) established a number of trials on the property "Territory Grapes" located on Pine Hill Station, approximately 190 km north of Alice Springs. This followed on from initial work conducted the previous season in California.

### **Dormex Research Project – 1999:**

Further research was conducted in 1999 to evaluate the effectiveness of Dormex combined with various surfactants when applied at various rates compared with Dormex applied at the recommended rate of 5% v/v. The recommended application of Dormex at this rate also included the addition of “non ionic wetter.”

Treatments consisted of the following: 5% Dormex + .05% Agral (recommended standard treatment), 2% Dormex + 3% Chemwet 600, 1% Dormex + 3% Chemwet 600, 2% Dormex + 3% Pulse, 1% Dormex + 3% Pulse, 2% Dormex, Unsprayed control.

#### **Method:**

The trials were conducted in three commercial tablegrape plantings comprising (*Vitis vinifera*) Cultivars Flame Seedless (own roots), Menindee Seedless (on sultana rootstock) and Thompson Seedless (own roots).

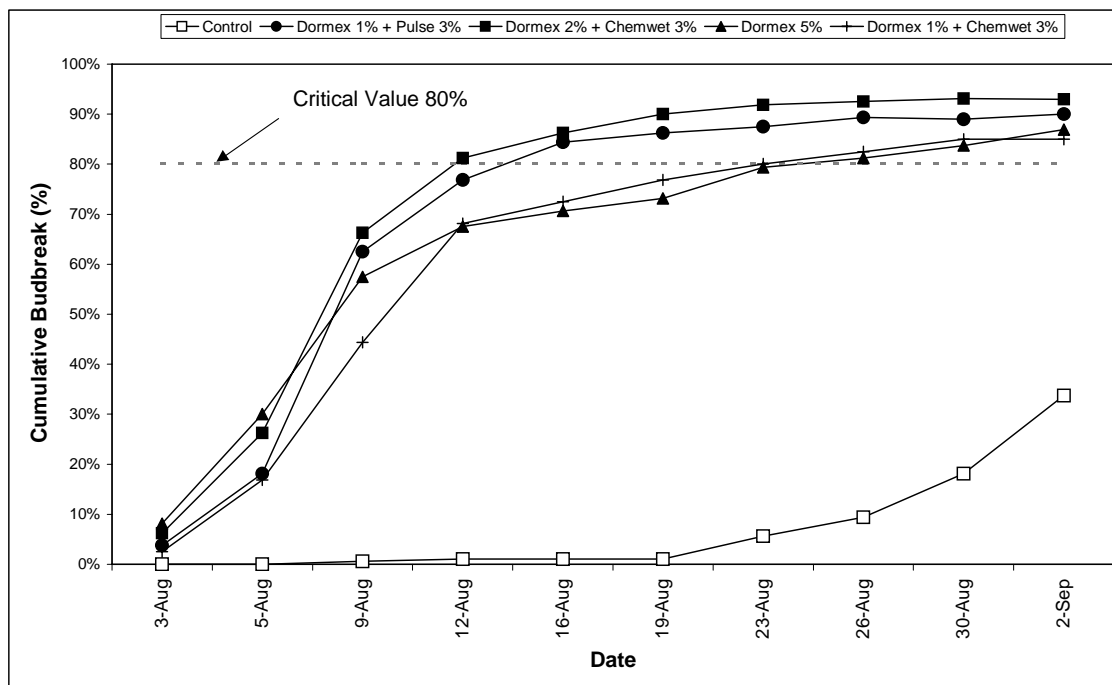
Ten two bud spurs on each Flame Seedless vine treated were tagged. The varieties Menindee Seedless and Thompson Seedless which were cane pruned had 20 buds marked on the eight canes which were wrapped down.

Treatments were applied on the 6/7/99 using a hand held spray lance. Approximately 320 mL of spray solution was applied to the canes or spurs on each vine depending upon the method of pruning. The spray was also applied to the crown of the vine.

The marked buds on spurs or canes were assessed twice each week. The effectiveness of each treatment was assessed on the number of days required for 80% of the buds on each treated vine to reach budburst after treatments had been applied.

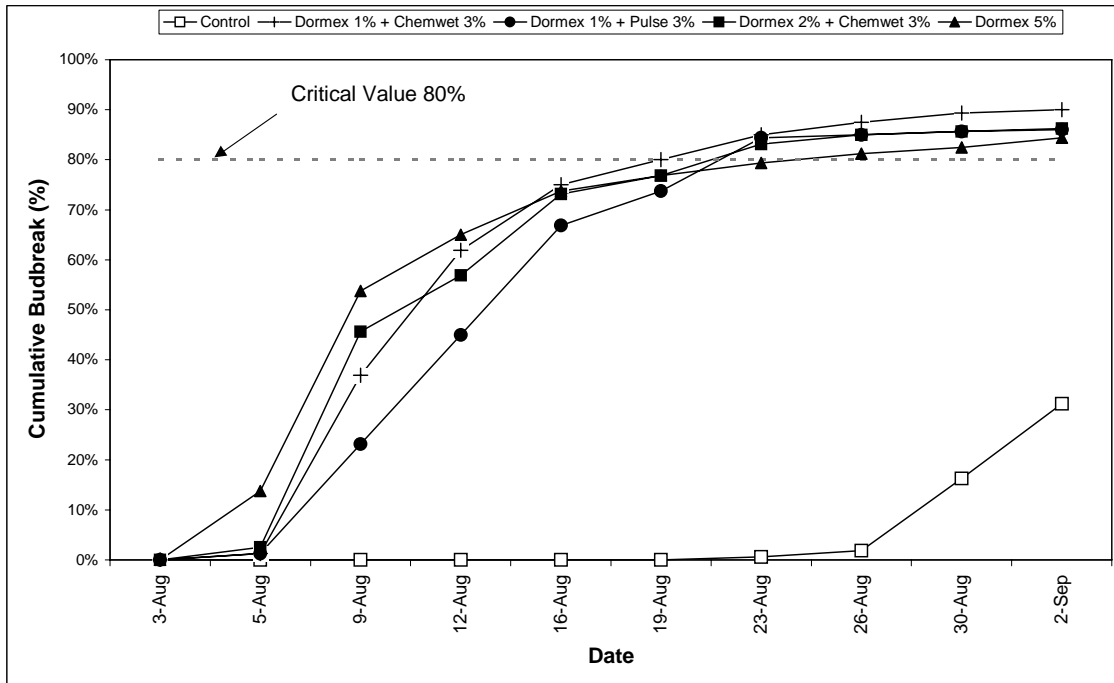
**Results:**

Flame Seedless; Vines treated with 2% Dormex + Chemwet 600 3% reached 80% budburst (39 days) after the spray application, followed by 1% Dormex + Pulse 3% (40 days), 1% Dormex + 3% Chemwet 600 (49 days), 5% Dormex (49 days), 2% Dormex + 3% Pulse (50 days). Other treatments had not achieved 80% budburst at this stage (see Figure 1).



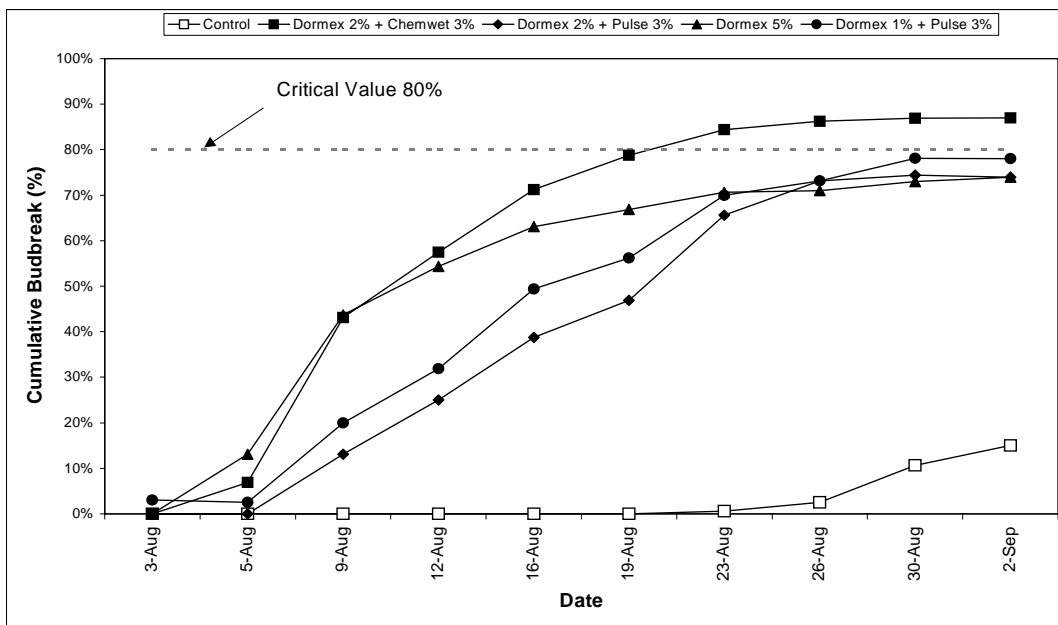
**Figure 1.** Number of days to reach 80% budburst in Flame Seedless after application of treatments

**Menindee Seedless;** Vines treated with 1% Dormex + 3% Chemwet 600 reached 80% budburst (44 days) after the spray application, followed by 2% Dormex + 3% Chemwet 600 (47 days), 1% Dormex + 3% Pulse (47 days), 5% Dormex (50 days). Other treatments had not achieved 80% budburst at this stage (see Figure 2).



**Figure 2.** Number of days to reach 80% budburst in Menindee Seedless vines on Sultana after application of treatments

**Sultana:** Vines treated with 2% Dormex + 3% Chemwet 600 reached 80% budburst (44 days) after the spray application. Other treatments did not achieve a budburst rate of 80% and included 1% Dormex + 3% Pulse (78% budburst in 58 days), 5% Dormex (74% budburst in 58 days), 2% Dormex + 3% Pulse (74% budburst in 58 days) (see Figure 3).



**Figure 3.** Number of days for Sultana vines to reach 80% budburst after application of treatments

### Cost Of Chemicals Used For Each Treatment:

Table 1 details a comparison of costs of spray chemicals required for each treatment. Costs are based upon the prices for spray materials in Central Australia and the amount required for 1,000 litres of spray mix.

**Table 1.** Cost of chemicals

Chemical Application Rate % v/v	Cost of Material Concentrate - \$/L	Cost /1,000 L of Spray Mix
Dormex - 5%	\$22.00	\$1,103.20
Agral .05%	\$6.40	
Dormex 2%	\$22.00	\$698.00
Chemwet 600 – 3%	\$8.60	
Dormex - 2%	\$22.00	\$1,334.00
Pulse – 3%	\$29.80	
Dormex – 2%	\$22.00	\$440.00
Dormex 1%	\$22.00	\$478.00
Chemwet 600 – 3%	\$6.40	
Dormex – 1%	\$22.00	\$1,114.00
Pulse – 3%	\$29.80	

### Discussion:

Research work which has been conducted over the past few years indicates that the application of 2% Dormex v/v in combination with the surfactant Chemwet 600 – 3% v/v may be as effective in breaking dormancy in table grapes in the Alice Springs region of Central Australia as the current recommended application of Dormex 5% v/v and a non ionic wetter.

The application of 2% Dormex v/v and Chemwet 600 – 3% v/v is more cost effective than the standard application of 5% Dormex v/v and a non ionic wetter – see Table 1.

**NB. Chemwet 600 is now marketed under the trade name Surfactant 600.**

### Further Research:

Research results to date have been based upon the application of Dormex and Dormex surfactant combinations to vines in small replicated plots using a hand held spray lance.

There is a need to evaluate the effectiveness of the various treatments compared with the standard treatment (Dormex 5% and Agral .05%) when applied using standard commercial application methods i.e. boom spray behind a tractor.

## **Appendix 1:**

### ***Technical Information On Surfactants Used In Dormancy Breaking Trials***

Spraymate Chemwet 600 – now marketed as SURFACTANT 600

Active Constituent; 600g/L non ionic ethoxylates

Manufacturer: Nufarm

#### **Pulse:**

Active Constituent; 1,000g/L modified polydimethylsiloxane

Manufacturer: Monsanto

#### **Agral:**

Active Constituent; 600g/l nonyl phenyl ethylene oxide

Manufacturer: Crop Care

#### **Acknowledgment:**

This work would not be possible without the cooperation of the owners, management and staff at Territory Grapes. This is much appreciated and gratefully acknowledged.

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**PROJECT:            Assessing the Effect of Gypsum on Sodium and Chloride Levels in Vines and Soil at Ti Tree Farm**

**Project Officers:    G. Kenna, D. Salter, D.King and S. Nagarajah**

**Location:            Ti Tree**

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#### ***Objective:***

***Improve the productivity and profitability of the table grape industry in the NT.***

#### **Introduction:**

Past research in table grape plantings in the Ti Tree/Pine Hill area has identified an increase in levels of sodium and chloride in soils irrigated for table grape production. Levels of sodium and chloride in virgin soils however are very low.

Bore water in the Ti Tree/Pine Hill area tends to contain moderate levels of sodium and chloride however this water also has high levels of bicarbonate which increases the effect of the available sodium in the water and its potential effect on sodium levels in the soil and vine.

The level of sodium in water is measured using the term "sodium absorption ratio (SAR)". This figure gives an indication of the relationship between sodium and calcium and magnesium in the irrigation water. Higher levels of bicarbonate in this water will increase the SAR value. The higher the SAR the greater the probability that infiltration rates and water flow through the soils will deteriorate.

Soils which have higher levels of sodium and a high pH due to irrigation with water of high SAR and pH are classified as sodic soils. These soils have high levels of sodium attached to the clay particles. When irrigated these soils swell and disperse so that when they dry again the soil pores are blocked. These soils are then susceptible to poor water penetration, poor aeration and water logging.

It was decided to monitor soils at Ti Tree Farm to assess the effect of the application of bore water with similar characteristics on vine health and soils.

**Method:**

Soil samples were taken in June 1999 from an area which was to be planted with Menindee Seedless vines on own roots. The planting was established in July 1999 and irrigated with water with SAR values up to 5. The bore water contained chloride levels up to 300 mg/L and sodium levels up to 200 mg/L.

Soil samples were again taken from four rows in the planting on the 29/10/99. Exchangeable Sodium Percentage (ESP) values for the soils at various depths indicated that the soils were accumulating levels of sodium and chloride which may have had a detrimental effect on plant health. An ESP reading of 6 or above is considered have potential to effect vine health. ESP levels for both sampling dates are listed in Table 4.

It was decided to assess the effectiveness of gypsum in reducing the accumulation of sodium in the vines rootzones and preventing a further increase in ESP values.

Gypsum was applied to half of each of the four trial rows in the planting of vines. It was applied by hand in a band approximately 1 m wide under the vine canopy at the rate of 5 t/ha on the 10/11/99.

Soil samples were taken from both treated and untreated parts of the vine rows to depths of 0-30 cm, 30-60 cm and 60-90 cm after harvest in late March 2000. It was intended to sample in February however heavy rainfall through February and March prevented this.

Leaf petioles were also sampled from vines in each half of the trial rows for levels of sodium and chloride.

**Results:**

Exchangeable Sodium Percentage (ESP) values from soils samples in June and October 1999 are listed in Table 1.

ESP values for the samples taken from treated and untreated areas of the vine rows in March 2000 are listed in Table 2.

**Table 1.** ESP values - June and October soil sampling

Soil Depth	June	Oct Row 25	R 50	R 75	R 100
0-30 cm	5.3	6.9	2.3	4.7	2.1
30-60 cm	7.1	8.3	3.7	5.1	3.2
60-90 cm		9.3	8.2	7.5	6.7

**Table 2.** ESP values for March soil sampling

Row No	Sample Depth cm	Control	Gypsum	Difference (ESP) control vs gypsum
25	0-30	2.3	2.0	0.3
	30-60	3.4	2.4	1.0
	60-90	2.7	5.1	-2.4
50	0-30	3.2	2.3	1.0
	30-60	4.1	2.3	1.8
	60-90	2.4	2.6	-0.2
75	0-30	3.4	2.9	0.5
	30-60	3.5	4.1	0.6
	60-90	1.2	3.1	-1.9
100	0-30	3.8	2.8	1.0
	30-60	4.6	2.3	2.3
	60-90	3.2	0.9	2.3

**Table 3.** Vine petiole nutrition levels

Nutrient	Treatment – Control	Sodium ppm	Chloride ppm	Calcium ppm	Potassium ppm
Row 25	Gypsum	0.6	1.8	1.7	3.4
	Control	0.6	1.7	1.5	3.7
Row 50	Gypsum	0.5	1.9	1.8	3.3
	Control	0.5	1.8	1.6	3.4
Row 75	Gypsum	0.6	1.8	1.7	3.6
	Control	0.6	1.8	1.8	4.0
Row 100	Gypsum	0.6	1.6	1.7	3.9
	Control	0.6	1.6	1.7	3.2

**Discussion:**

As mentioned earlier ESP levels of 6 and above in soils are considered to pose a potential risk to vine health. Gypsum was applied when ESP levels reached 6 and above in some levels of the soil profile in October.

Sampling in March revealed that there was very little difference in the trend in ESP levels between treated and untreated plots. All plots had levels well below 6. This indicates that the effect of the gypsum application in reducing the ESP was minimal.

Heavy rainfall events in February and March resulted in falls of 440 mm and 33 mm, respectively. It seems more probable that the high rainfall had a significant leaching effect in reducing the levels of sodium as indicated by the low ESP values across all rows regardless of whether or not gypsum was applied.

Vine petiole nutrition figures are similar for vines in treated and untreated plots. These figures indicate that although gypsum was applied the vines in the treated plots still took up as much sodium as the untreated vines. The levels of calcium in the treated vines did not differ from the untreated vines. Either the vines did not take up the calcium from the gypsum in the soil profile or more likely the calcium was leached from the vine roots.

In this particular instance the application of gypsum on the surface of the soil under the vine was not of any benefit possibly due to the leaching effect of the high summer rainfall events. A lack of rainfall postharvest which is more likely to occur in an average season may necessitate the use of gypsum to reduce sodium in the vine rootzone. This may warrant further investigation.

**Acknowledgement:**

The assistance of Dr P Rengasamy is gratefully acknowledged.

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**PROJECT:            Evaluating the Effectiveness of Leaching Applications of Water to Reduce Salt in Vine Rootzones**

**Project Officers:    G.Kenna, D.Salter, D.King and A.Nesbitt**

**Location:            Ti Tree**

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***Objective:***

***Improve the productivity and profitability of the table grape industry in the NT.***

**Introduction:**

Previous research work in table grape plantings on various properties in the Ti Tree/Pine Hill area has identified soil levels of sodium and chloride in the rootzone of vines, which could affect plant growth and productivity.

Research in 1998-1999 identified an increase in sodium and chloride levels in soils and a corresponding increase in the levels within the vines growing in these soils. Leaching irrigations are one means by which salt levels in the soil can be reduced. This involves the application of a volume of water in excess of that required for normal growth by the vine. Leaching irrigations are usually calculated as at least 10% in excess of the required water requirement. The application of this water, which is in excess of the vines requirements remove excess sodium and chloride which has accumulated in the vine rootzone during normal irrigation practices.

It was decided to investigate the effectiveness of the application of high volumes of water in a table grape planting as a means of removing excess sodium chloride, from the soil surrounding the plant roots. The time taken to reduce the levels of salt in the vines which received leaching irrigations compared with vines which were irrigated using the normal irrigation scheduling on the property would also be compared.

**Method:**

**Irrigation applications**

Two panels of vines were selected in each of four varieties at Territory Grapes. Each panel consisted of three vines in Flame Seedless, Menindee Seedless, and Sultana which are on their own roots. A similar number of panels were also selected in Menindee Seedless on sultana rootstock.

Soil was hilled up around each panel of vines so as to contain the water which was applied over an area similar to the normal wetting pattern produced by the vine drippers. Water was applied to one panel in each planting at the rate of 700 litres per irrigation.

A panel of vines in each variety received an application of water at three weekly intervals commencing on the 29/4/99. A total of four irrigations were applied.

Another panel of vines in each variety received a similar volume of water at three weekly intervals commencing on the 2/6/99. A total of two irrigations were applied.

A comparison of the Exchangeable Sodium Percentage (ESP) levels in soils and sodium and chloride levels in leaf petioles of the vines under both irrigation schedules compared with vines irrigated using the normal schedule vines where a lesser number of applications of water were made.

**Soil and petiole sampling:**

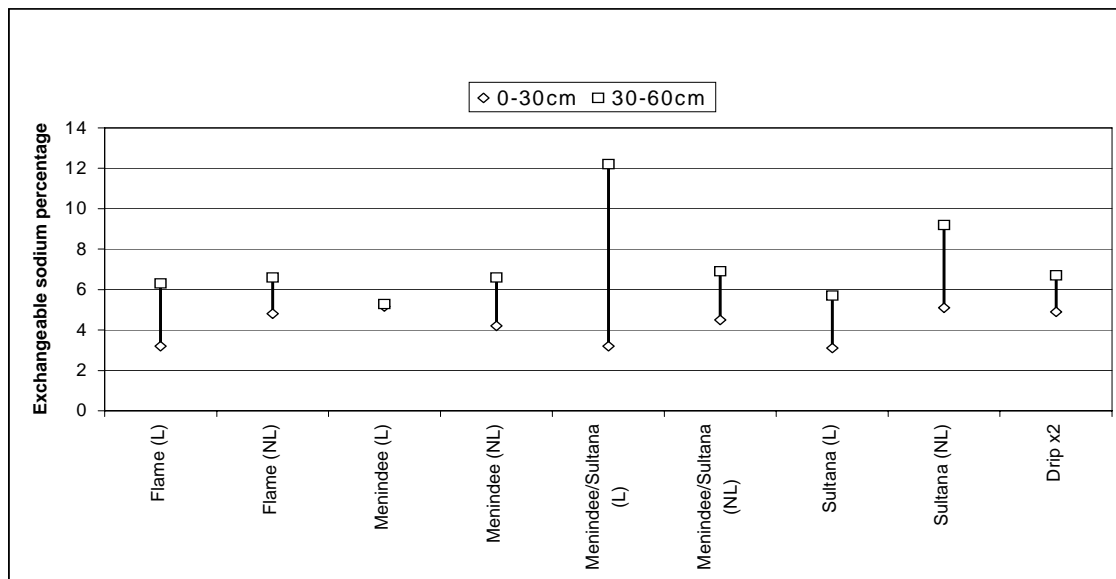
Soil samples were taken on the 14/4/99 at depths of 0-30 cm and 30-60 cm before the treatments were commenced. Soil in an untreated panel of vines in each variety was also sampled. Soil samples were again taken on the 29/6/99 and again in August 1999.

Leaf samples were taken from both treated panels of vines and an untreated panel of vines in each variety at flowering.

Soil and leaf samples were also taken from a row of Menindee Seedless on own roots which is irrigated by two drip lines. Although the volume of water applied to these vines is similar to those vines with a single drip line the aim was to determine whether there was a difference in salt levels in the soil and petioles due to a different wetting pattern created by the two lines.

**Results:**

ESP values for soil samples taken at 0-30 cm and 30-60 cm depths in both areas to be leached and control areas in April are shown in Figure 1.

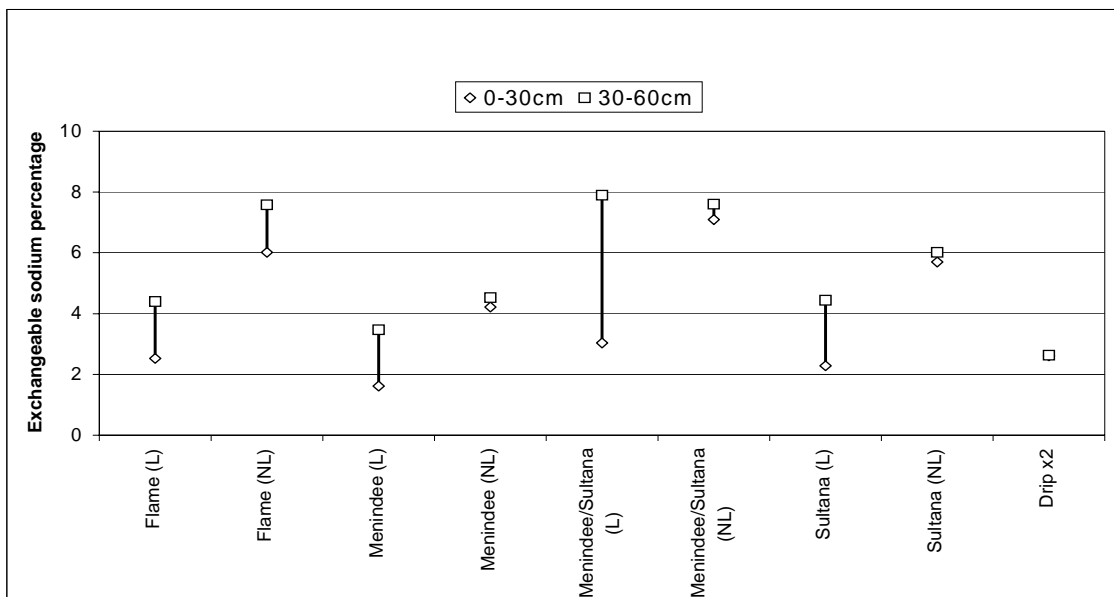


**Figure 1.** Exchangeable sodium percentages for leached and control areas – April 1999

**Table 1.** Exchangeable sodium percentages for each treatment and sample depth

Variety	Leached* or Control	Sample depth	ESP
Menindee	L-1	0-30	5.6
	L-1	30-60	4.1
	L-2	0-30	1.3
	L-2	30-60	2.2
	Control	0-30	1.4
	Control	30-60	1.5
Menindee/Sult	L-1	0-30	3.6
	L-1	30-60	8.3
	L-2	0-30	3.1
	L-2	30-60	4.2
	Control	0-30	4.8
	Control	30-60	5.4
Sultana	L-1	0-30	2.6
	L-1	30-60	2.2
	L-2	0-30	1.4
	L-2	30-60	2.0
	Control	0-30	1.8
	Control	30-60	2.8
Flame	L-1	0-30	1.6
	L-1	30-60	2.7
	L-2	0-30	1.3
	L-2	30-60	2.2
	Control	0-30	8.2
	Control	30-60	9.0
Double Drip		0-30	2.6
		30-60	2.6

L-1 = First leaching treatment, L-2 = Second leaching treatment



**Figure 2.** Exchangeable sodium percentages for leached and control areas – June 1999

**Table 2.** Vine petiole levels of sodium and chloride in various treatments

Variety	Leached or Control	Sodium - %	Chloride - %
Menindee	L-1	0.9	1.6
	L-2	0.9	1.6
	Control	1.1	2.0
Menindee/Sult	L-1	0.7	1.9
	L-2	0.6	1.8
	Control	0.7	1.8
Sultana	L-1	1.4	1.6
	L-2	1.3	1.6
	Control	1.5	1.6
Flame	L-1	1.5	2.2
	L-2	1.5	2.1
	Control	1.5	2.4
Double Drip		1.4	2.2

**Discussion:**

Table 1 lists ESP values for soils sampled from the two treatments compared with the non-leached (control) areas. These samples were taken in August 1999. It would be expected that if the leaching applications had been successful, ESP values on both treatments would be lower than the control. ESP readings varied considerably across all treatments, controls and varieties. Readings were high in some leached plots and low in control plots. In other plots those areas receiving less leaching applications of water recorded lower ESP values than those plots receiving high volumes of water over a longer period.

The samples taken from the double dripper row were initially low (0-30 cm – ESP 4.9 and 30-60 cm– ESP 6.7). This row did not receive any specific leaching applications. Applications of water to the vines in this row were as per the normal irrigation schedule. At the August sampling the ESP levels were lower (0-30 cm– ESP2.6 and 30-60 cm – ESP2.6).

Levels of sodium and chloride in vine petioles were very similar across all varieties and treatments. The vines growing in the double dripper line row had similar levels of sodium and chloride as all other vines sampled. The vines had already absorbed these elements during the previous growing season before the samples were taken. After leaf fall in June 2000 levels may be lower.

Data collected suggests that the application of leaching irrigations to reduce sodium and chloride in soils and vines was not successful. There may be a number of reasons for this including the timing of the irrigations and the method by which the water was applied. It may also indicate that to achieve a satisfactory leaching effect in a vines rootzone it is necessary to apply leaching irrigations on a regular basis throughout the year – both during the growing season and the dormant period.

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**PROJECT:           Irrigation and Salinity studies in Grapevines at Ti Tree**

**Project Officers:   S.Nagarajah, G. Kenna, A. Nesbitt and D. Salter**

**Location:           Arid Zone Research Institute, Alice Springs**

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**Objectives:**

- *To monitor the soil moisture levels in a vineyard through the growing season.*
- *To measure the sodium and chloride levels in bore water.*
- *To monitor the sodium and chloride levels in grapevines and the soil through the growing season.*
- *To compare the salt exclusion capacity of different cultivars.*

**Introduction:**

Soil moisture measurements were made to find out whether there was excess irrigation or under irrigation in a vineyard.

Salinity is a problem in Ti Tree vineyards. However, there is little information on the different aspects of this problem

**Materials and Methods:**

**Irrigation**

*Soil moisture* - Tensiometers and a neutron probe was used to measure the soil moisture levels at three sites in a vineyard. Flame, Red Globe/Ramsey and Menindee grew at these sites. The measurements were made at weekly intervals from September 1999 to June 2000.

**Salinity**

*Bore water* - The sodium and chloride levels were measured in 27 samples of bore water samples.

*Grapevines* - The petiole sodium and chloride levels were measured at flowering in all the grapevine cultivars grown at Ti Tree. The cultivars included Flame, Flame/Ramsey, Menindee, Menindee/Ramsey, Menindee/Sultana, Menindee/Schwarzmann, Red Globe/Ramsey Sultana/Ramsey and Sultana. In addition, the petiole sodium and chloride levels were measured at periodic intervals through the season in Flame, Menindee, Menindee/Sultana, Red Globe/Ramsey Sultana and Menindee/Schwarzmann in two vineyards.

*Soil* - The exchangeable sodium percentage in the soil at 0-30 cm and 30-60 cm depths was measured at three monthly intervals in two vineyards.

**Results and Discussion:**

**Irrigation**

*Soil moisture* - The tensiometer and neutron probe data indicated that there was excess irrigation in the vineyard (Figure 1). This conclusion is based on using the current recommendation at which irrigation is scheduled for table grapes in South Africa as reference value. Excess irrigation has a number of harmful effects. It leads to a waste of water and increases salt absorption by the vine. Furthermore, excess irrigation would increase nitrogen absorption from the bore water, which is

known to contain high nitrate levels. High nitrogen and water levels in the vines have two harmful effects. They reduce fruitfulness of the canes and delay berry maturity. Finally, excess irrigation increases power/fuel bills.

### **Salinity**

*Bore water* - In many bore water samples, the sodium and chloride levels were higher than in the Murray River (Figure 2).

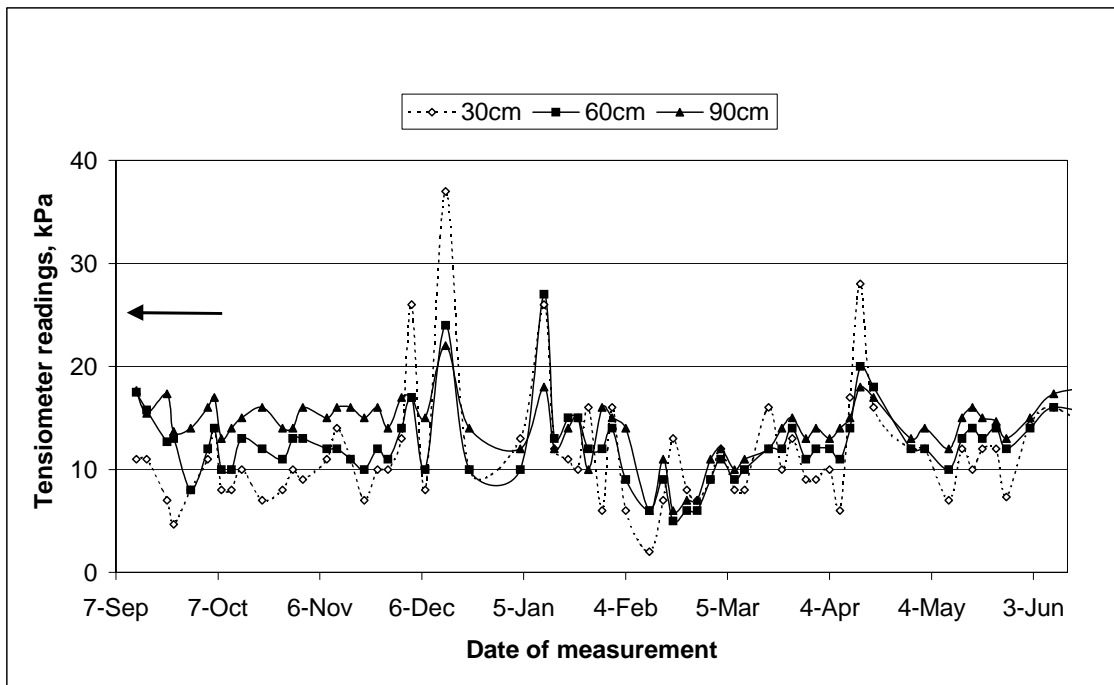
*Grapevines* – At flowering, the percentage of petiole samples, which had toxic levels of sodium and chloride, were 33 and 52% respectively. The petiole sodium and chloride levels increased through the season in all the cultivars (Figures 3 and 4). All the cultivars, except Menindee/Schwarzmann, showed some form of salt damage symptom towards the end of the season. The damage was either a salt toxicity symptom (Menindee) or potassium deficiency symptom (Sultana, Flame, and Red Globe/Ramsey). Cultivar differences were observed in the capacity of vines to exclude sodium and chloride. Menindee/Schwarzmann had the best capacity to exclude both sodium and chloride. Menindee/Sultana had a good capacity to exclude sodium but not chloride. Red Globe/Ramsey excluded sodium and chloride early in the season but not late in the season. Sultana and Menindee on own roots had a poor capacity to exclude sodium and chloride. Scion rootstock interaction in Menindee/Sultana increased the capacity of Sultana roots to exclude sodium.

*Soil* - The exchangeable sodium percentage values were less than 6% i.e. the soil was not sodic (Figure 5). Therefore, the main source of salt for the vines was the bore water and not the soil. The low soil ESP values indicate that there was no need to use gypsum to displace sodium from the soil.

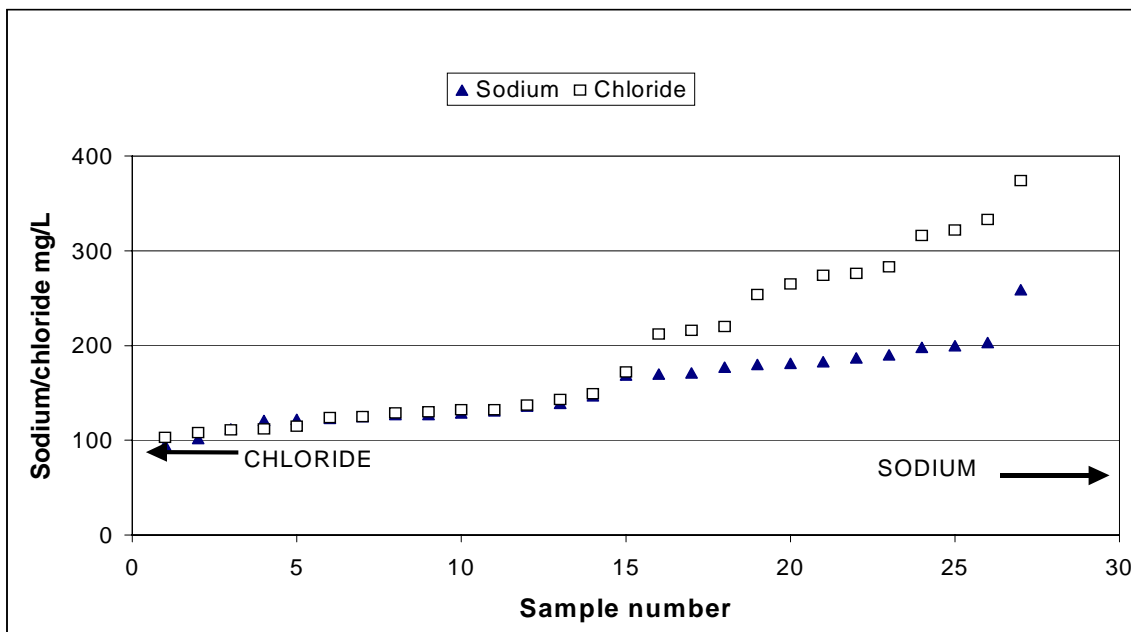
Salt toxicity is likely to reduce the quantity and quality of grape berries (Prior et al. 1992). The control measures for salt toxicity are improved irrigation management and planting of vines on salt tolerant rootstocks. Both excess irrigation and under-irrigation increases the salt levels in grapevines. Only, Menindee/Schwarzmann had a good capacity to exclude salt. There is a need to find salt excluding rootstocks, which can be used, for other cultivars such as Sultana, Flame and Red Globe which are grown at Ti Tree.

### **References:**

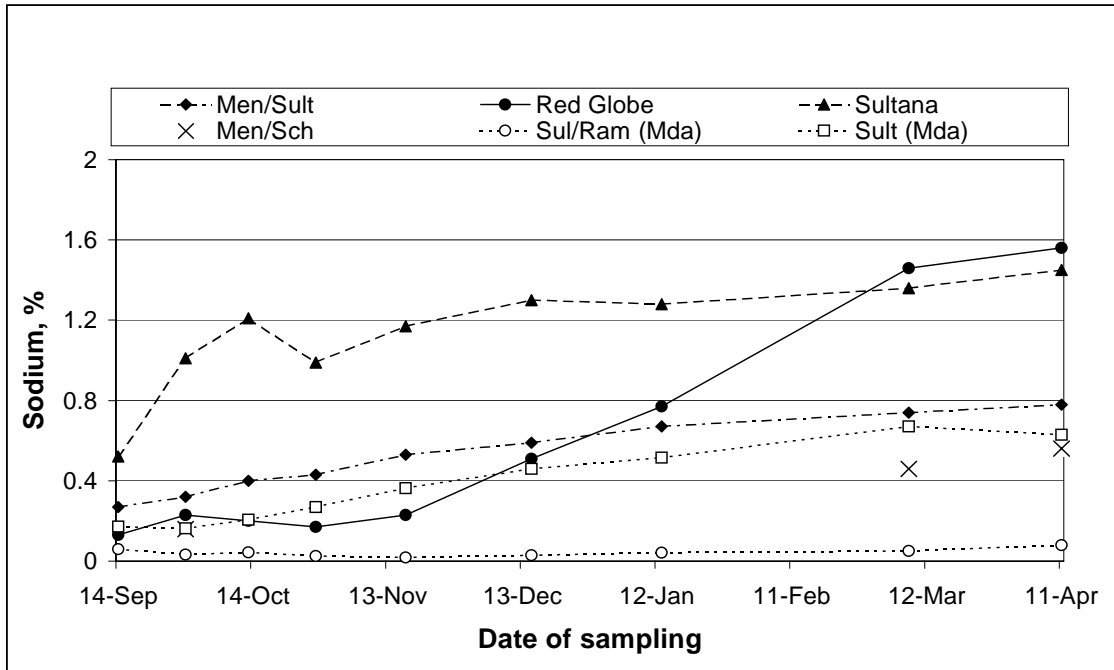
Prior, L.D., Grieve, A.M. and Cullis, B.R. (1992) Sodium chloride and soil texture interactions in irrigated field grown sultana grapevines. 1. Yield and fruit quality. *Aust.J.Agric.Res.*43, 1051-66.



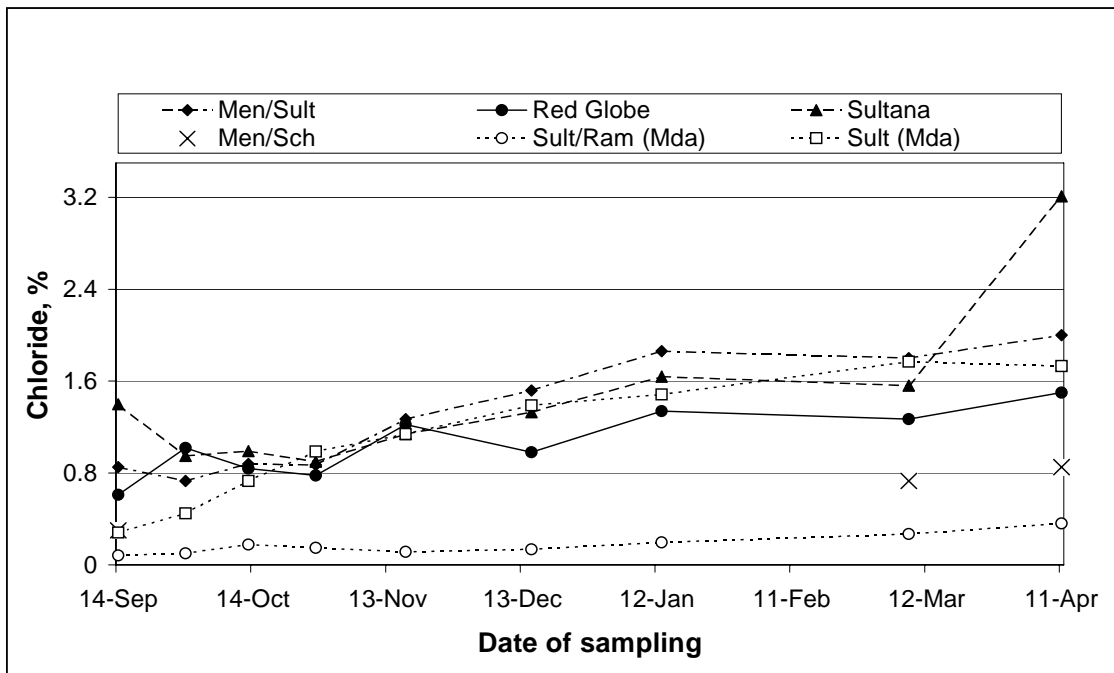
**Figure 1.** The readings on the 30, 60 and 90 cm depth tensiometers in Red Globe from September 1999 to June 2000. The horizontal arrow indicates the readings at which table grapes are irrigated in South Africa



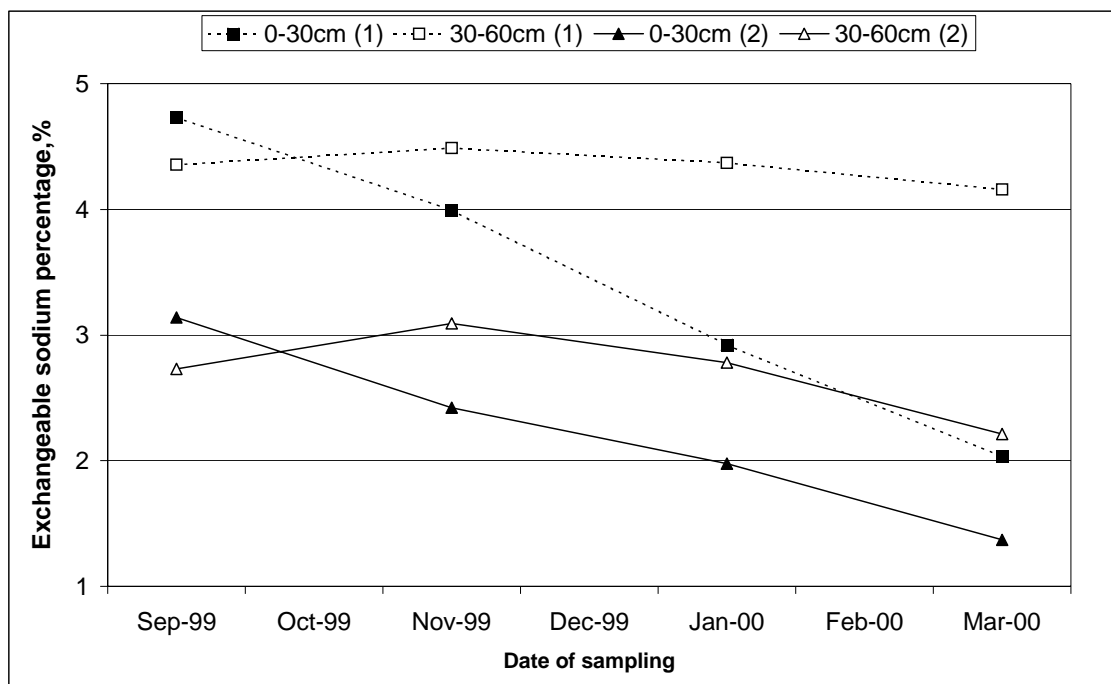
**Figure 2.** The sodium and chloride levels in 27 bore water samples from Ti Tree. Sodium and chloride values in Murray River, indicated by horizontal arrows, are given for comparison



**Figure 3.** The changes in petiole sodium in Sultana, Menindee/Sultana, Red Globe/Ramsey and Menindee/Schwarzmann at Ti Tree. Sultana and Sultana/Ramsey (1997/98) data from Mildura are included as reference values



**Figure 4.** The changes in petiole chloride in Sultana, Menindee/Sultana, Red Globe/Ramsey and Menindee/Schwarzmann at Ti Tree. Sultana and Sultana/Ramsey (1997/98) data from Mildura are included as reference values



**Figure 5.** The changes in exchangeable sodium percentage (ESP) from September 99 to March 00 in 0-30 cm and 30-60 cm depths in two vineyards indicated as 1 and 2. The soil is sodic only when the ESP value exceeds 6%

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**PROJECT: Improving Grapevine Nutrition at Ti Tree**

**Project Officers: S.Nagarajah, A. Nesbitt and D. Salter**

**Location: Arid Zone Research Institute, Alice Springs**

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**Objective:**

*The effect of potassium fertiliser on petiole potassium levels.*

**Introduction:**

Potassium fertiliser is widely used in Ti Tree vineyards because the sandy soils contain low potassium levels. However, grapevines could have a problem in readily absorbing potassium from these fertilisers. This is because salinity is a problem at Ti Tree. Consequently, sodium/potassium interaction can reduce the uptake of potassium (Maathuis and Amtmann 1999, Makihara et al 1999).

**Materials and Methods:**

The study was carried out using Menindee grapevines in two vineyards. The rates of potassium sulphate fertiliser used were 0, 25, 50 and 75 kg K/ha. The fertiliser was applied on 1/9/99 to groups of ten vines and water applied by hand to the soil surface to move the fertiliser into the root zone. The petiole potassium and sodium levels were measured in petiole samples collected on 13/10/99, 15/11/99 and 5/1/00.

## Results and Discussion:

The October petiole results presented Figure 2 show that:

- the potassium levels increased at 50 and 75 kg K/ha in Vineyard 1 but not in Vineyard 2,
- the sodium level in Vineyard 1 was about half that in Vineyard 2 ,
- the increase in potassium was associated with a reduction sodium level.

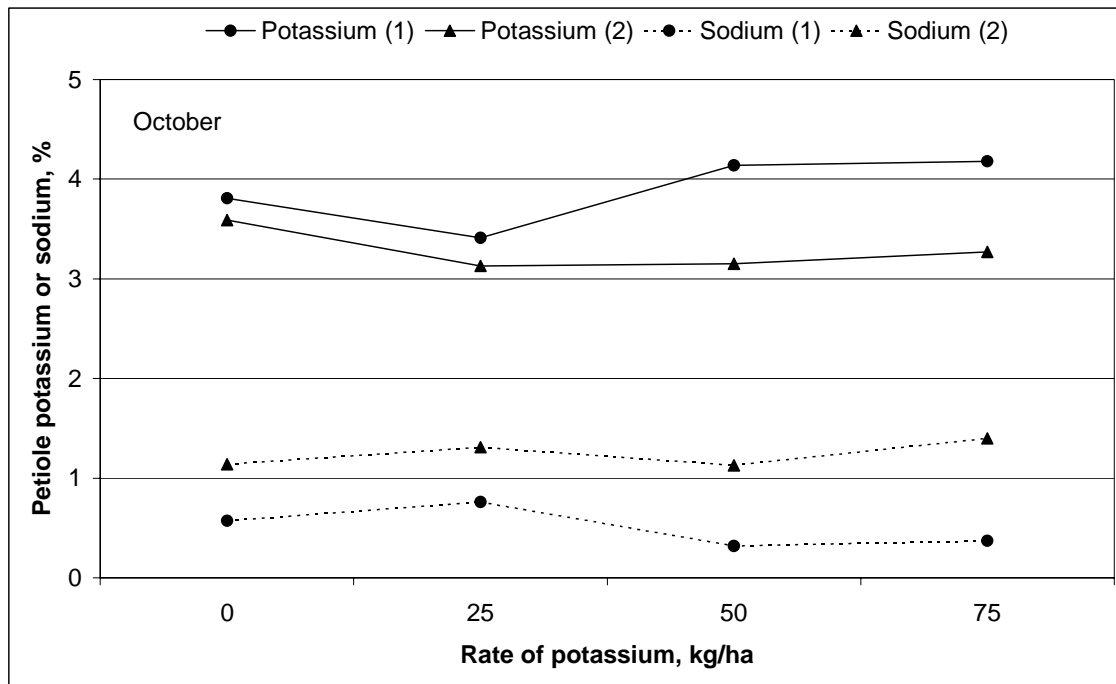
Similar results were observed in petiole samples collected in November and January. The petiole data from the three sampling dates showed that there was a negative correlation between potassium and sodium levels (Figure 1).

Potassium/sodium interaction can inhibit the absorption of potassium at Ti Tree. In Menindee, this inhibition occurred when the petiole sodium level reached about 1%. The results point to the need to check sodium levels in vines prior to applying potassium fertiliser. When the sodium level is high, it should be reduced by improved irrigation management before applying potassium fertiliser.

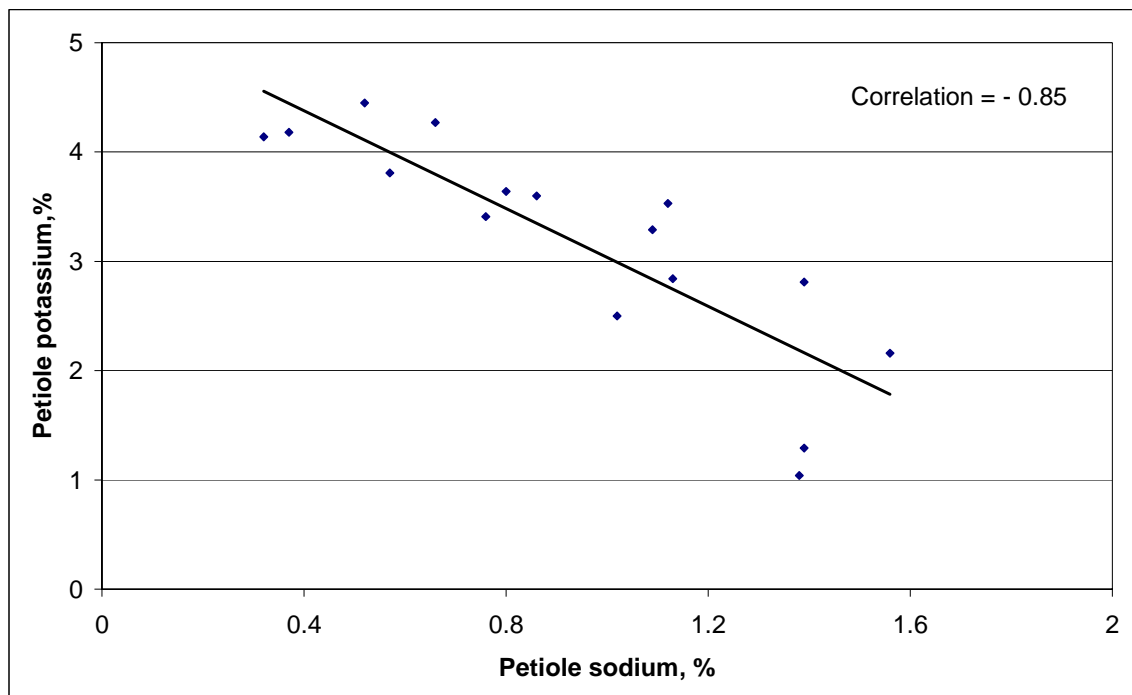
## Reference:

Maathuis, F.J.M and Amtmann, A. (1999). K<sup>+</sup> nutrition and Na<sup>+</sup> toxicity: the basis of cellular K<sup>+</sup>/Na<sup>+</sup> ratios. *Annals of Botany*, **84**, 123-133.

Makihara, D., Tsuda, M., Hirai, Y. and Kuroda, T. (1999). Effects of saline irrigation at various growth stages on rice yield. *Japanese Journal of Crop Science*, **68**, 487-494.



**Figure 1.** The effect of potassium fertiliser at four rates on the petiole potassium and sodium levels in Menindee grapevines in two vineyards. The data from the two vineyards are indicated as 1 and 2



**Figure 2.** The inverse relationship between petiole potassium and sodium levels in Menindee

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**PROJECT:            Improving Grapevine Nutrition at Ti Tree**

**Project Officers:    S.Nagarajah, G. Kenna, A. Nesbitt and D. Salter**

**Location:            Arid Zone Research Institute, Alice Springs**

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***Objective:***

***To identify nutrient problems in grapevines at Ti Tree***

**Introduction:**

Grapevines require adequate supplies of nutrients for growth and fruiting. The excessive supplies of nutrients and nutrient deficiencies can affect the quantity and quality of grape berries. Therefore, there is a need to identify nutrient problems in vineyards and take the necessary corrective action. This would improve the productivity of vineyards.

**Materials and Methods:**

The diagnostic tools used to identify the nutrient problems were petiole and soil analysis and deficiency/toxicity symptoms. Petiole and soil samples were collected at periodic intervals from the vineyards and nutrient levels measured. Although all the nutrients were measured, the main focus was on nitrogen, phosphorus and potassium.

## Results and Discussion:

The petiole nutrient data showed that the nutrient problems at Ti Tree were:

- high nitrogen and phosphorus levels;
- marginal or deficient levels of phosphorus, potassium, calcium, magnesium, iron, copper and zinc.

Ramsey rootstock vines had high nitrogen levels. This is to be expected in rootstock vines because their extensive root system absorbs large amounts of nitrogen. The harmful effect of excess nitrogen is that it promotes excessive vigour. Potassium deficiency was a serious problem in all the cultivars, except Menindee/Schwarzmann. Phosphorus deficiency was very severe in Menindee/Sultana.

Nutrient interactions were observed between potassium and sodium and between phosphorus and chloride. Negative correlations were observed between these two pairs of nutrients. The consequence of this interaction is that sodium can inhibit the uptake of potassium and chloride can inhibit the uptake phosphorus. These inhibitory effects are likely to affect the potassium and phosphorus levels in grapevines because salinity is a problem at Ti Tree.

Grapevines showed leaf symptoms caused by potassium, magnesium, iron and zinc deficiencies. A new potassium deficiency symptom was observed around January. The symptom was the gradual drying up of the exposed leaves in the canopy. These leaves eventually dropped off the vine. All the cultivars, except Menindee/Schwarzmann, showed this symptom. The only toxicity symptom observed was that caused by salt.

Soil nitrate level was not excessive although bore water contained high nitrate levels. Denitrifying bacteria could have been responsible for not finding high soil nitrate levels. After the application of phosphorus fertiliser, Olsen soil phosphorus levels showed a marked reduction within six months. This would suggest the fixation of phosphorus in the soil in an unavailable form. Applying low rates of phosphorus at frequent intervals can reduce the losses of phosphorus due to fixation in the soil.

The soils at Ti Tree contained low levels of potassium, calcium and magnesium.

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**PROJECT:           Root Distribution Patterns in Grapevines at Ti Tree**

**Project Officers:   S. Nagarajah, C. Kinnaird, D. Salter and A. Nesbitt**

**Location:           Arid Zone Research Institute, Alice Springs**

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### ***Objectives:***

- ***Compare lateral root growth into the traffic row relative to root growth along the vine row.***
- ***Study vertical root growth in the soil.***
- ***Compare the root systems in different cultivars.***

### **Introduction:**

The root distribution pattern was studied in a vineyard as part of the research program to improve irrigation management. Information on root distribution is required when installing irrigation scheduling aids such as tensiometers and neutron probe access tubes. In addition, root data can be

used to determine the depth to which the soil should be collected when measuring soil nutrients. Data of the root distribution pattern from another vineyard was presented in the 1998/99 Technical Annual Report.

### **Materials and Methods:**

The study was carried out using mature Sultana, Flame, Menindee and Red Globe/Ramsey grapevines. The grapevines were growing in a sandy loam soil and drip irrigated. The roots system was studied by collecting roots using an auger (diameter 72 mm). The root samples were collected at different distances from the vine trunk, both in the direction of the traffic row and along the vine row. At each position roots were collected at 15 cm depth increments to a depth of 150 cm. The root data was used to calculate the root density i.e. mm/cm<sup>3</sup>.

### **Results and Discussion:**

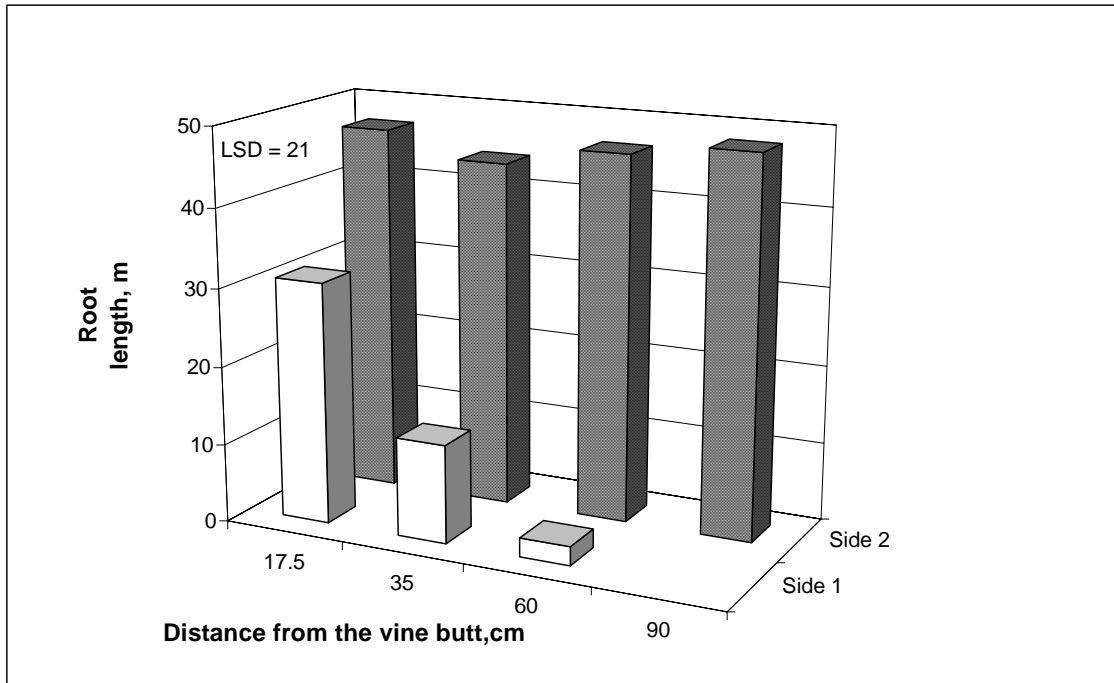
The lateral distribution of roots in Red Globe is shown in Figure 1. Similar results were obtained in Sultana, Menindee and Flame. The root system was confined to a narrow strip along the vine row with very little lateral root growth into the traffic row. This is to be expected in drip irrigated vineyards because of the limited wetting pattern of the soil. The vertical distribution of roots in the four cultivars is shown in Figure 2. The high-density root zone was the 0-30 cm or 0-45 cm soil layer. About 80% of the roots were in the top 90 cm of the soil. A few roots were growing below a depth of 150 cm. In sandy soils, roots can grow down to a depth of 220 cm (Nagarajah 1987). Cultivar differences were observed in the root density in the soil profile and in the distribution of roots in the soil profile. However, the size of the root system in the cultivars was similar. Red Globe on Ramsey rootstock did not have a bigger root system than own rooted vines. This is rather unusual because rootstock vines generally have a bigger root system than own rooted vines (Nagarajah 1987).

The root distribution data indicated the following points in relation to soil moisture measurements and collection of soil samples to measure nutrients:

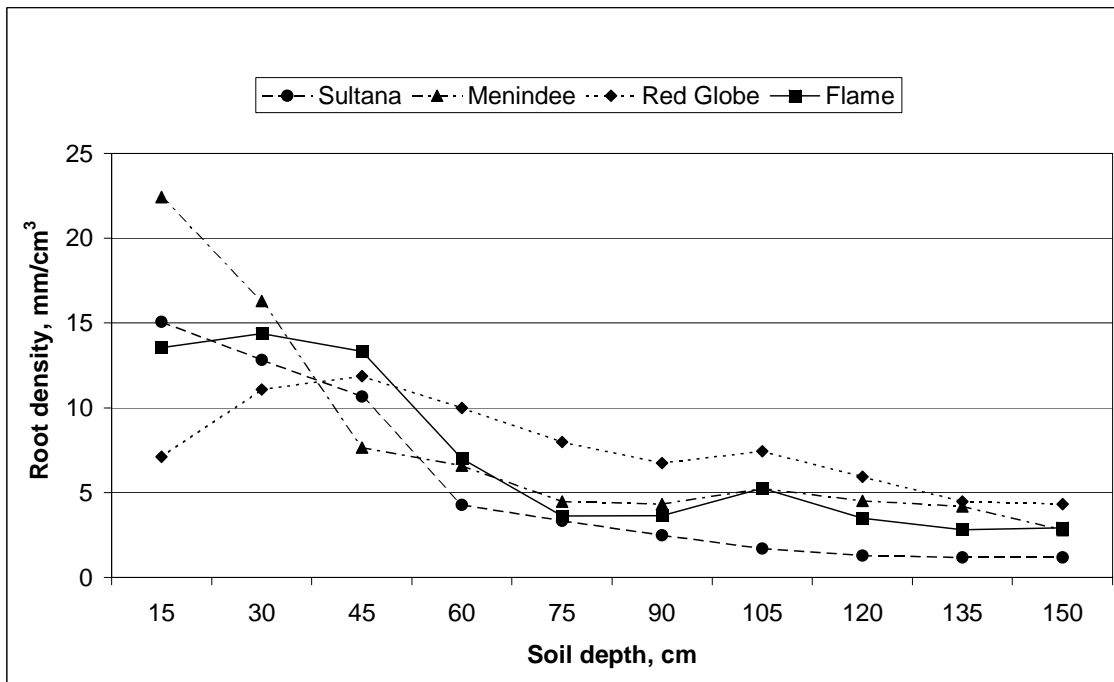
- soil moisture measurements and soil sampling for nutrient measurements should be carried out along the vine row,
- for irrigation scheduling it would be sufficient to monitor the soil moisture level in the top 100 cm of the soil,
- for nutrient measurement it would be sufficient to collect soil samples to a depth of 30 cm.

### **Reference:**

Nagarajah, S. (1987). Effects of soil texture on the rooting patterns of 'Thompson Seedless' vines on own roots and on Ramsey rootstock in irrigated vineyards. *American Journal of Enology and Viticulture*. **38**, 54 - 59.



**Figure 1.** Comparison of the total root length in soil cores collected to a depth of 150 cm at different distances from the vine trunk into the traffic row (Side 1) and along the vine row (Side 2) in Red Globe grapevines. The LSD at  $p=0.05$  for the roots collected at the four positions along the traffic row is shown in the figure



**Figure 2.** The root density at 15 cm depth increments of the soil to a depth of 150 cm in Sultana, Menindee, Red Globe and Flame grapevines. The data is from root samples collected along the vine row

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**PROJECT: Banana Nutrient Monitoring**

**Project Officers: M. Darcey, K. Blackburn and M. Traynor**

**Location: NT Banana Industry**

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**Objective:**

*The Objective of the project is primarily to facilitate ongoing banana group discussion using the foundation of nutrient monitoring and comparison as the basis for discussion. Initially, when the project started in 1994, the objective was to assist banana growers to optimise banana nutrition. However that goal has been achieved through growers improved experience and a significantly reduced number of commercial producers resulting from Panama disease.*

**Discussion:**

Ongoing sampling for nutrient monitoring has been taken over by growers due partly to the risks associated with DPIF staff moving Panama disease from farm to farm. Leaf and soil analysis is undertaken by DPIF laboratories and interpretation conducted jointly by growers and DPIF staff.

The advent of several outbreaks of Panama disease on all major production farms has overshadowed nutrient management issues in recent months.

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**PROJECT:           Miscellaneous Exotic Fruits Research****Project Officers:   G. McMahon and C. Wicks**Location:

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**Objective:**

- **Research, identify and evaluate suitable fruit crops for Top End production.**
- **Multiply and release known pitaya varieties, and low land longan varieties to industry.**
- **Identify suitable multiplication techniques and develop best management practices for Top End conditions.**

**Fruiting Cactus Species:**

No work has been carried out on this exotic fruit this year, because the position was vacant for more than eight months.

However a trial block of pitaya has been established at CPHRF. Cuttings were planted against concrete fence posts (100 mm x 100 mm x 1.8 m) placed into a steel collar which was buried into the ground. Some posts have wooden crossarms attached to the top of the post, while some had wooden uprights as supports. The steel collars were wrapped with cocoa mat, and 1 m<sup>3</sup> of potting mix, with Dolomite, super, and Nitrophoska Blue added, was mounded around each post to a height of 30 cm.

In August 1999, the pitaya cuttings were planted into each mound and tied to the posts. One cutting for each pole, with five poles in four rows, and the last row has two cuttings per pole. The cuttings were collected from Queensland, Vietnam and Darwin, and included the red/white type (*Hylocereus undatus*), the red/red type (*Hylocereus polyrhizus*), and the yellow pitaya (*Selenicereus megalanthus*). Growth rates for the pitaya have not been recorded, but a table of plant size at planting, and growth after 11 months is shown below.

**Table 1.** Average Plant Growth of Pitaya at CPHRF.

<b>Support type</b>	<b>Fruit type</b>	<b>Average height at planting (cm)</b>	<b>Standard Development</b>	<b>Average height at 11 months (cm)</b>	<b>Standard Development</b>
cross	red / white	59.33	15.31	223.33	62.42
upright	red / white	62.28	13.96	206.00	49.17
cross	red / red	36.66	20.43	32.33	10.69
upright	red / red	42.66	19.13	136.33	76.89
cross	yellow	46.00	7.55	218.33	43.68
upright	yellow	41.00	4.35	223.33	51.31

## New Introductions:

New introductions of exotic fruit were made by Melinda Gosbee from Vietnam, Chris Wicks from Vietnam, Yan Diczbalis and Mark Hoult from Sabah. Melinda visited Vietnam in November 1999 and brought back longan seed of two varieties, Tieu, and Long. The seed has been subsequently distributed to interested growers. Tieu is the most commonly grown variety in Vietnam. The fruit has a small seed with a good amount of flesh, and produces three crops in two years. No rootstock is required in drier soils. Long generally has inferior fruit but is useful as a rootstock. Melinda also brought in some longan marcotts of which one survived and has been successfully propagated on. Chris visited Vietnam in June 2000 and brought back longan seed and budwood of which none have survived. Yan and Mark visited Sabah and brought back a longan variety called Diamond River (ex Singapore) This has been released from quarantine and is being grown at CPHRF. A large amount of cocoa was introduced during the year. This will be discussed separately. No other introductions occurred during the year.

A review of the BARC shade house was recently completed and all remaining accessions from previous years were taken to CPHRF, and placed in a larger, more open shade tunnel. Of these five *Rheedia madruno* (ex. Queensland), and five *Baccaurea unguolata* (Uchong, ex. Sarawak) were planted out in the Exotics netted area. The remaining species are listed below.

**Table 2.** Exotic fruit tree species relocated at CPHRF

<b>Botanical Name</b>	<b>Common Name</b>	<b>Origin</b>
<i>Genipa americana</i>	Genipapo	Brazil
<i>Rheedia madruno</i>	Madrono	Queensland
<i>Baccaurea unguolata</i>	Uchong	Sarawak
<i>Citrus nobilis</i>	Cam Sanh	Vietnam
<i>Citrus</i> sp.	Lemon/mandarin	Queensland
<i>Lansium domesticum</i>	Langsat	Sabah
<i>Artocarpus odoratissimus</i>	Marang	Sabah
<i>Artocarpus integer</i>	Mit to Nu	Vietnam
<i>Artocarpus</i> sp.	Jackfruit	Vietnam
<i>Spondais tuberosia</i>	Imbu	Brazil
<i>Spondais cytherea</i>	Hog plum	Brazil
<i>Diospyros discolor</i>	Velvet apple	Sabah
<i>Hylocereus undatus</i>	Red/white pitahaya	Vietnam
<i>Hylocereus polyrhizus</i>	Red/red pitahaya	Darwin
<i>Garcinia mangostana</i>	Mangosteen	
<i>Garcinia combogia</i>		Sabah
<i>Stercular chicha</i>	Chicha	Brazil
<i>Dimocarpus longan</i>	Long	Vietnam
<i>Dimocarpus longan</i>	Tieu	Vietnam
<i>Dimocarpus longan</i>	Xuong Com Vang	Vietnam

A review of the orchards at BARC is being undertaken with the view of multiplying and relocating trees of interest to CPHRF, or releasing material to other collectors.

In the new orchard at BARC, some more deaths have occurred, mainly in the newer plantings, possibly due to the extreme conditions experienced. Flowering is occurring again and some fruit set has been recorded.

New plantings in the exotic net at CPHRF took place in April 1999. One row of papaya was planted which consisted of NT red, Exotica 6, and Sunrise.

Four rows of longan seedlings, ex. Vietnam, were planted, which included Xuong com vang and Mata Kuching varieties.

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**PROJECT:           Rambutan Temperature Monitoring Project**

**Project Officers:   M. Gosbee, L. Thom (DTW) and A. Lim, Curtin University**

**Location:            BARC**

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***Objective:***

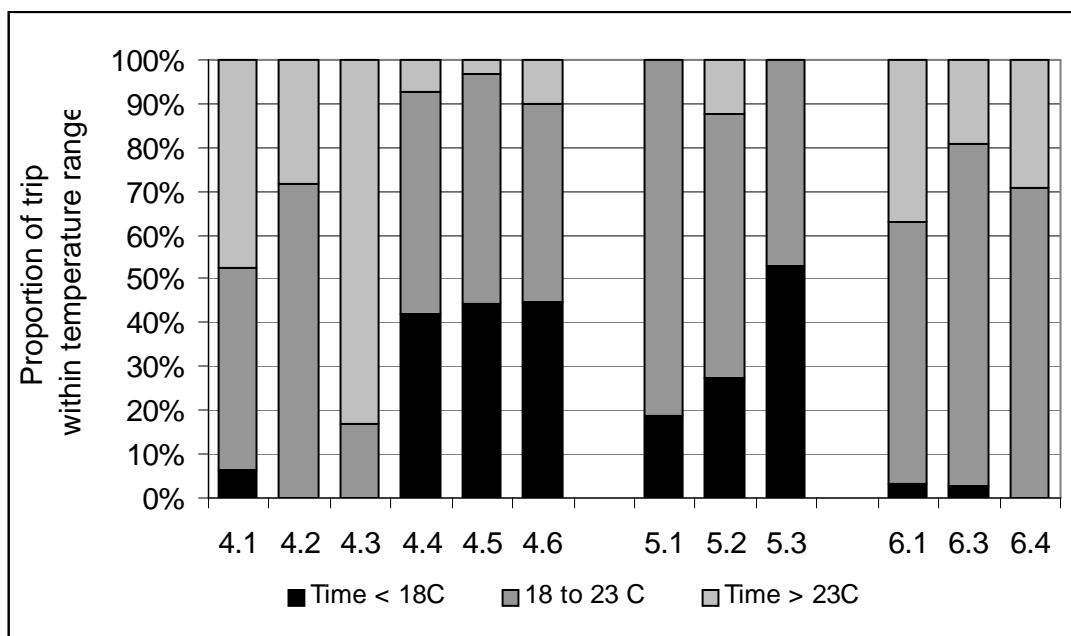
***To investigate the temperatures that rambutans are exposed to during handling.***

This project was conducted as part of the National Temperature Monitoring Project, funded by the Department of Transport and Works and managed by the Air Freight Council of Western Australia. It was initially intended to monitor horticultural produce and seafood exported overseas, however mango exports were few so domestic air freight of rambutans was chosen instead.

A total of 12 successful trips were monitored from three growers during December 1999 and January 2000. Results are presented in Figure 1. Total time for a complete trip was usually 35 hours, while occasionally this was extended to as long as 69 hours. Recommended storage temperatures for rambutans is 10 to 12°C, however some growers tend to use 18°C as their preferred temperature. The period the these fruit were monitored included overnight in the coolroom at the growers' property. This should result in at least 40% of the trip where the temperature of the fruit was less than 18°C. Obviously, time at temperatures greater than 23°C should be minimised.

Each grower had a different arrangement for packing and cooling their fruit. Fruit from grower 4 took a long time to cool. This was rectified in the later trips. Grower 5 did quite well, while fruit from grower 6 was rarely below 18°C, which may have a significant impact on shelf life.

These exercises are beneficial in demonstrating to growers what is really going on in their handling chain.



**Figure 1.** Proportion of each trip that the temperature was recorded at less than 18°C, between 18 and 23°C, and above 23°C. The labels below each column represent grower and trip number, ie: 4.2 is grower 4 trip 2

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**PROJECT:**            **Nutrition and Irrigation Management of Rambutan for Maximisation of Yield and Quality (RIRDC project DNT 26A)**

**Project Officers:**    **C. Wicks and A. Hosking**

**Location:**            Various commercial Rambutan orchards in the rural area

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**Objective:**

***To improve the understanding of nutrient and irrigation management in rambutan, with particular emphasis on management through the fruit filling stage.***

This project will improve our understanding of nutrient and irrigation management in rambutan, with particular emphasis on management during the fruit-filling stage. This will lead to improved yield and fruit quality with more efficient use of fertiliser and irrigation inputs and hence increased profitability.

The project involves monitoring fertiliser and irrigation inputs on a number of commercial orchards in the Darwin Rural Area. The performance of orchards where regular “fertigation” is practised will be compared to those where fertiliser is applied conventionally. The irrigation-monitoring component is mainly being used as an extension tool to assist the growers in the development of irrigation scheduling and monitoring.

The project is being run in conjunction with the NT Rambutan Growers Group, a subgroup of the NT Horticultural Association. Each grower is contributing financially to the project as well as providing

complete details of their fertiliser and irrigation regimes plus tree yields. The growers meet at least four times per year with DPIF staff to discuss the results.

### **Methodology:**

Nutrition - 14 commercial properties plus CPHRF are having soil and leaf samples taken quarterly. These are analysed for a large number of different nutrients including leaf N, K, and Ca, and Soil pH, Ca and Mg. When used in conjunction with grower-supplied fertiliser inputs and tree response/growth, we can get a very good picture of rambutan nutritional requirements.

Irrigation - 9 (of the 14) commercial properties plus CPHRF are being monitored weekly for irrigation inputs, soil water status, temperature and RH, and tree status. This is being done using tensiometers and capacitance-based soil water detection devices to monitor soil water status; water meters to monitor irrigation inputs; electronic loggers to monitor temperature and RH; and visual assessment to monitor tree status.

### **Results:**

To date there have been nine rounds of soil and leaf sampling with the first occurring in June 1998 while the fourth round was completed in late May 2000. Data from these nine samplings show that soil and leaf nutrient levels do not always correspond. For example growers with high soil zinc (Zn) levels do not necessarily have sufficient levels of Zn in the leaf. Similarly soil and leaf levels of potassium (K) do not always match with some growers having low soil levels of K having more than sufficient leaf levels. An important trend which is already showing, is that growers who have high soil magnesium (Mg) levels may have low levels of leaf calcium (Ca) (see Figure 1) despite having sufficient levels of soil Ca. The current thinking is that growers with high soil Mg levels are irrigating with water from dolomite bores high in Mg. The high levels of Mg are replacing Ca in the soil and hence making it harder for the trees to take up Ca.

The project is already proving to be of value to rambutan growers. The initial nutritional data is creating much grower thought and management changes. This is seen in the upward trend in soil pH away from some dangerously low levels (see Figure 2).

Hopefully the irrigation monitoring equipment will do the same. The next phase of the irrigation monitoring will include grower assessment with the hope that at the end of the project a large majority of the growers will be monitoring their irrigation themselves. The next one and a half years of the project should see a lot more information gained on how management inputs influence the productivity of rambutans.

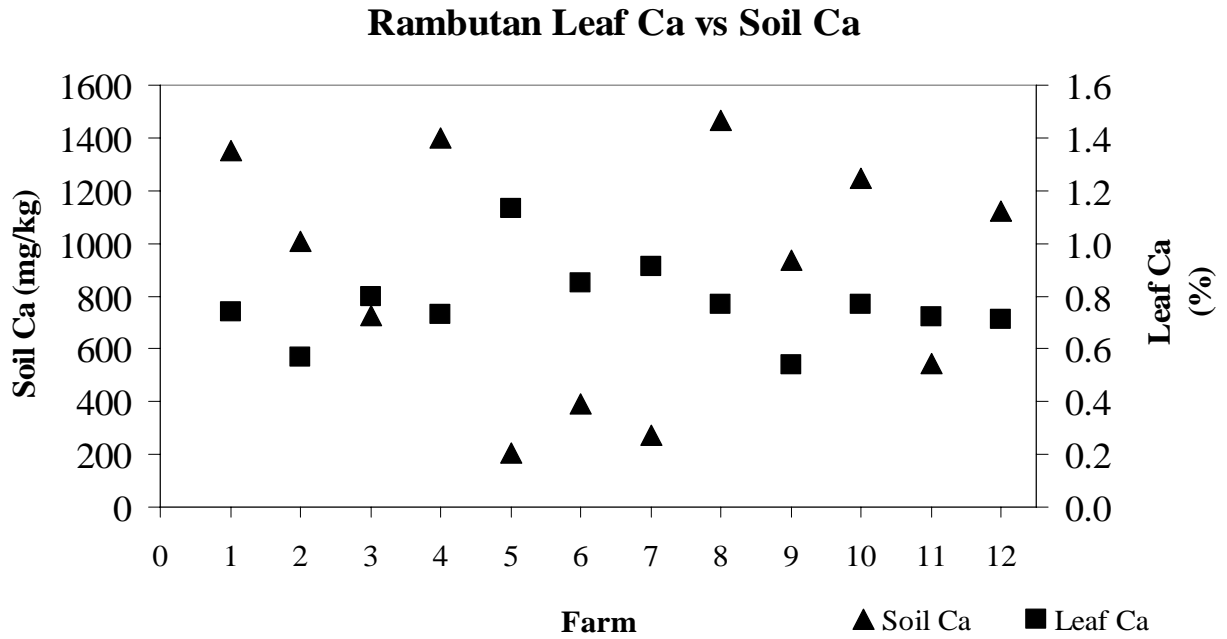


Figure 1.

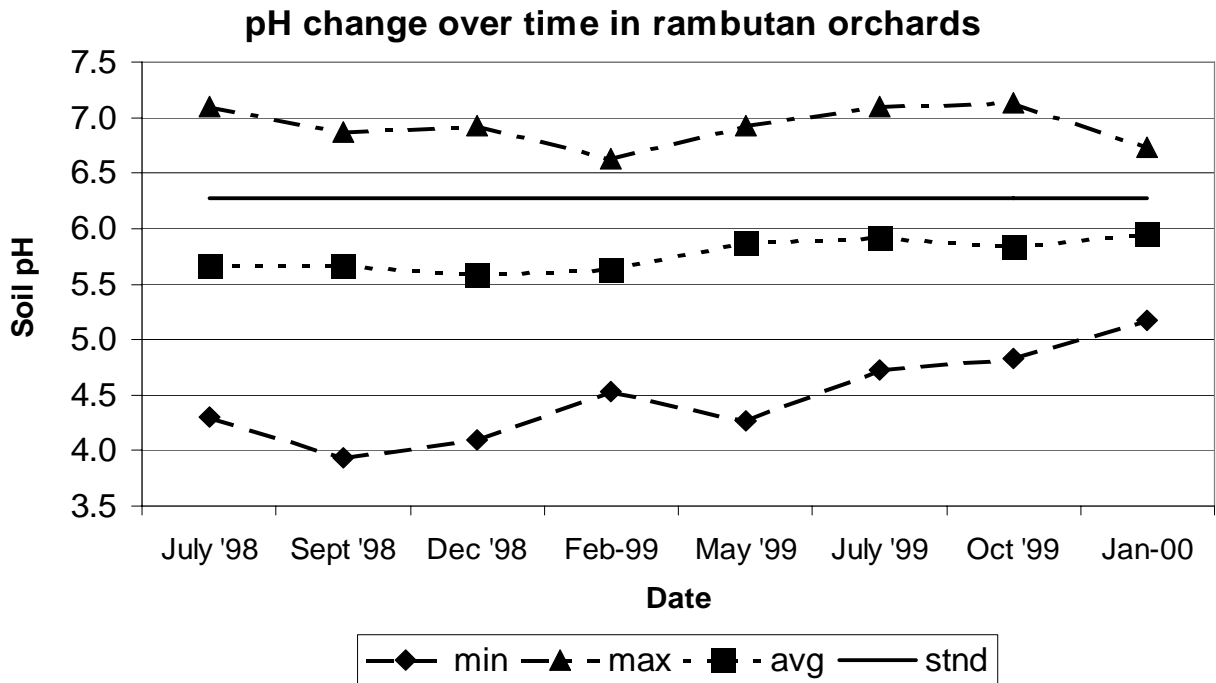


Figure 2.

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**PROJECT: Northern Australia Cocoa Development (RIRDC Project DAQ-256A)**

**Project Officers: C. Wicks, J. Orchard, and A. Hosking**

**Location: CPHRF**

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***Objective:***

***To generate an in-depth knowledge of cocoa production in Northern Australia. Using that knowledge to refine an economic model for cocoa production with the aim of making a decision regarding the economic viability of cocoa production in northern Australia.***

In late 1997, Cadbury Schweppes Australia approached DPIF, Agriculture WA and Queensland DPI with a proposal to commence a collaborative feasibility study into developing a cocoa industry in North Australia. Cadbury Schweppes are concerned that the increasing demand from Eastern Europe and China, combined with the continuing supply problems from traditional cocoa growing areas may lead to a shortfall in production. Currently low cocoa prices are forecast to increase significantly over the next five years.

At present Australia imports approximately 40,000 tonnes of cocoa (dry bean equivalent) for its chocolate, beverage and confectionery requirements. To replace half of this requirement, at an average yield of 4 tonnes/ha of dry beans, would require 5,000 ha of producing trees. At current world prices, the value of this production would be \$50m per annum.

After various study tours, and an economic analysis carried out by an independent consultant, a number of meetings were held. The attendees included representatives from DPIF, Cadbury Schweppes, Rural Industries Research and Development Corporation, Queensland Department of Primary Industries and the WA Department of Agriculture. These organisations agreed to form an alliance, the "North Australia Cocoa Development Alliance", which will coordinate all activities, including future commercial development subject to feasibility of the crop. It was agreed that the DPIF would be directly involved in cocoa yield evaluation and clonal introduction projects.

These trials are currently being implemented. In the NT, a Technical Officer (Mr. John Orchard) has been employed, a large experimental plot has been prepared for the hybrid evaluation trial and local clonal material has been collected and orders made to overseas sources of seed and clonal material. Some of these overseas materials have arrived, but there have been difficulties sourcing seed from Malaysia. Further attempts are being made to source this Malaysian seed.

The delay in purchasing the Malaysian seed as meant that the Hybrid trials are now using seed from PNG (CCRI). The crosses being planted are KA82 x KEE5, KA82 x KEE12, KA2-106 x KEE12 and KA2-106 x KEE23. A fifth cross, KA82 x KEE43 was also purchased but is not being used in the hybrid trial as it is susceptible to *Phytophthora* diseases and Vascular Streak Dieback.

The crosses requested from Malaysia (MCB) are UIT1 x NA33, UIT1 x NA34. UIT1 x SCA12, UIT2 x PA7, UIT2 x SCA6, UIT2 x SCA12, UIT1 x SCA6, PA173 x SCA9, PA156 x IMC67, PA156 x SCA9, PA 138 x SCA9 AND IMC67 x SCA9. The clonal material has been arriving from the Cocoa Germplasm Collection at Reading University, UK. The lines requested from the UK are NA33, PA300, Amazon1515, SCA6, IMC67, P4A, P4B, EET399, ICS1, ICS8, ICS95 AND ICS98. The number of grafted trees for some of the lines is good, however the numbers of trees in the lines IMC67, SCA19, EET339, ICS1, NA33 and PA300 are either very low or zero.

This project is scheduled to finish in 2003.

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**PROJECT: Control of Phytophthora Diseases in Durian****Project Officers: C. Wicks, A. Hosking and G. McMahon**Location: Berrimah Farm, CPHRF and Mrs. Siah's Durian Block at Lambells Lagoon

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**Objective:*****To develop (in conjunction with other workers in Australia and Overseas) an IDM system for controlling Phytophthora related diseases of Durian.***

The main objective can be broken down into the following objectives:

- screening for resistant durian genotypes,
- conducting orchard management studies,
- conducting on-farm trials investigating the various IDM systems,
- carrying out preliminary grafting and marcotting trials to identify viable rootstock/scion combinations (including multiple rootstocks),
- examining, in pots, the effects of different mulch and organic fertiliser types on disease incidence,
- examining the effect of introduced and indigenous antagonists on disease incidence.

**Mulch and green manure trial in field**

The aim of this trial is to identify, in the field, a best practice for reducing the incidence of *Phytophthora* disease in durian, by using mulches and/or (ground cover) living manure. There are three mulching treatments (none, hay, hay+chicken manure) and three living manure treatments (none, Wynn Cassia, Sabi grass) which results in nine treatments in total. Each treatment is replicated four times and the entire trial is blocked twice. Measurements being taken include temperatures, soil water status, tree phenology and size (including root assessments) plus qualitative assessments of soil biota status.

To date no *Phytophthora* has been detected. There have been some tree deaths but these can be put down to poor water management and competition by the Wynn Cassia. It has also been noted that without shading the young trees become sickly, this may predispose them to attack by *Phytophthora* in the future.

The Wynn Cassia is growing so well that it is out-competing the young trees, again possibly predisposing them to attack by *Phytophthora*. This competition is demonstrated best by the respective tree heights and can be seen in Table 1. The April heights are after the Wynn Cassia in direct competition with the trees was removed.

**Table 1.** Tree heights at Durian Phytophthora Field Trial in November 1999 and April 2000

Treatment	Tree Height (cm) [mean ± se]	
	November 1999	April 2000
No Cover	134 + 10	163 ± 16
Sabi Grass	122 + 12	124 ± 15
Wynn Cassia	114 + 9	132 ± 15

A further result of the treatments is the improvement is visible root health under hay mulch conditions. The hay mulch is encouraging (or possibly allowing) the durian roots to grow near the

surface. This can be seen in Table 2, which shows the number of visible roots in a 100 cm<sup>2</sup> quadrant near the tree stem.

**Table 2.** The number of durian roots detected under various mulch treatments in the field

Treatment	Number of visible roots [mean ± se]
Mulch as per Ground Cover	0 ± 0
Hay Mulch	5.3 ± 2.03
Compost + Hay Mulch	1.7 ± 0.88

This project has many years to go before any concrete conclusions can be made. However, it is already becoming clear that early competition from green mulching is detrimental plus mulching aids root growth.

### Mulch, fertiliser type, and fertiliser and irrigation rate trial in pots

The aim of this trial is to quantitatively identify (with trees in large pots) various management factors that may influence the incidence of *Phytophthora* disease in the field. Various types of organic manures of different age are being added to pots to test the hypothesis that fresh, young manure may burn the roots or introduce pathogens to the soil. Various levels of chemical fertiliser are being added to pots to test the theory that high levels of fertiliser either burn or weaken roots which then increases the incidence of *Phytophthora* disease. Various levels of irrigation with different application strategies are being used to test the theory that extreme cycles or levels of soil water status increase the incidence of *Phytophthora* disease.

There are no results to report. Efforts to inoculate the pots with *Phytophthora* have been unsuccessful. Alterations to the methodology have been identified and will be trialled. The other problem with the trial is the crowding which is encouraging leaf disease and causes a large degree of competition for light. This has been remedied by erecting a much larger shade house and putting the potted trees in there.

### Screening, marcotting and grafting trials

The aim of this trial is to identify possible resistant varieties of durian and to test their compatibility as rootstocks with popular commercial scions. This is being done by testing as many possible durian varieties (and other *Durio* species) with a number of *P. palmivora* isolates, from orchards in the Darwin rural area. The most resistant varieties or trees are then being vegetatively propagated to allow rootstock compatibility testing.

Some preliminary results of the screening process can be seen in Table 3. In Table 3 is the summarised data (with standard errors) for the response of the leaves, of various durian cultivars, to *P. palmivora*. The data shown is the length of a lesion (on a strip of durian leaf) at days 3 and 7 after inoculation.

**Table 3.** The mean length (± se) of *P. palmivora* caused lesions on the leaves of various durian varieties at days 3 and 7 after inoculation

Day	Variety					
	D123	Gob	Gumpun	D10	Chanee	Hew2
Three	6 ± 2	6 ± 0.8	4 ± 2	6.5 ± 2	4 ± 1	5 ± 1.2
Seven	10 ± 3	10 ± 1.3	10 ± 3	9 ± 2	7 ± 1.5	9 ± 2.3

While a number of possibly resistant varieties/trees have been identified, more testing has to be done. There has been little success at vegetatively propagating these varieties/trees with most success coming from work in north Queensland. The climate in north Queensland appears to be better suited to marcotting though the number of live marcotts in the greenhouse is less than 10% of all the marcotts attempted.

As part of this project, Chris Wicks traveled to north Queensland, Thailand and Vietnam. These trips were to carry out research in north Queensland; to inspect the major durian-growing region of Chanthaburi and to attend a workshop in Vietnam. All these trips were funded externally and were part of the original project plan.

This research has already identified a useful management practice for growing durian. The use of living manures is not practiced by the large majority of growers. The benefits are obvious to the growers even with the death of young plants.

The results of this project will provide growers with some clear direction as to management of orchard durian to control *Phytophthora* related disease. This is a high priority outcome identified by the Australian Durian Growers Group in the business plan.

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**PROJECT: TED002 Miscellaneous Exotic Fruits Research - Katherine Component**

**Project Officers: J. Mansfield and R. Renfree**

**Location: Katherine Research Station**

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***Objective:***

- ***Identify suitable tree species and cultivars of those species, suited to the Katherine region.***
- ***Screen those cultivars for their ability to produce economic yields during the specific market niches.***
- ***Assess methods such as cincturing, de-foliation and moisture stress, to manipulate harvest periods, to coincide with specific market niches.***

The main tree crops grown commercially in the Katherine region are mango, grapefruit and lemons. In this project, other tree species such as avocado, casimiroa, atemoya, lychee, pomegranate, guava, carambola, sapodilla, *Artocarpus* sp., caimito and other Annonaceae and Sapindaceae species are being trialed for their suitability as commercial crops for the Katherine region.

A number of subtropical species such as avocado and lychee have in the past failed to fruit in the Katherine region. This is due to the warm conditions and the lack of sustained periods of cool nights. While for some species in this trial only seedling trees have been planted, for other species such as avocado, annona and lychee a range of cultivars have been planted. For avocado, it is only cultivars from the West Indian avocado race, or hybrids derived from them, that are considered to possess the ability to fruit under conditions at Katherine. Although the market opportunities for this crop are considered limited, these trees will be monitored until they commence fruiting. It is hoped that it will be possible to at least identify a cultivar suitable for small scale commercial production. While the primary aim of this project is to record the growth patterns of the trees in the region in relation to the timing of harvestable fruit, it is also intended to investigate some techniques such as girdling and timing of pruning to induce cropping.

## **Materials and Methods:**

The following trees are planted in the Horticultural Research Block at the Katherine Research Station:

Guava: Two seedlings (planted April 1992 and April 1993)

Rollina: One seedling and one tree of "T10" grafted onto a seedling (planted April 1993)

Camito: Two seedlings and one tree of "Haitian" grafted onto a seedling (planted April 1992 & April 1993)

Carambola: Two trees of cultivar "B2" and one tree of the cultivar "Fwang Tung" grafted onto seedlings (planted April 1993)

Jackfruit: One seedling (planted 1993)

Casimoria: One seedling and one tree of the cultivar "Reinikie Commercial" and one tree of the cultivar "Golden Globe" both grafted onto seedlings (planted April 1993)

Pomegranate: A cutting of the cultivar "Veles" (planted 1994)

Feronia limonia: One seedling (planted 1993)

Sapodilla: Two trees of the cultivar "Krasuey" with one grafted on to a sapodilla seedling and the other onto a *Mimusops hexandra* seedling, one tree of "Tropical sapodilla" grafted onto a sapodilla seedling (planted 1994)

Imbe: One seedling (planted May 1995)

Mamoncillo: Two seedlings (planted 1994 and 1995)

Black sapote: One tree on the cultivar "Superb Black" grafted onto a seedling

Sapindaceae: Marcotts of the two lychee cultivars Tai-so (planted June 1994) and Kwai may-pink (planted February 1995). Four seedling trees of the Vietnam longan.

Avocado: Trees of the cultivars Semil 34, Hall, Choquette, Peterson, Pollock, Waldin, Tower 2, Victoria, Booth 8, Dr Dupius 2, Kimberly and T6 were grafted onto Zutano seedling rootstocks and planted in the field in October 1995.

Annonaceae: Pinks mammoth, Gefner, African pride and Bradley trees grafted onto Atemoya seedling rootstock were field planted at KRS in October 1995. Two seedlings of *Annona reticulata* and one of *A. muricata* were also planted at the same time.

## **Results and Discussion:**

The trees in the orchard were heavily pruned in December 1999 to improve orchard management. Subsequent follow-up prunings were conducted during 2000. Due to this pruning, limited work on monitoring of the growth patterns of the trees was conducted in early 2000 so as to allow the trees to re-establish normal growth patterns following the pruning.

Some of the avocado cultivars started flowering in early July 1999. Some fruit of the cultivars "Hall", "Peterson" and "Booth No 8" were harvested in late December 1999. Some more fruit of the cultivar "Peterson" was harvested in mid-February 2000. While this was only small quantity of fruit (between

1 to 4 kg per tree) it gave some indication of the timing of fruit production in the Katherine region and indication of fruit size. The average fruit size ranged from 158 g for fruit of the cultivar "Booth No 8" to 675 g for fruit of the cultivar "Peterson" (Table 1).

**Table 1.** Weight, number and average fruit weight of fruit from different avocado cultivars

<b>Date</b>	<b>Cultivar</b>	<b>Weight (kg)</b>	<b>Number</b>	<b>Av. Fruit wt (g)</b>
22/12/99	Hall	1.35	4	338
22/12/99	Peterson*	3.8	9	422
22/12/99	Booth No 8	2.5	16	156
10/02/00	Peterson*	4.05	6	675

\*These were two different trees of the cultivar "Peterson"

Bird damage to the fruit has been a consistent problem with the sapodilla and guava trees and it appears that netting the trees may be necessary if fruit is to be harvested. Similarly, while the Fwang Tung carambola tree produced fruit during most of the year, it could not be harvested due to insect damage.

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**PROJECT: Stone Fruit Evaluation in the Alice Springs Region**

**Project Officers: D. King, N. Isgro, D. McDonald, A. Nesbitt and G. Kenna**

**Location: AZRI and Ti Tree Research Farm**

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***Objective:***

***To enhance the profitability and productivity of stonefruit in the Alice Springs region.***

**Introduction:**

Although there are no commercial plantings of stonefruit at present in the Alice Springs region, there are indicators that potential markets for Central Australian stonefruit may exist in the Northern Territory.

There have been research plantings of stonefruit at AZRI in the past. Initially these plantings grew well and produced satisfactory crops, however they eventually became unthrifty and had a short life span. The rootstock used for these earlier plantings was Nemaguard. This rootstock was not able to adapt to the high pH levels of our soils, or the high soil temperatures we experience through the summer period.

**Method:**

New plantings were established at AZRI in 1996, 1997 and 1998 consisting of peaches, nectarines, apricots and plums. Presently there are six varieties of apricots, five varieties of plums, 10 varieties of peaches, and 17 varieties of nectarines planted. Four new varieties of apricots were planted in 1999. These will be trained to grow on trellis in a bid to improve production and quality.

A planting was also established at Ti Tree Research Farm in 1998. This planting includes eight varieties of peaches, five varieties of nectarines and two varieties of apricots. These have yet to come into production.

The aim of these plantings is to evaluate the potential for the commercial production of dessert stonefruit under Central Australian conditions using a range of rootstocks and to assess the suitability of varieties with varying chill requirements.

The main rootstock used on a number of low chill selections of peaches and nectarines is Bright's Hybrid, (a peach/almond hybrid). This rootstock has nematode resistance and a tolerance to high soil temperatures and pH levels. Plum and apricot varieties are grown on plum rootstock Microbalan 29C and Marianna.

**Results:**

In 1997 low chill peaches and nectarines, in their second year, produced their first crop. Flowering began at the end of August and harvest commenced in mid November. Fruit counts weights and diameters were recorded. In 1998 the same trees carried their second crop and were assessed as for 1997, including brix measurements. In 1999, carrying their third crop there was an overall increase of 18.16 kg of fruit. (See Figure 2).

**Table 1.** Stonefruit Harvest 1997, 1998, and 1999

Variety	1997 Average Yield/kg	1998 Average Yield/kg	1999 Average Yield/kg
Sundowner (6/3) [N]	2.51	15.32	14.59
Sunraycer (84/16) [N]	1.14	3.52	8.35
Unknown [N]	2.46	4.06	10.16
Flordagold [P]	1.66	11.8	12.3
Flordaglo [P]	4.24	14.66	23.24
Desert Red [P]	0.94	12.05	9.41
Moorpark Early [A]	0	0.02	N/A
Trevatt [A]	0	0.16	N/A
Moorpark [A]	0	0.05	N/A

### **Peaches:**

For the 1997 harvest, Flordaglo peach had the highest average yield per tree, followed by Flordagold and Desert Red. Overall yields increased markedly for the 1998 harvest with Flordaglo again having the highest yield per tree, followed by Flordagold and Desert Red.

In 1999 Flordaglo again had the highest followed by Flordagold with Desert Red recording slightly less than the previous year.

### **Nectarines:**

For the 1997 nectarine harvest, Sundowner (6/3) had the highest average yield per tree, followed by Sunraycer (84/16). In 1998 the harvest yields also increased markedly, with Sundowner (6/3) having the highest average yield per tree followed by Sunraycer (84/16).

In 1999 Sundowner (6/3) yields dropped slightly while Sunraycer (84/16) more than doubled its yield. This provided an overall increase of 5.5 kg of fruit.

### **Apricots:**

The apricot trees yielded their first crop in 1998. The yield was very light with the Trevatt variety being the only producer. In 1999 the trees again had minimal bearing. These trees need more time to establish but it is expected that their yield will increase in future years. The planting of new varieties, (to be trained onto trellis) will hopefully give a better indicator of the potential of this stonefruit.

Results from leaf nutrient analysis have indicated low to deficient levels of zinc throughout the planting. Copper and calcium levels were marginal. Copper oxy chloride sprays have been used to overcome the copper deficiency problem.

A major problem that has occurred in the past at AZRI is the amount of fruit damaged by birds as it is ripening. The use of a gas powered 'scatter' gun has reduced the impact of birds on the trial however early maturing crops still suffered heavy losses.

**Table 2.** Average Brix for each variety of stonefruit harvested

Variety	Brix
6/3 (N)	11.9
84/16 (N)	11.6
Unknown (N)	12.4
Flordagold (P)	11.9
Flordaglo (P)	12
Desert Red (P)	12.60
Moorpark Early (A)	N/A
Trevatt (A)	N/A
Moorpark (A)	N/A

### Chill factors:

Different varieties of stone fruit have different chill requirements. Varieties are classified as having low, medium or high chill requirement.

To achieve a quality product, each tree needs to be exposed to a certain number of hours below 7°C over the dormancy period. If this fails to happen, flowering and fruit set may not occur, buds may fall from trees and fruit quality may be affected (i.e. fruit shape.) Delayed and spasmodic foliation may occur and maturity sequences may be affected.

Alice Springs has a chill factor estimated at approximately 600 hours. Ti Tree is estimated at 300 hours. Low chill varieties need up to 450 hours; medium chill between 450 and 800 hours and high chill 800 hours upwards below 7°C. High temperatures can negate accumulated chill hours. Chill unit accumulation is affected by how many hours, and to what extent, the temperature climbs above 14C. For example, if over a 24 hour period, a tree acquired 10 hours under 7°C but then the temperature rose to over 14°C for six hours, the tree would have only accumulated four chill hours over that period. Generally the higher the chill requirement of a variety, the better quality of fruit produced. Therefore a peach, for example that requires 900 chill hours would be of better quality than a peach that only requires 300 hours.

Below are some examples of low, medium and high chill stonefruit at the AZRI planting.

### Peaches

*Flordaglo*: Low chill, approximately 175 hours. Early ripening, fruit size is large, attractive and has an excellent shape. Flesh is white and firm. Skin has an 80% highly attractive red blush over a bright yellow ground colour; produces very consistent quality. Flordagold and Desert Red are also low chill.

*Flavorcrest*: Medium chill, approximately 650-750 hours. Fruit has a good flavour and excellent colour. Flesh is yellow, firm and juicy. Skin has 90% bright attractive blush over a bright yellow ground colour. Flesh is yellow, firm and juicy.

*O'Henry*: High chill, approximately 1,100 hours. Fruit is large with a tough skin and good flavour. Flesh is yellow and very firm. 30-80% red blush over a yellow ground colour (better colour in warmer regions).

## Nectarines

Sundowner	Low chill.
Sunraycer: (84/16)	Low chill
Snow Queen:	Medium chill
May Grande:	High chill

## Plums

All varieties of plum are medium to high chill.

## Apricots

All varieties of apricot are medium to high chill.

Currently no low chill apricots exist, but in South Australia they are experimenting with different cultivars in the hope of producing a low chill variety

**Table 3.** Varieties planted at AZRI and TTRF and corresponding estimated chill requirements

Variety	Estimated Chill Units	Variety	Estimated Chill Units
<b>PEACHES</b>		<b>NECTARINES</b>	
Tropic Beauty	150	Sunwright	150
Desert Red	150	84/16 (Sunraycer)	250
Flordaglo	200	90/3 NW	250
Earligrand	200	6/3 (Sundowner)	300
Tropic Snow	250	Snow Queen	650
Aztec Gold	300	Fairlane	700
Flordagold	325	Late Le Grande	750
88/3	350	Red Gold	850
Flavour Crest	650-750	May Grand	900
O'Henry	1,100	Independence	800-850
TAT 204	High Chill	Firebrite	850-900
		Nectared	Unknown
		Goldmine	Unknown
<b>PLUMS</b>		Mayfire	Unknown
Mariposa	500	Flamekist	Unknown
Satsuma	600	Bynon 404	Unknown
Santa Rosa	600	Rose Diamond	Unknown
Angelina	High Chill	Mayfair	Unknown
Tegan Blue	Unknown		
<b>APRICOTS</b>		<b>APRICOTS</b>	
Hunter	Medium-high Chill	Castlebrite	Medium-high Chill
Moorpark	Medium-high Chill	Taminick Gold	Medium-high Chill
Trevatt	Medium-high Chill	Goldrich	Medium-high Chill
Moorpark Early	Medium-high Chill	Rival	Medium-high Chill

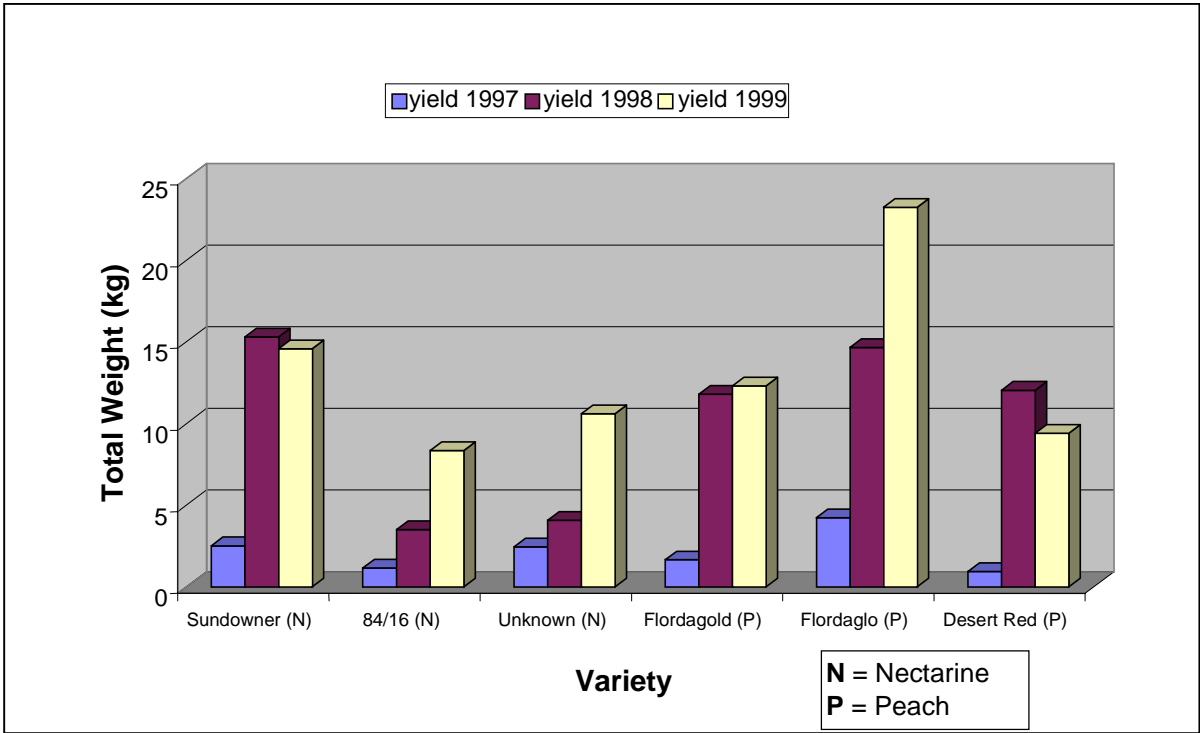


Figure 1. Average yield per tree

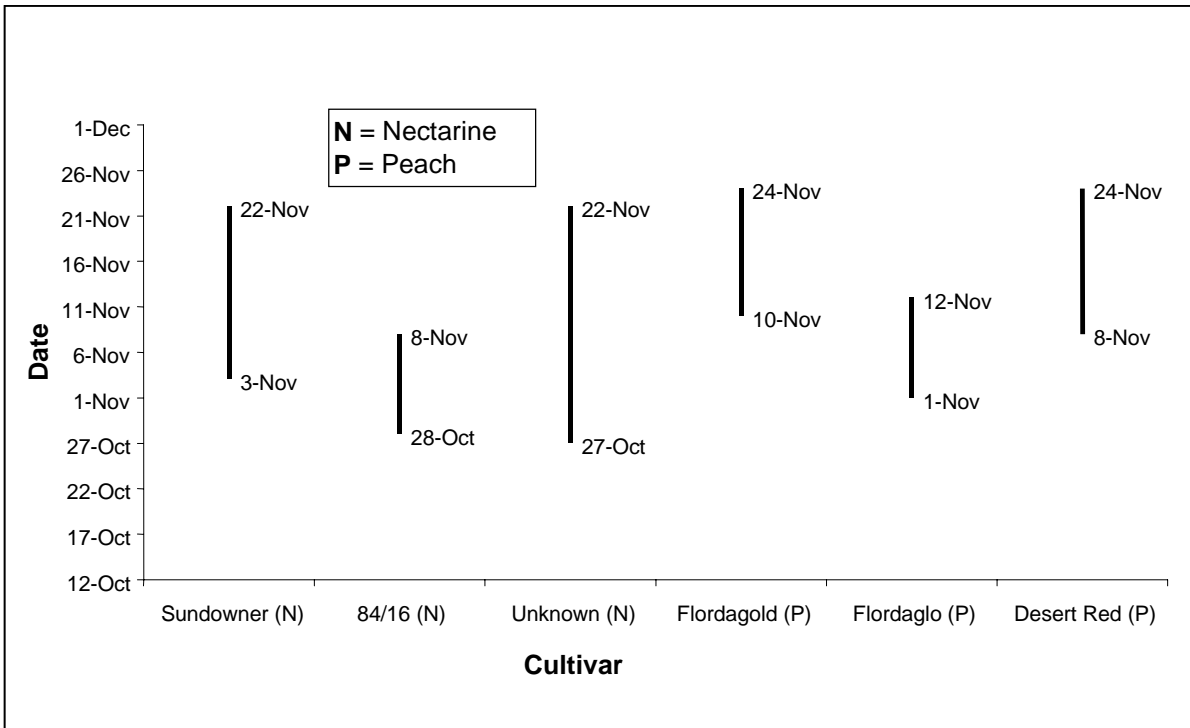


Figure 2. 1999 harvest range

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**PROJECT: Citrus Research in the Alice Springs Region  
Evaluation of Navel Oranges, Lemon and  
Mandarin Cultivars**

**Project Officer: N. Isgro**

**Location: AZRI, Alice Springs**

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***Objective:***

***To enhance the profitability and productivity of a number of citrus fruit crops***

***Objective of this trial is as follows:***

***Evaluate the adaptability of navel, lemon and mandarin cultivars to growing conditions in Central Australia.***

**Introduction:**

At present, the supply of navel oranges, lemons and mandarins to domestic markets is very limited between the months of March to June for navels, from December to April for lemons and January to March for mandarins. The Queensland citrus industry is the first to supply early navel oranges for domestic consumption and replace imported Californian navels. Demand for lemons and mandarins are also strong with supplies limited and market prices at a premium from December to April. Limited evaluation work on these fruits in the Alice Springs region has indicated that it may be possible to produce high quality, early maturing navel oranges. Additional work is also required to evaluate the potential for the production of high quality lemons and mandarins.

**Arid Zone Research Institute**

Some of this work is being done on the existing navels and mandarins along the driveway into AZRI. These include maturity times and quality. With the new plantings, assessments will be made on fruit quality and yields to determine which cultivars have commercial potential for production in Central Australia. Also assessment will be made on fruit maturity to determine harvest times with a view to supplying domestic markets when supplies are limited.

**Method:**

**Arid Zone Research Institute**

A trial plot of navels and lemons was planted in 1997. The planting is still too young to produce enough yield information for the different cultivars. Orange cultivars consist of Leng Navel on Swingle, Washington navel on Citrange, Barnfeild summer navel on Trifoliata. Lemon varieties consist of Fino, Verna, and Lisbon all grown on Citrange rootstock. The planting consists of 10 trees of each cultivar on the nominated rootstock per row.

The mandarin cultivars were planted early this year. The mandarin cultivars consist of five Ellendales on the rootstock Swingle, five Ellendales on Troyer Citrange, five Imperials on Sweet Orange and five Imperials on Cleopatra.

An old planting of navel and Valencia oranges also exists at AZRI. These trees are roughly 25 years old; the varieties include Thompson navel, Valencias and Thorny mandarin on unknown rootstocks. This planting provides us with useful yield data and maturity information.

### Ti-Tree Research Farm

A planting of navel, lemon and mandarin of selected cultivars on a variety of rootstocks was established in the spring of 1999 at TTRF. Future work will be carried out on evaluating the fruit for it's maturity and adaptability to our climate

### Results:

Data collected from the driveway includes sugar/acid ratios and juice percentages for both navel and mandarins.

Maturity of navels and mandarins is determined by calculating the brix sugar/acid ratios of the fruit. The National standards state the minimum brix sugar/ acid ratio for navel oranges is 10:1 and for mandarins 7:1. Juice percentage is another important measure of fruit maturity and quality. For navels it is 40% minimum and for mandarins 33%.

The data collected and analysed in mid April, indicates maturity was well above the Australian standard for brix sugar-acid ratios in navel oranges (Brix/Acid ratio of 10.0:1).

A summary of the 2000 maturity data collected for AZRI can be seen in Table 1.

**Table 1.** Sugar-Acid ratio and juice percentages for Thompson navels, Imperial and thorny mandarins harvested mid April 2000

Harvest Date	Cultivar	Rootstock	% Juice	Brix/Acid Ratio
18/04/00	Thompson navel	Unknown	50	14.7
<b>Standard Brix/Acid Ratio And Juice %</b>			<b>40</b>	<b>10.0</b>
18/04/00	Imperial mandarin	Unknown	54	5.7
18/04/00	Thorny mandarin	Unknown	38	8.0
<b>Standard Brix/Acid Ratio And Juice %</b>			<b>33</b>	<b>7.0</b>

Unlike other varieties of citrus, lemons are assessed by juice percentage and not by brix sugar/acid ratios. The Australian standard of juice percentage starts at a minimum of 33% and a minimum diameter of the fruit at 45 mm which most our varieties exceeded.

Lemon varieties growing as guard rows around the red fleshed grapefruit planting in their fifth year produced their second crop for maturity evaluation. Sampling commenced on 17 February, and the second sampling took place on 6 April. The varieties analysed were Eureka on Citrange, Lisbon on Citrange, and Lisbon on Troyer Citrange.

Data was also taken for juice percentages in 1999 and compared to data collected in 2000 shown in Table 2 as percentages.

**Table 2.** Juice percentage for lemon cultivars harvested 1999 and 2000

Cultivars/Rootstocks	1999		2000	
	Mid February	Mid June	Mid February	Mid April
Lisbon/Troyer Citrange	40%	54%	29%	39%
Lisbon/Citrange	36%	43%	31%	35%
Eureka/Citrange	34%	45%	23%	38%

Data was also taken for average yield per tree and fruit counts for 1999 and compared to data collected in 2000 shown in Table 3.

**Table 3.** Average yield per tree and fruit counts, AZRI

Cultivar/Rootstock	1999		2000	
	Fruit No	Yield	Fruit No	Yield
Lisbon/T.Citrange	167	18.34	273	37.67
Lisbon/Citrange	451	54.19	356	40.36
Eureka/Citrange	500	59.63	446	69.41

**Discussion:**

Data collected so far from the mature navel trees along the drive into AZRI show early maturity and good skin colour. This is a major advantage of a high quality product.

Lemons on the other hand especially the early maturing varieties such as Eureka do need de-greening to be marketable.

Early this season high rainfall recorded in February and March had an effect on the production of some cultivars by reducing fruit yields and maturity compared to the 1999 season shown in Tables 2 and 3.

The new planting of navels and lemon cultivars at the horticultural block at the AZRI was established in the spring of 1997, trees will come into production in 2001 for their first assessable crop.

**Expected outcome and benefits to Industry:**

Establishment of a new industry using the best-suited varieties, which have been evaluated and which have a high market demand and which will help create further expansion of the horticultural industry in Central Australia.

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**PROJECT: Citrus Research in the Alice Springs Region -  
The National Red Flesh Grapefruit Trial**

**Project Officer: N.Isgro**

**Location: AZRI, Alice Springs**

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***Objective:***

***To enhance the profitability and productivity of a number of citrus fruit crops***

***Objectives for the Red fleshed grapefruit trial are as follows:***

- ***Evaluate the adaptability of new grapefruit cultivars to growing conditions in Central Australia by measuring and recording tree growth performance and cropping characteristics.***
- ***Assess fruit quality and yields by recording fruit maturity and quality characteristics to determine which cultivars have commercial potential for the best production in Central Australia.***

**Introduction:**

Red fleshed grapefruit is popular with consumers in the United States, Israel and Western Europe. The demand is also growing in the Asia region. Horticulture Australia has indicated that there is potential in the near future for Australia to export up to 100,000 tonnes of red fleshed grapefruit to these countries and Japan.

A national project, which is funded by the Rural Industries Research and Development Corporation, has been established to introduce red fleshed selections and a white flesh low acid cultivar, Oroblanco, into established citrus production areas and those areas with potential for citrus development throughout Australia.

Commercial selections of red fleshed varieties were introduced into Australia in 1986. Participation in a National trial has enabled these selections to be made available for commercial assessment in Central Australia. The South Australian Research and Development Institute is coordinating this project.

**Method:**

**Arid Zone Research Institute**

Seven clones consisting of Marsh, Oroblanco, Ruby Pink, Henderson, Ray Ruby, Rio Red and Star Ruby on two rootstocks, Carrizo Citrange and Swingle, have been planted. They are arranged in single tree plots with four replicates of each in a random design.

Preparation for the planting commenced in the middle of April and planting took place in July 1995. There are 56 trees, with a surrounding guard row consisting of lemon and orange trees.

**Ti-Tree Research Farm and Murray Downs Station**

Demonstration plantings have been established at these locations. The plantings at Ti-Tree Research Farm and Murray Downs consist of one tree of each cultivar on each of the two rootstocks (Carrizo Citrange and Swingle).

## Results:

### AZRI, 1999 season

Data collected included fruit maturity, which includes recording of Brix and Brix/Acid ratios, fruit characteristics, juice percentages, counts, weights, diameters, seed counts and rind thickness.

A summary of the 1999 yield data for AZRI can be seen in Table 1. This table shows average yields for each of the seven varieties planted. According to the data, Marsh and Oroblanco had similar yields and performed satisfactorily when grown on the rootstock Carrizo Citrange. Marsh also performed satisfactorily on Swingle however Oroblanco had a poor yield in terms of fruit numbers per tree. The fruit was of poor quality and a low percentage of flesh.

Ruby Pink and Ray Ruby had similar yields when grown on the rootstock Swingle, but yields were higher when grown on the rootstock Carrizo Citrange.

Yields were highest on the combinations Rio Red on Swingle followed by Henderson on Carrizo Citrange.

This year we were able to collect a small amount of data from Star Ruby on the rootstock Swingle, however the combination of Star Ruby on Carrizo Citrange did not produce at all, possibly due to its inability to adapt to our climatic conditions.

At this time the data indicates a trend towards Carrizo Citrange being the better rootstock for most varieties except for Rio Red and Star Ruby which performed better on Swingle at AZRI.

**Table 1.** AZRI Fruit Counts and Weights per tree for 1999

Variety	Swingle			Carrizo Citrange		
	Fruit Count	Average Weight (g)	Total Weight (kg)	Fruit Count	Average Weight (g)	Total Weight (kg)
Marsh	41	420	17	35	434	15
Oroblanco	6	455	3	24	593	14
Ruby pink	44	368	16	47	405	19
Henderson	35	331	12	69	327	23
Ray ruby	53	288	15	38	367	14
Rio red	62	374	23	31	410	13
Star ruby	9	390	3	#	#	#

Data collected for average yield per tree for 1998 and compared to the data collected in 1999 shows some large increases in production (Table 2).

**Table 2.** Average yield per tree (kg), AZRI

Cultivars	Rootstocks			
	Swingle		Carrizo Citrange	
	1998	1999	1998	1999
Marsh	2	17	0	15
Oroblanco	1	3	1	14
Ruby pink	5	16	3	19
Henderson	3	12	3	23
Ray ruby	3	15	2	19
Rio red	4	23	1	13
Star ruby	2	3	0	0

Maturity of citrus is determined by calculating the sugar/acid ratio of the fruit. The National standards state the minimum sugar/acid ratio for Grapefruit is 4.5 to 5.0:1. A summary of the 1999 brix sugar/acid data for AZRI can be seen in Table 3. The data collected indicates that all varieties had reached maturity at the start of sampling in early April. The lowest ratio recorded was Ray Ruby on the rootstock Swingle at 4.8:1. The highest ratio was Oroblanco on the rootstock Carrizo Citrange at 16:1. The second sampling in late May and the data collected indicates that the majority of the cultivar combinations had increases in their sugar/acid ratios except for Marsh and Oroblanco.

**Table 3.** Brix Acid Ratios for 1999 season, AZRI

Cultivar	Rootstocks			
	Swingle		Carrizo Citrange	
	Early April	Late May	Early April	Late May
Marsh	6	5.5	5.2	4.9
Oroblanco	11.8	11.3	16	14
Ruby pink	5.3	6.3	4.8	5.4
Henderson	5.25	6	5.9	6
Ray ruby	4.8	6.1	6.1	6.4
Rio red	5.8	6.1	5.5	6.5
Star ruby	6.05	#	#	#

Juice percentage is an important aspect of maturity and marketability of the fruit. The National Standards set the minimum percentage of juice content is no less than 33%. Data collected in 1999 show that the majority of varieties are well above the standards except for Oroblanco on either rootstock (Table 4).

**Table 4.** Juice percentage for 1999 season, AZRI

Cultivar	Rootstocks			
	Swingle		Carrizo Citrange	
	Early April	Late May	Early April	Late May
Marsh	46.9%	48.3%	45.1%	49.5%
Oroblanco	30.0%	30.0%	33.3%	32.0%
Ruby red	45.5%	49.5%	40.3%	49.5%
Henderson	47.3%	49.4%	44.9%	56.3%
Ray ruby	47.6%	50.0%	47.6%	49.5%
Rio red	45.4%	52.9%	43.3%	50.0%
Star ruby	46.6%	#	#	#

**Ti- Tree Research Farm, 2000**

Data collected included fruit maturity, which includes recording of Brix and Brix/Acid ratios, fruit characteristics, juice percentages, counts, weights, diameters, seed counts and rind thickness.

A summary of the 2000 yield data for TTRF can be seen in Table 5. This table shows average yields for each cultivar on each of the two rootstocks (Carrizo Citrange and Swingle). According to the data collected Rio Red and Star Ruby performed just as good when grown on both rootstocks, Carrizo Citrange and Swingle. Henderson and Ray Ruby performed better on the rootstock Carrizo Citrange than on Swingle. Oroblanco had a slightly higher yield on Carrizo Citrange than Swingle with Ruby Pink recording low yields on both rootstocks.

The trend in the data does not show any influence from either rootstock on yields for the varieties of Redflesh grapefruit Rio Red and Star Ruby at TTRF at this time.

**Table 5.** Fruit Counts and Weights per tree for 2000 season, TTRF

Variety	Swingle				Carrizo Citrange			
	Tree No	Fruit Count	Average Weight (g)	Total Weight (kg)	Tree No	Fruit Count	Average Weight (g)	Total Weight (kg)
Marsh	1	70	433	30	2	72	397	28
Oroblanco	3	24	637	15	4	29	700	20
Ruby pink	5	19	410	8	6	3	680	2
Henderson	7	30	134	4	8	95	340	32
Ray ruby	9	4	384	1	10	39	367	14
Rio red	11	79	420	33	12	86	377	32
Star ruby	13	20	437	9	14	46	197	9

**Maturity data, TTRF**

A summary of the 2000 yield sugar/acid ratios data for TTRF can be seen in Table 6. The data indicates that all varieties had reached maturity in mid March. The lowest ratio recorded was Marsh on the rootstock Swingle at 5.8:1 while the highest ratio was Oroblanco on both rootstocks Carrizo Citrange and Swingle at 13:1. The second sampling took place mid May and the data collected indicates that the majority of the cultivar combinations had an increase in sugar/acid ratios except for Henderson, Ray Ruby on Carrizo Citrange, Rio Red and Star Ruby on both rootstocks.

**Table 6.** Brix acid ratio's for 2000 season, TTRF

Cultivar	Rootstocks			
	Swingle		Carrizo Citrange	
	Mid March	Mid April	Mid March	Mid April
Marsh	5.8	6.6	5.3	6.1
Oroblanco	12.7	16.3	13	15.5
Ruby pink	7.1	7.3	8.8	#
Henderson	7.8	#	8.7	6.7
Ray ruby	7.5	7.9	7.7	7.4
Rio red	8.5	7.8	8.6	8.5
Star ruby	7.5	6.9	8.8	8.6

Data collected in 2000 shows that the majority of varieties are well above the standards except for Oroblanco on either rootstock (Table 7).

**Table 7.** Juice percentages for 2000 season, TTRF

Cultivar	Rootstocks			
	Swingle		Carrizo Citrange	
	Mid March	Mid April	Mid March	Mid April
Marsh	43.4%	43%	44%	40.3%
Oroblanco	31%	32%	28.5%	32%
Ruby pink	44%	49.4%	42.4%	#
Henderson	37.5%	#	47%	53%
Ray ruby	48%	51.5%	44%	53.5%
Rio red	45%	51.4%	44%	43.1%
Star ruby	40%	45%	39%	36.1%

The Australian standard for juice percentage is 33%.

#### **Discussion:**

Total yields have significantly increased from the previous year. Yields and tree performance are variable due to instability of some varieties to adapt to climate conditions (Table 2).

One harvest has been completed at AZRI for the season of 2000. Fruit needs to remain on the tree longer to mature before the second harvest can proceed. From observation work Star Ruby on the rootstock Carrizo Citrange have bared this year at AZRI which maturity analysis work can be carried out.

One management problem that we have overcome is the ability to correct minor trace element deficiencies such as zinc and manganese by applying these nutrients as foliar sprays.

The abnormally high rainfall experienced early February and April this year may have affected the production of some cultivar combinations such as reducing fruit yields and timing of maturity.

The climatic conditions so far this year have also caused increased numbers of fruit piercing moth in the Ti-Tree farm area. We have also had isolated cases in the Alice Springs region.

Alice Springs has also experienced a large increase in fruit fly infestation this summer.

By improving our lateral irrigation lines from one line to two, one each side of the trees has improved the growth rates of the trees and will also improve watering patterns to increase root distribution and production.

Data collected from the red fleshed grapefruit trees at Ti-Tree suggests with improved management fruit maturity will be around the same time when the Katherine harvest season is completed, around early to mid March. The trend continues with Alice Springs fruit maturity following on from Ti-Tree.

**Summary:**

The outcomes so far for this project indicate that red fleshed grapefruit production has potential in the southern region of the Northern Territory. Indications are that Katherine will first have mature fruit followed by the Ti-Tree area and Alice Springs.

There are strong indications that some of these selections have the potential to meet a market demand and lead to further expansion of the horticultural industry in Central Australia.

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**PROJECT: CTK001 Evaluation of Citrus Cultivars in the Top End - Grapefruit**

**Project Officers: J. Mansfield, A. Maddern, R. Renfree, C. Kinnaird, and H. Renfree**

**Location: Katherine Research Station**

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**Objective:**

***To evaluate the performance of various grapefruit cultivars in the Katherine region with particular emphasis on summer lemon production.***

While the grapefruit industry was traditionally based on grapefruit with white internal colour, in recent times grapefruit with red internal colour have been released for commercial production. These red-fleshed grapefruit are expected to be popular in Australia because they are visually more appealing and some cultivars are more palatable than the traditional white-fleshed cultivars.

**Materials and Methods:**

There are two plantings of grapefruit at the Katherine Research Station

*Planting 1 (Described in the previous Horticulture Division Technical Annual Report as Citrus Rootstock/Cultivar Evaluation (Katherine)- Grapefruit)*

Five super red cultivars: Star Ruby, Rio Red, Flame, Ray Ruby and Henderson were planted on a range of rootstocks at KRS during 1992-1995. These rootstocks were C35 citrange, Swingle and Trifoliata. However, not all scions were grafted onto each rootstock. There is one tree of each of the following combinations: Flame on Swingle (planted 14/7/92 and budded October 1995), Ray Ruby on C35 (planted 14/7/92 and budded 15/12/92), Rio Red on C35 (planted 14/7/92 and budded 11/8/94), Rio Red on Swingle (planted 14/7/92 and budded 11/8/94), Star Ruby on C35 (planted 14/7/92 and budded 11/8/94), and Star Ruby on Swingle (planted 14/7/92 and budded 15/12/92). There are two trees of Henderson on Trifoliata (planting date unknown) and Ray Ruby on Trifoliata (planted 14/7/92 and budded 15/12/92) and three trees of Henderson on Swingle (planted 14/7/92 and budded 15/12/92) and Ray Ruby on Swingle (planted 14/7/92 and budded 15/12/92). There are

no trees of Flame on either C35 or Trifoliata, Henderson on C35, Rio Red on Trifoliata or Star Ruby on Trifoliata

*Planting 2 (Described in previous Horticulture Division Technical Annual Reports as National Red-flesh Grapefruit Cultivar Trial)*

Eight cultivars of grapefruit were budded on to two different rootstocks and planted in randomized, single tree plots in 1995. Originally, there were four replicates of each cultivar/rootstock combination. The eight cultivars are: Marsh, Oroblanco, BCP3-Ruby type grapefruit, Henderson, Ray Ruby, Rio Red, Star Ruby and Flame (established eight months later). The rootstocks used were Swingle Citrumelo and Carrizo Citrange. However, because there were a number of existing red grapefruit trials and plantings in the Katherine region, and due to limited staff resources, it was decided to reduce the size of the trial by removing some trees in January 1999. This then left two replicates of each combination except for Flame on Swingle where there was one replicate and Oroblanco on Swingle where there were three replicates.

From July to September 1999, the trees in the citrus evaluation trial at the Katherine Research Station were heavily pruned. The trees appeared to have had minimal pruning since planting and had very poor internal branch structure. While the trees have been yielding well, the fruit quality has been poor and harvesting of the fruit was difficult. Following the heavy pruning, the trees were given subsequent lighter prunes to shape the trees.

For the grapefruit the pruning involved removing internal structural branches to leave five to six branches. All small branches inside the tree were removed and the outer canopy was thinned. Over the next few years, the trees will be monitored to see how this pruning affects tree performance. Several grapefruit trees were left unpruned for comparison.

In the 2000 season, there were only small amounts of fruit produced on the pruned trees. Fruit was picked from the grapefruit in Planting 1 for assessment of fruit quality on 20 April. All the trees were stripped of their fruit on 9 May. The number of fruit and total fruit weight was recorded to calculate average fruit weight.

**Results and Discussion:**

The juice percentage for the Ray Ruby and Henderson fruit assessed was all in the mid to high 40's and the brix:acid ratio was above 7 (Table 1). The current market standard for grapefruit is a brix:acid ratio of 4.5:1 and a juice percentage above 33% (NSW Grading, Packaging and Labeling Requirements) and therefore in mid April these grapefruits were well above these standards.

The fruit measured around 100 mm in length and width, with a rind thickness around 7.5 mm and an average fruit weight between 420 g and 510 g (Table 2). On the unpruned trees total yields of 155 kg (390 fruit) for Henderson on Swingle and 125 kg (310 fruit) for Ray Ruby on Swingle were obtained. However, it must be stressed that these were single trees and this is total yield, not marketable yield.

**Table 1.** Percentage juice, average number of seeds per fruit and brix:acid ratio for different grapefruit cultivar/rootstock combinations when sampled on 20 April 2000. The results are an average of one to three trees

Scion	Rootstock	Number of trees	% Juice	Seeds/fruit	brix:acid ratio
Ray Ruby	Swingle	1	47.6	3.2	7.5
Henderson	Swingle	3	46.7	3.6	7.7
Henderson	Trifoliata	1	45	5.5	7.1

**Table 2.** Fruit length and width, rind thickness and average fruit weight for different grapefruit cultivar/rootstock combinations when sampled on 20 April 2000. The results are an average of one to three trees

Scion	Rootstock	Number of trees	Length (with rind) (mm)	Width with rind (mm)	Rind thickness (mm)	Av. Fruit Wt (g)
Ray Ruby	Swingle	1	97.4	96.3	7.45	420
Henderson	Swingle	3	96.3	100.2	7.3	438
Henderson	Trifoliata	1	100.5	105.3	7.5	510

**Table 3.** Average fruit weight (g) for grapefruit scion/rootstock combinations in the two different grapefruit plantings at Katherine Research Station when measured on 9 May 2000. The results are an average of one to three trees

Scion	Rootstock	Number of trees	Average Fruit Wt (g)
<i>Planting 1</i>			
Henderson	Swingle	3	400
Henderson	Trifoliata	2	441
Ray Ruby	C35	1	459
Ray Ruby	Swingle	3	408
Ray Ruby	Trifoliata	1	400
Star Ruby	Swingle	1	550
<i>Planting 2</i>			
Oroblanco	Swingle	2	550
Oroblanco	Carrizo	1	803
Rio Red	Carrizo	1	600
Ruby	Swingle	1	417

The average fruit weight when the trees were stripped on 9 May 2000 varied between cultivars but ranged from 400 g to 800 g. The smallest average fruit weight was for Henderson on Swingle trees while the largest average was from Oroblanco on Carrizo trees. While there are differences between the same scions on different rootstocks in relation to average fruit weight, this different should not be interpreted as being a rootstock difference due to the small sample numbers (Table 3).

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**PROJECT: CTK001 Evaluation of Citrus Cultivars in the Top End - Lemon**

**Project Officers: J. Mansfield, A. Maddern, R. Renfree, C. Kinnaird, and H. Renfree**

**Location: Katherine Research Station**

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***Objective:***

***To evaluate the production performance of various lemon cultivars in the Katherine region with particular emphasis on summer lemon production.***

There is a strong interest in growing citrus in the Top End. This is because the high temperature during the time when fruit is maturing makes the region ideal for quality, early grapefruit production. By controlling the growth patterns of the trees, lemons can be produced in January to March when prices on the domestic market are at their highest. There is also potential for export of lemons into South-East Asian markets such as Japan for the restaurant industry.

**Materials and Methods:**

At Katherine Research Station four cultivars Meyer, "Taylor" Eureka, "Prior" Lisbon and Villa Franca, were budded on 15/12/92 to Benton rootstock planted on 14/7/92. Fino and Verna were budded on 15/4/93 to Benton rootstock planted on 14/7/92. For each cultivar, except Meyer, there are two trees of each. For Meyer there is only one tree.

From July to September 1999, the trees in the citrus evaluation trial at the Katherine Research Station were heavily pruned. The trees appeared to have had minimal pruning since planting and had very poor internal branch structure. While the trees have been yielding well, the fruit quality has been poor and harvesting of the fruit was difficult. Following the heavy pruning, the trees were given subsequent lighter prunes to shape the them. The lemons were large trees (5 m high and 5 m wide) and appeared to be unproductive for their size. The trees were skeletonised at a height of 1.5 m to 2 m above the ground to leave a structural framework with very little canopy.

**Results and Discussion:**

While the lemon trees have responded to the pruning and have produced new growth they failed to flower and fruit in the 2000 season.

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**PROJECT: CTK001 Evaluation of Citrus Cultivars in the Top End - Pummelo**

**Project Officers: J. Mansfield, A. Maddern, R. Renfree, C. Kinnaird and H. Renfree**

**Location: Katherine Research Station**

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**Objective:**

***To evaluate the performance of various pummelo selections and seedlings in the Katherine region with particular emphasis on summer lemon production.***

The pummelo is considered the best suited of the citrus species to tropical conditions. However, the greatest impediment to the development of large-scale pummelo production in Australia is the lack of thin-skinned, high quality cultivars. The introduction of known overseas cultivars has been severely restricted by quarantine restrictions. Citrus canker, citrus dieback and greening, navel orange worm, citrus mal secco, orange stem pitting (OSP) strain of tristeza and citrus fruit borer are all potential quarantine risks that could be introduced via overseas propagating material. Therefore, it is very difficult and expensive to import cultivars. However, seeds from some overseas cultivars have been introduced. The selections currently grown in Australia have been selected from these seeds, as well as from local promising seedlings. Pummelo, unlike most other citrus, produce seedlings that are genetically different from the parent. This is unfortunate in that seeds cannot be used as a reliable means of importing known cultivars from overseas. However, it is advantageous as a way of selecting superior cultivars within Australia since a wide range of plants with different characteristics is available – though most are inferior.

**Materials and Methods:**

*Planting 1 {Described in the previous Horticulture Division Technical Annual Report as Citrus Rootstock/Cultivar Evaluation (Katherine)- Pomelo (sic)}.*

Seedlings of six pummelo lines introduced from overseas by CSIRO Merbein, Victoria were planted at Ti Tree Farm on 11 June 1987. The seedlings of CS43 Blood red pummelo showed the most potential with five seedlings (CS43-4, CS43-5, CS43-6, CS43-8 and CS43-9) producing fruit with some potential. The "CS43" number given to this selection is the CSIRO Division of Horticultural Research identification number. It was originally an introduction from the Horticultural Research Laboratory, USDA, Orlando. The number after the "CS43" is the seedling number.

Budwood from these five seedlings were used to propagate up more trees for further evaluation at Katherine Research Station. Each selection was grafted onto Trifoliata and Swingle rootstocks and one replicate of each combination was planted in June 1994. Most of the trees with Trifoliata as the rootstock have died due to termite damage and other causes.

*Planting 2 (Described in previous Horticulture Division Technical Annual Reports as Breeding/Selection of Citrus Cultivars).*

Seed of a red-fleshed pummelo type from Israel were sown at KRS in September 1996, and transferred to the field in July 1997. A total of 46 trees from this material have been established (on their own roots). Seed from a low acid pummelo type (Leeman pomello) from Darwin were also sown at KRS and from these 24 trees were field planted in May 1997 (again on their own roots).

From July to September 1999, the trees in the citrus evaluation trial at the Katherine Research Station were heavily pruned. The trees appeared to have had minimal pruning since planting and

had very poor internal branch structure. While the trees have been yielding well, the fruit quality has been poor and harvesting of the fruit was difficult. For pummelo in planting one, the pruning involved removing internal structural branches to leave five to six branches. All small branches inside the tree were removed and the outer canopy was thinned. In the 2000 season, there were only small amounts of fruit produced on the pummelo trees in planting one. All the trees were stripped of all their fruit on the 9 May. The number of fruit and total fruit weight was measured to calculate average fruit weight.

**Results and Discussion:**

The average fruit weight of the pummelo selections varied from 400 g for selection "43-5" on Swingle rootstock to 800 g for "43-4" on Trifoliata rootstock (Table 1).

**Table 1.** The average fruit weight for pummelo scion/rootstock combinations when measured on 9 May 2000. The results are based on one tree of each selection

<b>Selection</b>	<b>Rootstock</b>	<b>Average Fruit Wt (g)</b>
43-4	Trifoliata	800
43-4	Swingle	631
43-5	Swingle	400
43-6	Swingle	740
43-8	Swingle	788
43-9	Swingle	621

The trees in planting two are yet to start producing fruit.

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**PROJECT: CTK004 Write Up Previous Citrus Research Conducted at Ti Tree Research Farm**

**Project Officers: J. Mansfield**

**Location: Katherine Research Station**

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***Objective:***

***To document the previous citrus conducted at Ti Tree Research Farm.***

This item was not completed in 1999/2000 due to the difficulty in locating and interpreting all the data. A review is to be conducted in 2000/2001 of all the citrus cultivar and rootstock evaluation research undertaken in the Territory. This review will identify which components of the citrus research conducted at Ti Tree Research Farm from 1987 to 1994 should be written up and which components have been superseded with new research.

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**PROJECT: CTK005 Evaluation of Rootstocks for Lemons and Grapefruit in the Top End**

**Project Officers: J. Mansfield and A. Maddern**

**Location: Co-operators' properties in the Katherine Region**

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**Objective:**

***One of the main aims of this trial is to determine which rootstocks are best suited to the alkaline pH which occurs in the Katherine area due to the use of irrigation water high in calcium carbonates.***

Most citrus trees are grown as budded trees. That is, the trees are composed of at least two distinct individuals, the rootstock and the scion, growing together as one, dependent upon each other and affecting the performance of the other. The rootstock can influence the performance of the tree in a number of ways:

- tree shape and size;
- yield;
- maturity times;
- size and colour of the fruit;
- adaptability of the tree to certain soils and climates;
- resistance of the tree against diseases.

**Materials and Methods:**

Four cultivars of lemons were budded to seven different rootstocks, resulting in 21 cultivar/stock combinations. Cultivar/stock combinations were originally replicated four or six times depending on the site. Field layouts have been designed with cultivar/stock combinations randomly assigned to single tree plots. The four scion cultivars are Eureka, Lisbon, Fino and Verna. The seven rootstocks are Benton Citrange, Cox Mandarin, Lockyer Rough Lemon, Rangpur, Nelspruit hybrid 639, Volkameriana (Volker) and Lemon, Swingle Citrumelo. The trial was to be planted on three different soil types namely Tippera, Blain and River levee. The Tippera site was established in mid-1996 and the Blain site was planted in November 1997. However, the River levee site was planted in October 1997 but was severely damaged by the Australia Day 1998 flood and was not replanted.

Three cultivars of grapefruit were budded to seven different rootstocks, resulting in 19 cultivar/stock combinations. Cultivar/stock combinations were originally replicated four or six times depending on the site. Field layouts have been designed with cultivar/stock combinations randomly assigned to single tree plots. The three scion cultivars are Rio Red, Flame and Star Ruby. The seven rootstocks are Benton Citrange, Cox Mandarin, Cleopatra Mandarin, Carrizo Citrange, Trifoliolate Orange (*Poncirus trifoliata*), Nelspruit hybrid 639, and Swingle Citrumelo. The trial was planted on two different soil types namely Tippera and Blain. The Tippera site was established in mid-1996 and the Blain site was planted in November 1997.

In January 1999, both the planting of grapefruit and lemon at the Tippera site was reduced from six replicates to three due to the co-operator wishing to pursue other crops. In January 2000, most of the grapefruit trees at the Blain site were removed as they were failing to grow due to pumpkins being grown as an intercrop.

## Results and Discussion:

The lemon and grapefruit trees at both the Tippera and Blain sites have failed to grow sufficiently in the four years and three years, respectively since planting and very little flowering or fruiting has occurred. At one site, this was partly because it was not ideally suited to growing citrus due to shallow soil depths. In addition, subsequent to the planting of the trials both co-operators decided that they no longer wished to proceed with commercial plantings of citrus in addition to the trial plantings. This has resulted in them both pursuing other horticultural crops. If these trials fail to start flowering and fruiting in the near future then consideration will be given to removing them.

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**PROJECT: CTK007 Developing Management Strategies to Manipulate Cropping Patterns in Citrus in Northern Australia**

**Project Officers: J. Mansfield and C. Kinnaird**

**Location: Co-operator's property in the Katherine Region**

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### **Objectives:**

- **Assess water usage of lemons in the Katherine region.**
- **Determine if cropping can be manipulated through the regulation of water usage.**
- **Ascertain the most appropriate method of irrigation to optimize production of citrus in Northern Australia.**

The water requirement in other citrus growing regions of Australia is well established. However, the climate of the Katherine region is different to these other areas. Therefore, the irrigation requirements are also different to the established citrus irrigation schedules in these other regions. By taking neutron probe reading on some of the different citrus species a pattern of water usage in relation to phenology and climate will be developed. This information will then be used to develop an irrigation scheduling method for citrus trees in Northern Australia.

A period of stress may be beneficial in synchronising flowering in citrus in northern Australia. The absence of a cool period in the top end causes flowering to be erratic. Stressing citrus through droughting for a period will induce flowering, and the time of stress can manipulate the time of production to fill market niches.

In April 2000, eight Sentek enviroscan probes were installed at a co-operator's property in the Venn area growing lemons. The lemons are Lisbon on Troyer rootstocks and are three years old. These probes have sensors at depths of 20, 40, 60 and 100 cm. In June 2000 tensiometers and water meters were installed at the same property. Readings are being taken weekly from tensiometers and water meters.

While this project is still in the formative stage there will be some assessment on the lemons this year. All lemons are being watered at ten-day intervals at present. Data collected in 2000 will include fruit drop, yield and fruit size. Next year the trial will be extended to include neutron moisture probe, porometer and pressure bomb measurements to assist in the assessment of water usage.

In 2001, the lemon block will be stressed for different periods. This will determine the most appropriate period of stress for optimizing production.

Different water availability, quality and system design all determine what type of sprinkler or drippers are to be used in the orchard. To determine the most efficient and effective irrigation system a number of methods used throughout Northern Australia have been installed at the Katherine Research Station.

At the Katherine Research Station, six rows of eight-year-old grapefruit have been given different types of irrigation. These treatments are:

- Adjustable shrub sprays (two per tree)
- In-line dripper tape
- Orbiters between trees
- Orbiters under trees
- Adjustable drippers (four per tree in two rows)
- Streammaster spinners

These different treatments have been regulated to apply 90 L/hr/tree. In April 2000, tensiometers were installed, and readings are being taken regularly. Water meters were installed in June 2000 and readings have commenced.

In 2001, neutron probe access tubes will be installed to monitor soil moisture content. A grid pattern of soil samples will be taken to assess width and depth of water movement in relation to rooting patterns. These measurements will be compared to assess the most appropriate method of applying irrigation water.

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**PROJECT: CTK008 Provide Assistance to the Citrus Industry and Assist with its Future Expansion - Top End**

**Project Officers: J. Mansfield, J. Bright, C. Kinnaird, A. Maddern, C. Wicks, M. Gosbee, M. Hoskins and G. Owens**

**Location: Katherine and Darwin**

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***Objective:***

***To assist the development and expansion of the citrus industry in the Top End.***

In February 2000, survey forms were sent out to citrus growers in the Katherine/Mataranka to record tree planted. This survey indicated that at May 2000 there were 32,000 citrus trees in the region, of which 13,000 are grapefruit and 16,500 are lemon. Almost all of the planted trees in the region are not bearing currently.

Workshops on soil assessment, nutrition and irrigation were organised for citrus growers in 1999/2000. In July/August 1998, the Northern Territory Citrus Growers Association and DPIF organised workshops in Katherine and Darwin on soil assessment for growing citrus. The workshops was to be conducted in August by consultant, Geoff Kew of Kew/Wetherby. Chris Wicks from DPIF presented workshops on citrus irrigation to growers in Darwin and Katherine in October 1999. In February/March 2000, the Northern Territory Horticultural Association and the Northern Territory University organised nutrition workshops in Darwin and Katherine.

On 5 May, citrus growers from Darwin, Kununurra and Katherine visited the Katherine Research Station as part of a field day organised by the Department in conjunction with Northern Territory

Cittgroups. They were given presentations on pest and ant monitoring and control, citrus pruning, citrus degreening, the citrus quality manual and the citrus CD Rom. In the afternoon, visits were conducted to two citrus properties in the Venn area, near Katherine. On Sunday 6 May, a meeting was facilitated by departmental staff with citrus growers from the Darwin and Katherine Region to discuss setting up citrus grower discussion groups. The present growers expressed an interest in setting up these groups. A number of issues were identified that growers wished to discuss in these groups.

Because of interest in setting up citrus discussion groups, a questionnaire was prepared for citrus growers in the Darwin/Katherine area. The questionnaire was designed to determine what issues growers wanted to discuss in citrus grower discussion groups if they were established. It also asked growers to prioritise industry issues that were raised at this meeting. In addition, it asked growers if they were interested in participating in the collection of data on the growth patterns of trees and management practices on their properties. Darwin growers were also asked to complete a survey on the number of trees of each scion/rootstock combination that they had on their property. Further work with these discussion groups will continue in 2000/2001.

During 1999/2000 in the Katherine region, most queries on management issues were in relation to pruning. These were mainly about implementing the pruning principles taught at the pruning workshops delivered in May/June 1999 by Greg Moulds (NSW Department of Agriculture District Citrus and Grape Horticulturist - Dareton). There were also a number of queries on citrus rootstocks suitable for the Top End. This indicated that a publication on this topic may be necessary to document the performance of rootstocks in the region. In addition, queries on other management issues are received and may need published information on nutrition, irrigation, weed control, insect control and degreening.

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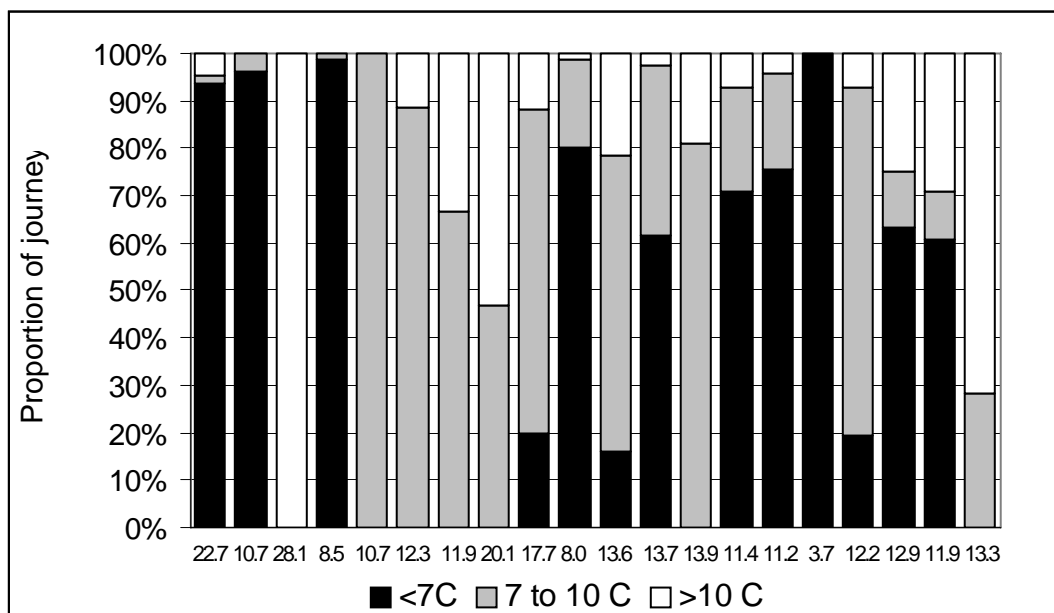
**PROJECT: Vegetable Cool Chain****Project Officers: M. Gosbee and S. Marte**Location: BARC

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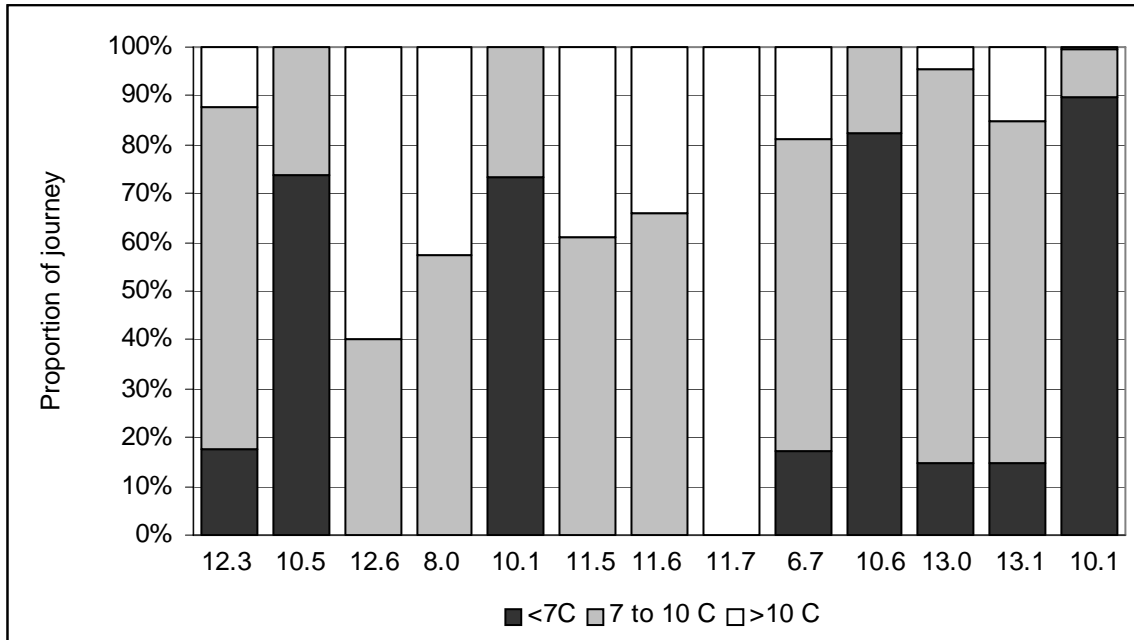
***PART 1: Temperature monitoring******Objective:******To investigate the cool handling of Asian vegetables and the effects on quality.***

The Vegetable Cool Chain project is funded by HRDC and is a joint project between the South Australian Research and Development Institute, Agriculture Victoria and DPIF. Part of the project was the temperature monitoring of bitter melon and snake bean during transport via road freight from Darwin to Melbourne. Data loggers were placed in cartons at Darwin, and records of the quality of the produce taken. In Melbourne, the consignment was met at the market, loggers were removed for collection of data and product quality was again recorded. A total of 20 successful consignments of bitter melon and 13 of snake beans were monitored.

Data is presented in Figures 1 and 2 as the proportion of the journey that the produce spent in three selected temperature brackets. The optimum storage temperature for physiological quality of bitter melon and snake beans is 7 to 10°C; however they are often transported at much lower temperatures to ensure heat damage does not occur. Above 10°C bitter melon will start to ripen, and snake beans produce enough heat through respiration to damage the product. A typical time interval is 80 to 100 hours, from produce arriving at depot for consolidation to being sold in the Footscray markets.



**Figure 1.** Proportion of journey that temperatures of <7, between 7 and 10° and over 10°C were recorded in boxes of bitter melon transported by road freighted to Melbourne. Initial vegetable temperatures are displayed under each column



**Figure 2.** Proportion of journey that temperatures of <7, between 7 and 10° and over 10°C were recorded in boxes of snake beans transported by road freight to Melbourne. Initial vegetable temperatures are displayed under each column

Of greatest concern is the proportion of time the temperature was above 10°C. For all the times recorded, bitter melon spent 20% of its transit time above 10°C. For snake beans, this proportion was slightly higher at 24%. Snake beans and bitter melon spent 46% and 37% respectively in the optimum temperature range, and the remaining 30% and 43% of the total recorded time at less than 7°C. Also of concern are the high temperatures of bitter melon at the beginning of the trip. Such produce is not adequately pre-cooled. This affects not only the shelf life of the product but also the ability of the refrigeration unit in the truck to cool it.

The quality of bitter melon was recorded in Darwin and Melbourne. In the Melbourne market, one carton was recorded as excellent quality, three as good quality, nine as satisfactory and five as non saleable. The main reasons for loss of quality were physical damage to the product, usually insect or other preharvest damage, and ripening. Often the seeds inside the sampled bitter melon were turning red.

**PART 2. Microbial sampling.**

**Objective: To determine microbial levels on vegetables at the time of harvest.**

As part of the Vegetable Cool Chain project, the effect of breaks in the cool chain on microbial spoilage are being studied. This data is available courtesy of Janine Jaeger of Agriculture Victoria.

An investigation of the microbial levels of vegetables at time of harvest was carried out for all the five commodities chosen lettuce, broccoli, carrots, snake beans and bitter melon. Several farms were selected for sampling and several samples were collected from each farm and tested for total aerobic microorganisms, coliforms, yeasts and moulds, and fluorescent pseudomonads.

An indication of the variability of microbial inoculum from one plant to the next was provided by these tests. Total aerobic counts were used to give a general indication of the numbers of microorganisms on vegetables. Coliform counts give some idea of the possibility of human

pathogens present on the vegetables, especially if *Escherichia coli* were found. Yeast and moulds, and fluorescent *Pseudomonads* are indicators of the presence of plant spoilage organisms.

**Method:**

Several samples of each commodity were collected from several farms in Victoria and The Northern Territory. The number of samples and farms was dependent on the availability of commodities in an area and the restriction of how many samples could be processed on the same day as picking. Samples were placed in sterile bags and were transported to the laboratory with ice packs in an esky.

**Victoria**

Four or five carrots were picked from three locations in one field from each of three farms. Two or three heads of broccoli were picked from three locations in one field from each of four farms. One head of lettuce was picked from three locations in one field from each of three farms.

**The Northern Territory**

Eight to 10 snake beans were picked from five locations in one field from each of three farms. Two or three bitter melons were picked from three locations in one field from five farms.

Samples were tested on the same day as picking and the numbers counted as appropriate for each test over the next few days. All counts were then calculated as colony forming units per gram (CFU/g) of produce.

**Results:**

Microbial level on vegetables at time of harvest are shown in Table 1. These results are raw data, and are presented as an indication of a small base sample of the microbial population of these vegetables at harvest. They are not recommendations or standards and should not be interpreted in this way.

**Table 1.** Microbial levels (CFU/g) on vegetables at time of harvest

Commodity	Grower	Sample	Total aerobic	Coliform	Yeasts and Moulds	Fluorescent Pseudomonads	
Bitter Melon	1	1	121000	759	7630	15	
		2	51200	9	4720	1	
		3	171000	9	2760	482	
	2	1	< 45	< 4	476	0	
		2	1580	324	1440	0	
		3	90	4	585	0.5	
	3	1	>36000000	< 4	2920	539	
		2	650	< 4	2380	0	
		3	36000000	< 4	1350	0	
	4	1	75100	825	3210	0	
		2	513000	4	15200	0	
		3	494000	< 4	13700	0	
	5	1	178	4	1110	0.5	
		2	40300000	15200	582	277	
		3	< 45	4	8980	1	
Broccoli	1	1	64400	900	495	9	
		2	350000	359	539	135	
		3	124000	13	310	66	
	2	1	32800	399	266	2	
		2	17900	80	179	0	
		3	815000	4050	2750	180	
	3	1	152000	521	391	9	
		2	3460	35	71	0	
		3	46200	881	79	18	
	4	1	1570	895	582	0	
		2	1440	744	109	0	
		3	1260	52	349	0	
	Carrots	1	1	873	0	103	7
			2	> 5380000	4	40	27
			3	85100	4	582	7
2		1	138000	45	178	58	
		2	32800	88	745	1	
		3	> 5370000	76	89	0	
3		1	15600	4	80	0	
		2	> 5320000	4	66	1	
		3	21100	0	139	3	
Lettuce	1	1	> 5240000	0	131	8	
		2	49000	165	151	178	
		3	1870	0	125	5	
	2	1	986	0	99	10800	
		2	> 5360000	0	31	2140	
		3	2210	4	55700	1	
	3	1	55900	3370	755	46	
		2	11600	36	67	18	
		3	143000	1560	1830	580	

Commodity	Grower	Sample	Total aerobic	Coliforms	Yeasts and Moulds	Fluorescent Pseudomonads
Snakebeans	1	1	1980	0	3060	0
		2	1530	49	943	0
		3	399000	2080	16000	0
		4	4870	67	4160	0
		5	20200	0	2700	189
	2	1	96700	3870	15300	54
		2	296000	26	12400	486
		3	145000	3820	7470	3960
		4	42200	1120	13900	898
		5	307000	1200	1600	18
	3	1	166000	22	8510	0
		2	145000	0	2820	0
		3	446000	137	12400	353
		4	202000	1380	8740	0
		5	3570000	1290	2950	5810

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**PROJECT: Optimising Storage Conditions for Selected Asian Vegetables**

**Project Officers: M. Gosbee and S. Marte**

**Location: BARC**

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**Objective:**

***To determine optimum storage temperatures for some Asian Vegetable types.***

This work was begun by TK Lim and sections of it have been reported in previous Annual Reports. The following is an adaptation of a paper 'Postharvest handling of Asian vegetables in the Northern Territory' by M. Gosbee and TK Lim. It summarises several years work and includes new information on sinqua, snake beans and kang kong.

**Materials and methods:**

Five types of Asian vegetables were chosen for this study. Bitter melon (*Momordica charantia*) and snake beans (*Vigna unguiculata* cv. Group Sesquipedalis) are among the most commonly grown Asian vegetables, and frequently have deterioration problems. Okra (*Abelmoschus esculentus*) also tends to have similar problems, presumably due to its high respiration rate (Kader 1992). Sinqua, or angled luffa (*Luffa acutangula*) was chosen to be representative of several types of melon which are considered by growers to be less sensitive to temperature. Kang kong (*Ipomoea aquatica*) was chosen as a representative of common leafy vegetables.

Vegetables were packed in boxes of 3 to 10 kg. Pack sizes were chosen to simulate current industry practices. They were either commercial size (for bitter melon and sinqua) or scaled down but still a representative size (snake beans, okra and kang kong). Produce packed in paper wrapping had a double thickness placed at the top and bottom of the carton. Plastic bags were made of low density natural polyethylene. Perforated bags had large holes (10 mm diameter) 20 mm apart over most of the area, while peakfresh® bags were microperforated plastic bags with gas

exchange properties. Again, specific treatments were chosen depending on the type of vegetable and the types of packaging used by growers (Table 2). They were then placed in a coolroom at 5, 10, 15 or 20°C.

Vegetables were assessed twice a week for quality, and once a week for weight loss. Quality was scored on a 1 to 5 subjective scale of 1 = excellent, 2 = good, 3 = saleable, 4 = poor and 5 = very poor. Shelf life was determined as the number of days a product took from harvest to reach a score of less than 3. Ratings were continued until produced reached a score of less than 2. Weight loss is expressed as the percentage of initial fresh weight lost. This was determined with a slightly different sampling unit in each experiment (Table 1).

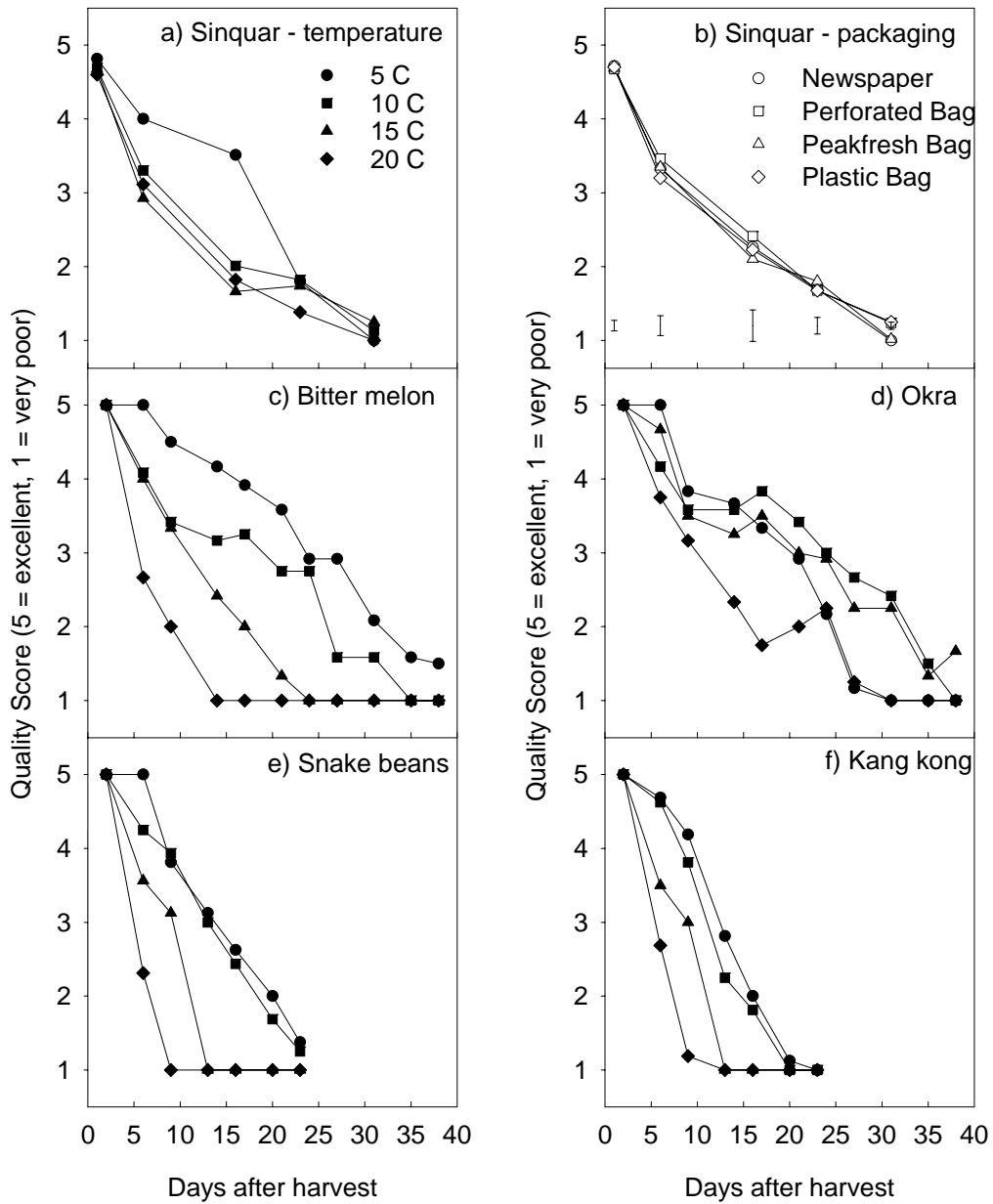
Two boxes of each packaging x temperature treatment were used. Unfortunately the effect of temperature could not be statistically analysed as only one coolroom was available at each temperature. Analysis of the effect of packaging on quality score was analysed using general linear models. Weight loss was significantly affected by packaging and data was analysed by analysis of deviance.

**Table 1** Packaging and pack size used in the assessment of optimum storage life and temperature of five Asian vegetables

	<b>Bitter Melon</b>	<b>Okra</b>	<b>Sinqua</b>	<b>Snake beans</b>	<b>Kang kong</b>
<b>Packaging</b>					
Paper wrapping	3	3	3	3	3
Perforated Bag	3		3	3	3
Peakfresh Bag		3	3	3	3
Plastic Bag	3	3	3	3	3
<b>Pack size</b>	10 kg	5 kg	10 kg	5 kg	3 kg
<b>Sample size for weight loss measurement</b>	combined weight of 5 fruit	combined weight of 10 fruit	individual weight of 5 fruit	total weight of 5 kg box	total weight of 3 kg box

### Results and Discussion:

Temperature had by far the greater effect on quality and shelf life than packaging. Differences in quality score of vegetables stored at different temperatures (Figure 1) were greater than that observed between vegetables stored in different types of packaging (Figure 1).



**Figure 1.** Effect of temperature (a, c - f) and packaging (b) on the quality of various 'Asian' vegetables during storage. Vertical bars (b) represent LSD ( $P < 0.05$ )

**Table 2.** Weight loss (% initial fresh weight) after approx. two weeks in storage. Results are averaged across the four temperatures. Values within columns followed by different letters are significantly different ( $P < 0.05$ )

	Bitter Melon	Okra	Sinqua	Snake beans	Kang kong
<b>Days after harvest:</b>	14	14	16	13	13
<b>Packaging</b>					
Paper wrapping	97.61 a	91.76 a	93.97 a	89.59 a	85.39 a
Perforated Bag	97.81 a		95.03 a	94.14 b	93.27 b
Peakfresh Bag		98.54 b	97.90 b	99.56 c	99.91 c
Plastic Bag	99.12 b	98.20 b	98.71 b	99.59 c	100.44 c

At any one temperature, however, packaging had a distinct effect on the rate of water loss. Vegetables stored in plastic lost significantly less water than product stored without any plastic covering. Perforated bags were intermediate (Table 2). The rates for okra, <2% for produce in bags, and 8.2% for paper wrapping, were similar to that reported by Perkins-Veazie and Collins (1992). The use of peakfresh bags did not significantly increase the storage life of any of these products over the use of plastic bags. As peakfresh bags are considerably more expensive, this information should save the grower significant and unnecessary cost.

The simple conclusion that every vegetable is best stored at 5°C in a plastic bag was not true (Table 3). The use of plastic bags to reduce water loss is only recommended when the temperature can be accurately controlled. Warm produce packaged in plastic bags is difficult to cool, due to the decreased ventilation. If temperature is not well controlled during transport, produce in plastic bags is more likely to 'cook' due to the heat produced as the vegetables respire. For produce like snake beans with a very high respiration rate (Zong et al. 1992), we currently recommend the use of perforated plastic bags as they have greater air flow capacity when the product is being cooled. This also highlights the importance of completely cooling produce prior to packaging.

**Table 3.** Optimum storage temperature and packaging combinations for maximising shelf life for five selected vegetables

	Temperature	Packaging	Shelf Life
Bitter melon	5 °C	Paper wrapping	3 weeks
Okra	10°C	Plastic bag	3 weeks
Sinqua	5°C	Any	2.5 weeks
Snake beans	5 - 10 °C	Plastic bag	2.5 weeks
Kang kong	5°C	Plastic bag	2 weeks

The use of plastic bags for bitter melon poses a different problem. This vegetable is close to maturity at harvest, it produces ethylene and is also sensitive to ethylene (Zong et al. 1992). Optimum stage of harvest is difficult to determine, and is clouded by the desire of growers to harvest heavier and therefore more profitable vegetable. As the bitter melon ripens, the flesh rapidly turns a brilliant yellow and splits open. This may induce the rest of the melons in the box to likewise ripen. Bitter melon is consumed immature, and ripe fruit is unmarketable. Low temperature reduces the rate of ripening and loss of quality (Figure 1), but packing bitter melon in paper wrapping increases ventilation within the box and reduces the possibility ethylene triggering the fruit to ripen.

In this trial, okra stored in paper wrapping succumbed to fungal decay more readily than that in plastic bags. It may be that the paper wrapping was a source of inoculum, or that water loss from the okra predisposed them to decay. From these results, plastic packaging is more beneficial than paper wrapping (Table 3).

Sinqua was different because the shelf life of vegetables stored at 20°C were not greatly different to that of vegetables stored at 15 or 10°C. This would be why sinqua, and other melons, have a reputation among growers for longer shelf life. Sinqua stored at 5°C had a significantly longer shelf life than that stored at any other temperature (Figure 1).

Kang kong is a leafy vegetable with a very short shelf life. Low temperatures of 5 to 10°C were beneficial in prolonging shelf life (Figure 1). Water loss was significantly greater in paper wrapping and perforated bags from day 6, and the use of plastic bags is strongly recommended. At 15 and 20°C, breakdown in kang kong was seen as wilting and yellowing of the lower leaves and fungal decay. At lower temperatures colour and turgor were maintained for longer.

Chilling injury was observed in bitter melon and okra after three weeks at 5°C. Dark watery pits first appeared on the bitter melon at this time and increased with time in storage. Zong *et al* (1992) suggested that none of these vegetables should be stored at less than 10°C for more than two weeks, due to chilling injury. That observation is more accurate as the vegetables were removed to 20° and chilling injury observed after two to three days. This was not attempted in our experiment and symptoms may have been more obvious had we held the vegetables at 20°C after removal from cooler temperatures.

At the present time, most growers cool their produce to 4 to 8°C, and temperatures of 4 to 6°C are used in road freight for periods of four days. While these temperatures may seem a bit low, the lower temperatures reduce the possibility of the vegetables heating up within packaging. The transit time of four days to southern markets is short enough to minimise the risk of developing chilling injury. When vegetables are properly pre-cooled, vegetable quality is maintained and produce reaches markets in a good condition.

Technology in terms of temperature and packaging exist for a range of vegetables. It is, however, important to match these not only to each vegetable in the case of its particular physiology but also to the capability of the growers and available transport options. Our recommendations may well change as the skill of the growers in postharvest handling and managing the cool chain increase.

#### **Acknowledgments:**

Thanks to Carole Wright for statistical analysis. Funding for this project by HRDC and RIRDC is gratefully appreciated.

#### **References:**

Bureau of Meteorology (1999), Commonwealth of Australia.  
<http://www.bom.gov.au/climate/averages/tables>

Kader A. A. (1992). Postharvest biology and technology: an overview. In: Postharvest Technology of Horticultural Crops. pg 15 to 20. University of California, USA.

Perkins-Veazie, P. and Collins, J. K. (1992). Cultivar, packaging, and storage temperature differences in postharvest shelf life of okra. HortTechnology 2:350-352.

Zong, R. J., Cantwell, M., Morris, L. and Rubatzky, V. (1992). Postharvest studies on four fruit-type Chinese vegetables. Acta Horticulturae 318:345-354.

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**PROJECT:**            **Bitter Melon (*Momordica charantia*) Selection Trial**

**Project Officers:**    **K. Blackburn and M. Traynor**

**Location:**            CPHRF

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***Objective:***

***To assess the suitability of a range of hybrid and open pollinated bitter melon cultivars in an observation trial for performance under local conditions.***

The Asian vegetable growers select their own bitter melon seed from open pollinated (OP) plants usually from the first fruit produced from the young plants. The selection criteria is generally on fruit size with fruit shape a secondary consideration. The rationale is to have a large fruit that will give them more flexibility at harvest or being able to achieve a suitable fruit size before the fruit matures and ripens. The original OP seed line is possibly a mixture of types that have been introduced over the years. Some of the bitter melon growers have been selecting seed for seven to 10 years and are prepared to reject up to 30% of their fruit for small size, over-maturity, and off-types as normal practice. The DPIF officers working on the project have always considered the local selection to lack fruit size and uniformity and the plants to lack vigour and yield potential.

**Materials and Methods:**

Fourteen varieties were sourced from interstate and overseas (Table 1). These were planted in an RCBD trial with two replications, with four plants in each replicate. Spacing was 1 m between plants, with 3 m between plots and rows. The plants were trained to grow up a vertical string and lateral branches were pruned off except where three horizontal wires were used to hold the lateral branches for fruit production. The plants were pinched off when they reached the third or top wire.

Specific nutrition programs were developed for the bitter melon trial. Nutrients were injected into the irrigation system.

25N : 5P : 18K kg/ha/week was used for early growth

12N : 5P : 18K : 5Ca kg/ha/week was used after fruit set or about six weeks onwards

Lime and basal fertiliser were applied and the necessary trace elements were injected during early crop growth. The trial irrigation was carefully monitored with soil moisture tensiometers and the trial plants developed vigorously and healthy.

**Results:**

Table 1 summarises the measurements taken on the average of 12 fruit during the five weeks of harvest. Yield records were not collected due to a shortage of resources in managing the trial. It was considered that the selection of types suited to market requirements was more important at this stage of investigation.

**Table 1.** Fruit measurements from bitter melon variety trial. Each measurement is the average of 12 fruit

Variety	Length (cm)	Width (cm)	Weight (g)	Flesh Thickness (mm)	Brix (mid fruit)
1. Baizin Green (hyb.)	23.5	6.0	360	9	2.8
2. Kiew Yoke 59 (hyb.)	32.0	5.0	380	7	3.5
3. Kiew Yoke 68 (hyb.)	28.0	5.5	365	8	3.0
4. Bitter Spindel (hyb.)	14.5	5.0	110	7	3.3
5. Polo (hyb.)	23.5	5.0	245	8	2.8
6. Known You Green (hyb.)	26.0	6.0	318	9	2.7
7. Verdure (hyb.)	17.5	7.0	311	10	2.8
8. Moon Rise (hyb.)	28.0	5.5	332	8	2.8
9. Moon Light (hyb.)	21.5	6.0	306	8	3.1
10. 'Long Type' (OP)	22.0	6.0	308	8	2.7
11. 'One End Large' (OP)	17.0	6.0	247	8	2.8
12. 'Big Dooms' (OP)	15.0	7.0	276	9	3.2
13. Vong 3 (OP)	24.0	7.0	395	10	2.9
14. Moon Beauty (hyb.)	20.5	7.0	367	9	2.9

Generally, most of the hybrids were uniform over the five week harvest period which could have been extended further. Hybrid Baizin Green was a particularly good type with good uniformity of shape and size while the three OP's 10, 11 and 12 were quite variable. The OP, Vong 3 is a particularly good type and similar to the local selection (a rough bumpy type). The first fruits were harvested some 10 weeks after transplanting.

Table 2 summarises the appearance of the fruit which is critical for market acceptance. Detailed field assessments on the plots showed varieties 2 and 3 had poor plant vigour, were sparse plants produced long thin fruit, and had poor leaf cover. Variety 4, Hybrid Bitter Spindel had very vigorous plants but was a very poor performer with small fruit size. The cultivars with most potential were the hybrids Baizin Green, Polo, Known You Green and Moon Light and the open pollinated line Vong 3. It is worth noting that the hybrids Baizin Green and Known You Green are very similar in appearance and performance.

Six relatively experienced growers, with five to six years experience in growing bitter melon, were invited to visit the trial site, closely inspect the cultivars and then make comments on the suitability of the lines for their markets. All the growers said that OP Vong 3 was a good type (rough irregular lumps). However, this line was developed by Dr Vong Nguyen and is not available commercially. One grower considered Variety 9, Moon Light to be a good smooth type, very shiny and bright with a good shape.

**Table 2.** Bitter melon appearance

Variety	Shape	Bumps	Skin Brightness	Skin Colour (Light/Mid/Dark)
1. Baizin Green (hyb.)	Good uniform even shape	Large smooth uniform ridges	Fair	Light/Mid
2. Kiew Yoke 59 (hyb.)	Fairly uniform, some bent. Long & thin	Uniform, medium size, smooth ridges	Fair	Light/Mid
3. Kiew Yoke 68 (hyb.)	Fairly uniform, some bent. Tapered.	Medium size, fairly smooth ridges	Poor/fair	Light
4. Bitter Spindel (hyb.)	Uniform small even shapes. Too small	Small, irregular, rough bumps	Poor	Light/mid/dark
5. Polo (hyb.)	Mostly uniform, some bulges	Mostly large, irregular smooth bumps	Good	Mid
6. Known You Green (hyb.)	Good uniform even shapes	Medium size, smooth uniform ridges	Fair	Mid
7. Verdure (hyb.)	Uniform short blocky shape. Tapered	Medium size, fairly smooth uniform bumps	Fair	Mid/Dark
8. Moon Rise (hyb.)	Fairly uniform, some bent. Long & thin	Fairly uniform, smooth bumps. Some ridges	Fair	Mid
9. Moon Light (hyb.)	Mostly uniform even shapes	Small/medium, irregular, smooth bumps	Very good	Mid/Dark
10. 'Long Type' (OP)	Variable. Some pointed, some blunt	Irregular. Some large ridges, some rough	Poor	Light/Mid
11. 'One End Large' (OP)	Very variable. Short and long shapes	Irregular medium bumps, mostly smooth	Fair/good	Dark
12. 'Big Dooms' (OP)	Variable short block or top shapes	Fairly smooth irregular bumps	Fair	Mid/Dark
13. Vong 3 (OP)	Mostly uniform, some bulges, some pointed	Small/medium irregular rough bumps	Fair	Mid
14. Moon Beauty (hyb.)	Fairly uniform. Some block shapes	Very irregular, small/large smooth bumps	Good	Cream/white

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**PROJECT:           Alternative    Growing    Techniques    Double  
                          Production of Bitter Melon**

**Project Officers:   M. Traynor and E. Crowson**

**Location:           Minh Bang Nguyens' farm, Buckley Rd, Humpty Doo**

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***Objective:***

***To demonstrate increased yields by adopting improved farming techniques.***

A demonstration trial was planted on a growers' property at Humpty Doo to demonstrate the alternative production techniques developed by the Department over many years of vegetable production research. These alternative growing techniques included the use of a green manure crop, soil testing, pH adjustment and application of basal fertiliser, mounds covered with plastic mulch and irrigated with drip tape under the mulch and fertiliser injection (or fertigation). Pest and disease were also monitored and sprayed with soft chemicals when losses reached threshold levels.

Bitter melon grown using the plastic mulch and drip tape produced fruit 3.5 weeks earlier than bitter melon grown the traditional way. The total period of harvest for bitter melon grown using the method recommended by DPIF was 12 weeks, compared to 8.5 weeks when grown the traditional way.

Yields were also higher. From the four 50 m beds used in the trial, growing using the recommended method produced 2,120 kg of bitter melon, while the traditional method produced only 910 kg. This increase was greater than expected, and has huge potential to increase the profitability for Asian vegetable farmers in the region. A similar increase was noticed for zucchini. Costs incurred for controlling pests and diseases were also nearly halved with application of soft chemicals when pest or disease incidence reached threshold levels.

This production system means slightly higher establishment costs but the increase in harvesting period and yield, and potential savings from reduced chemical use should more than offset this expense.

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**PROJECT:           Kabocha Variety Trial**

**Project Officers:   S. McAlister, R. Renfree and M. Gosbee**

**Location:           KRS**

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***Objective:***

***To evaluate kabocha as a possible new crop for the Katherine region.***

The prime aim of the RIRDC project 'Consolidating the Asian vegetable industry' is to determine what crops can be grown across a range of climates in Australia with a view to year round production for export. One of the most promising types of Asian vegetables is kabocha (*Cucurbita maxima* x *C. moschata*). Kabocha production in the Katherine region is out of season to the rest of Australia and would fill a useful timing slot in year round production.

The trial was started on 19 May 1999. Agronomic practices used were based on those developed for other cucurbit crops grown in the region e.g. watermelon and butternut pumpkin. Five varieties were planted, Kurijiman, Uchikikuri, Tetsukabuto, Delica and Pacifica. Two sources of seed were used for Kurijiman and Tetsukabuto. Plants were grown with black plastic mulch and tee tape emitters every 30 cm. Ten plants were grown in each of two replicate plots 7.5 m long. Row spacing was 1.5 m.

**Nutrition:**

Plants were side dressed with single super pre planting, with fertigation after flowering. Trace elements were applied with a foliar spray.

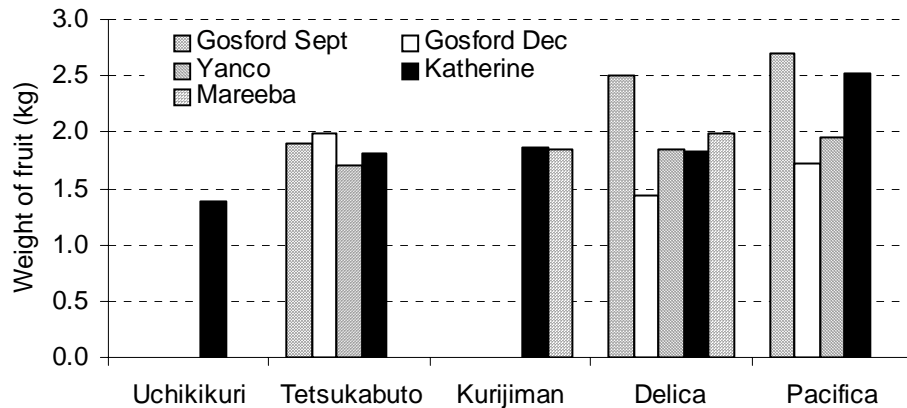
**Pesticides:**

Maldison @ 2 mL/L for the control of pumpkin beetle and cabbage moth used twice during the life of the crop. Afugan @ 0.5 mL/L for powdery mildew control.

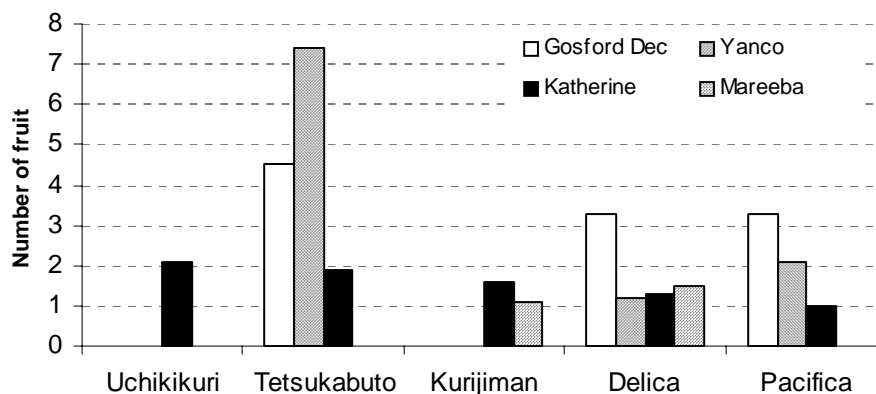
**Harvest:**

Kabocha were harvested on 7 September, 111 days after sowing. Fruit size from Katherine was comparable with that produced in other locations (Figure 1), however the number of fruit produced per plant was quite low (Figure 2).

Squash considered 'bad' was due to either green skin or powdery mildew damage. Yield per plant was quite low, with only 1 to 2.1 squash produced per plant. Fruit size was similar to that in other sites, however the number of fruit produced was quite low.



**Figure 1.** Average weight of an individual kabocha fruit



**Figure 2.** Average number of kabocha fruit produced per plant

Skin colour was darkest in Tetsukabuto (Table 1), and often lighter when kabocha was grown in Katherine than at other sites (Table 2). Sugars were generally high in Katherine. Uchikikuri turned out to be a red skinned cultivar. Flesh colour was also measured.

**Table 1.** Quality parameters of kabocha varieties grown at Katherine in 1999. Skin colour score: 1 = light, 5 = dark, which is desirable. Sugars measured in g/100 g flesh weight

Variety	Skin Colour	Sucrose	D-glucose	D-fructose	Total Sugars
Delica	2.3	0.83	0.97	0.22	2.02
Kurijiman	2.7	1.06	0.65	0.31	2.01
Kurijiman F1	2.5	0.98	0.70	0.33	2.02
Pacifica	2.5	0.16	1.25	0.09	1.49
Tetsukabuto	4.0	1.46	0.55	0.47	2.48
Tetsukabuto F1	3.8	1.23	0.55	0.40	2.18
Uchikikuri	red skinned	0.53	0.96	0.18	1.67

**Table 2.** Comparison of quality parameters of kabocha varieties Pacifica and Delica grown at Katherine and other sites in Australia. Skin colour score: 1 = light, 5 = dark, which is desirable. Sugars measured in g/100 g flesh weight

Location	Skin Colour	Sucrose	D-glucose	D-fructose	Total Sugars
<b>Delica</b>					
Katherine	2.3	0.83	0.97	0.22	2.02
Gatton	2.3	0.83	0.97	0.22	2.02
Gosford	4.0	0.525	0.955	0.1775	1.6575
Teesdale	3.8	0.06	1.27	0.04	1.38
<b>Pacifica</b>					
Gosford	4.0	0.095	1.195	0.0475	1.3375
Katherine	2.5	0.16	1.25	0.09	1.49
Swan Hill	3.6	0.08	1.21	0.01	1.29
Tatura	3.6	0.02	1.23	0.05	1.3

The trial will be continued in 2000 to see if the number of fruit per plant can be increased. Possible reasons for the low yield may be too much nitrogen, poor pollination or low temperatures.

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**PROJECT: VEK001 Cultivar Evaluation of a Host of Annual Crops - Katherine Component****Project Officers: J. Bright, C. Kinnaird and R. Renfree**Location: Katherine Research Station

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**Objective:**

*To screen several new vegetable cultivars for their production performance in the Katherine region.*

While the main aim of this trial was to screen several new vegetable cultivars, it was also used as a demonstration planting for the Annual Farm and Garden Day, held at the Katherine Research Station (KRS). The day includes a tour where the public visit the horticultural block and view the current projects. This enables the public to see what is being grown around the district. After the farm and garden day, the produce is harvested and assessed.

**Materials and Methods:**

In January 2000 a range of vegetable crops were planted under plastic at the KRS for the evaluation of new lines. These plantings are listed in Table 1.

**Table 1.** Vegetables and cultivars planted for the vegetable cultivar evaluation trial, 2000

Vegetable	Cultivar	Length of planting (m)
Honey Dew	Dew Crisp, Honey Babe, Solid Gold	10
Pumpkin	Jarradale, Mammoth	30
Rock melon	Dubloon, Eldorado, Hot Shot	10
Squash	Green Button, Yellow Ruffles	20
Watermelon	Bengal, Red Tiger	10
Zucchini	Zephyr.	10

Irrigation was carried out according to tensiometer readings at 30 and 45 cm. depths. Fertilizer application is outlined in Table 2.

**Table 2.** Fertiliser program for vegetable cultivar evaluation, 2000

Element	Product	Rate/Ha	Rate	Timing
<b>Inject</b>				
Nitrogen	Urea	14.4 kg	3.6 kg	Weekly 2-6
Potassium	KNO <sub>3</sub>	17 kg	3 kg	Weekly 6-10
Phosphorus	MAP	19 kg	3.4 kg	Weekly 6-10
Nitrogen	Urea	11 kg	2 kg	Weekly 6-10
Calcium	Calcium nitrate	10 kg	1.8 kg	Week 9
<b>Foliar</b>				
Molybdenum	Sodium molybdate	0.5 kg	9 g	Week 6 and Fruit set
Magnesium	Magnesium sulphate	2 kg	36 g	Week 6 and Fruit set
Zinc	Zinc sulph hept	2 kg	36 g	Week 6 and Fruit set
Copper	Copper sulphate	1 kg	18 g	Week 6 and Fruit set
Boron	Boron	0.5 kg	9 g	Week 7 and Fruit set

## Results and Discussion:

### Honey Dew

Solid Gold gave the highest yield per planting but on average had the smallest fruit. Honey Babe had the largest average fruit but total yield was smaller. Dew crisp was three days later to harvest than the other two varieties. Harvest results are found in Table 3.

**Table 3.** Harvest results for cultivars of Honey Dew melons

Cultivar	Days to harvest (av)	Average Fruit Wt (g)	Total weight (kg)/planting
Dew Crisp	101	1997.8	42.8
Honey Babe	98	2760.2	49.3
Solid Gold	98	1599.2	79.75

### Pumpkin

Mammoth pumpkins yielded 470 kg per planting with an average fruit weight of 2.5 kg. Jarradale yielded 164 kg and averaged 1.6 kg per fruit. Mammoth took 119 days until harvest while Jarradale took 120 days. An outbreak of pumpkin beetle was controlled in March using Carbaryl (Bugmaster Flowable®) at a rate of 20 mL/10 L in a knapsack.

### Rockmelon

Dubloon performed poorly in total fruit weight per planting, while Eldorado and Hotshot had similar total yields. Dubloon also averaged the smallest fruit, while Eldorado had the largest fruit. From planting to harvest, Hotshot took 86 days to harvest, Dubloon 110 days and Eldorado 98 days. Harvest results are shown in Table 4.

**Table 4.** Harvest results for cultivars of Rock melons

Cultivar	Days to harvest (av)	Average Fruit Wt (g)	Total weight (kg)/planting
Dubloon	110	1643.3	8.02
Eldrodo	98	2930.0	30.3
Hot Shot	86	2622.0	43.1

### Squash

Green Button and Yellow Ruffles squash took 102 and 104 days respectively to harvest. Average fruit weights were similar (432 g and 445 g), the weights being heavy due to fruit being left on the plant for too long. Yellow Ruffles yielded 239 kg per planting while the total for Green Button was 143 kg.

In March, a number of fungal problems occurred due to the wet season conditions. There were outbreaks of Cottony leak, Pythium and Choanephora fruit rot in March. Phosphonic acid (Foli-rfos®) was applied at a rate of 40 mL/8 L in a knapsack, and Propamocarb (Previcur®) at a rate of 1 L/100 L was applied using a boom spray to control these fungi.

### Watermelon

The new watermelon variety Bengal was planted with the industry standard for the Katherine area, Red Tiger. Red Tiger again proved the best variety of watermelon for the Katherine region. Red Tiger yielded 275 kg per planting at an average 7 kg per fruit. Bengal had a similar average fruit weight but yielded less than half of Red Tiger at a total of 114 kg. Bengal matured in 103 days, six days before Red Tiger.

## Zucchini

Zephyr zucchini took 97 days from planting to harvest with a total yield of 109 kg from the planting. The fruit was left on the plant for too long, which caused the high average fruit weight. Blossom end rot, *Rhizopus* sp. was controlled in March using Chlorothalinol (Rover 500 SC®) at a rate of 23 mL/10L in a knapsack.

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**PROJECT:**            **VEK002 Plant Nutritional Studies on a Host of Annual Crops - Petiole Sap Monitoring of Annual Crops in the Katherine region.**

**Project Officers:**    **J. Bright and S. McAlister**

**Location:**            Growers' properties in the Katherine Region

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### **Objectives:**

- ***Provide growers with a better understanding of plant nutrition.***
- ***Improve crop production by utilising the information provided.***
- ***To assist growers develop new nutritional and irrigation programs based on plant needs rather than following 'traditional fertiliser practices'.***
- ***To refine nutritional trends developed by Darwin DPIF to suit Katherine conditions.***

A meeting of the Katherine vegetable growers in 1999 identified the need to establish a plant nutritional analysis program. The program would look at providing growers with quick turn around information from petiole sap analysis. Results are made available to the growers within 48 hours and they could act on the information accordingly. Initially only two properties would be involved.

### **Progress Report:**

The vegetable season of 1999 proved very successful as far as the adoption of the plant nutritional monitoring program was concerned. The use of petiole sap analysis and interpretation and the quick turn around time of the results enabled the growers to make more informed decisions and be in control of their management strategies based on the gathered data.

In a number of cases "traditional fertiliser applications" proved to be inappropriate for the situation as can be seen in Figure 1 to 3. In general, it was found that sticking to routine programs was excessive in certain elements for the plant and such practices would only waste fertiliser and money. Figure 1 to 3 display the attempts of the growers to follow the optimal curve for rockmelons. At certain weeks, high and low points can be identified where the grower has excessively over-fertilised or over watered. Another issue raised during the period of this trial was the use of urea. In one case, urea was applied to the soil but the plant did not actually show an increase in nitrogen for two weeks, due to the need for urea to be broken down in the soil. The application of ammonium sulphate gave an immediate reaction in the plant sap analysis.

Previous trials by Blackburn and Traynor have set a trend line for various nutrients involved with rockmelon growth at certain stages of the plant's life. Other optimum levels were also available from numerous chemical companies and state departments. These were used as a reference for Katherine growers. The growers became aware that petiole sap levels for individual nutrients should be more inclined to follow the trends of these optimum lines rather than the actual values and that for most of the crops being grown this trend line will follow a similar course. The plant requires high nitrate levels in the early stages of its life until flowering and would then reduce through until harvest. Potassium needs to be maintained through to harvest as would calcium and

phosphorous. Growers were also aware of the importance of irrigation to maximise nutritional benefits. When growers viewed their performance against the optimum levels (Figure 1 to 3), they became aware that their fertiliser strategies needed modifying.

Figure 1. Nitrogen petiole Rockmelon

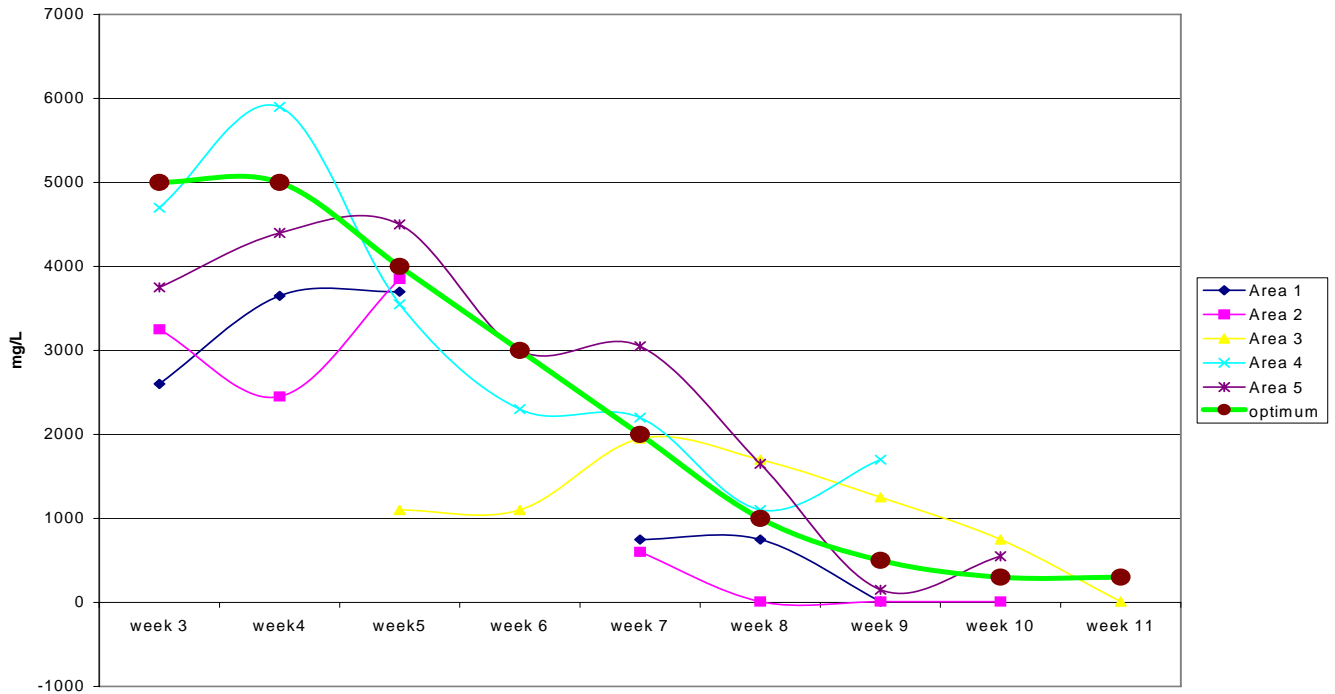


Figure 2. Phosphorus 1999 Rockmelon

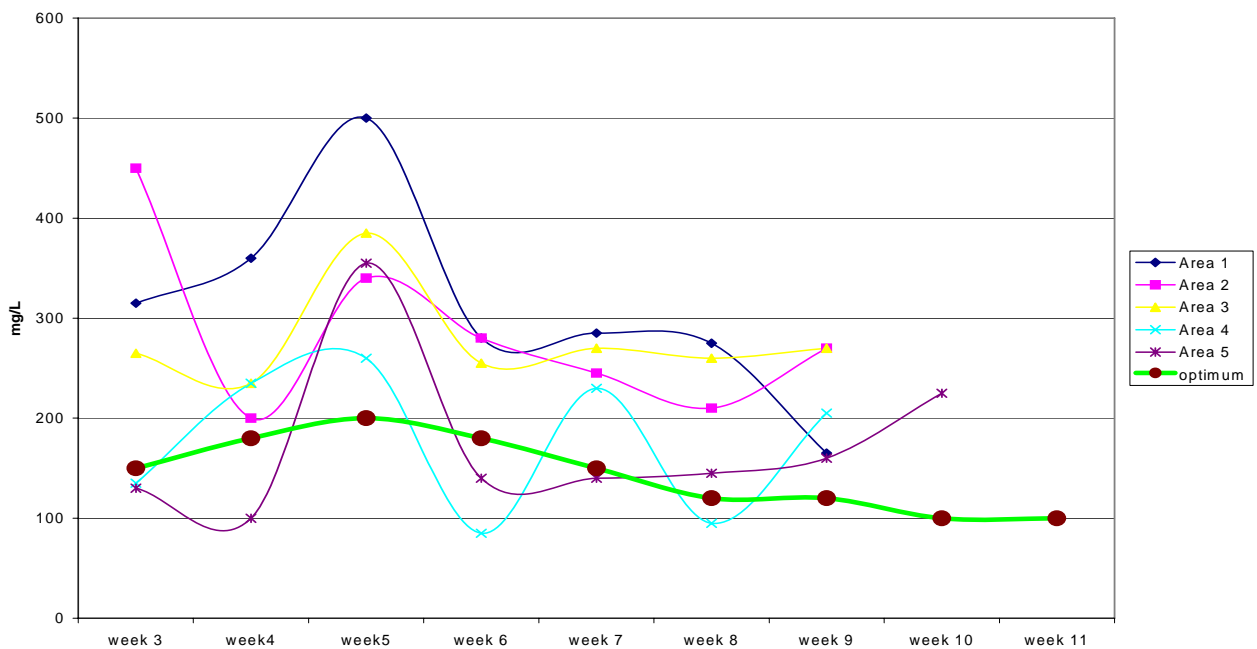
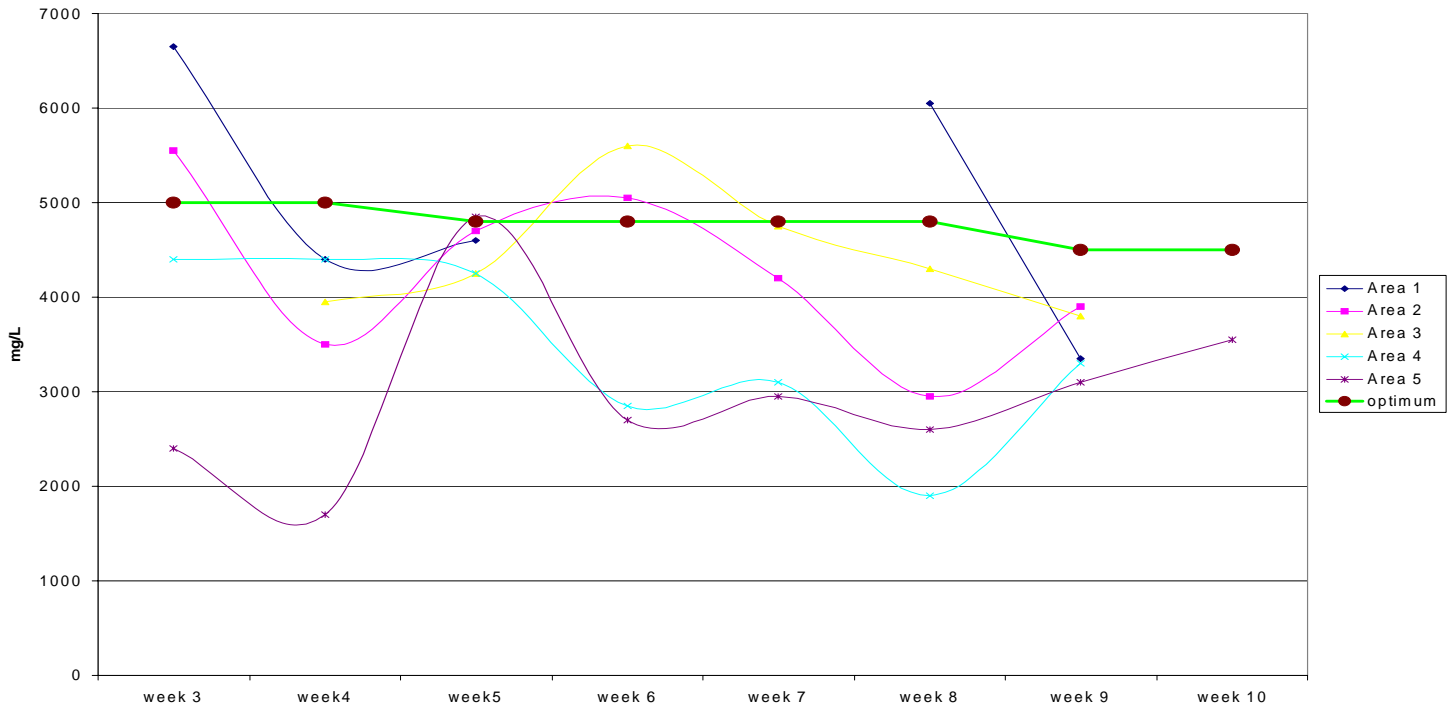


Figure 3. K petiole Rockmelon




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**PROJECT:** VEK003 Legume Green Manure Development - Katherine Component

**Project Officers:** J. Bright

**Location:** Katherine Research Station

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**Objective:**

**To determine the effect of green manure crops on the performance of vegetable cultivars in the Katherine region.**

A crop of *Centrosema* cultivar Cavalcade was planted in the horticultural block. It was harvested late due to mechanical breakdowns and unavailability of other machinery. This meant that no work was undertaken on this project in the 2000 season.

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**PROJECT: VEK004 Asparagus Cultivar Evaluation****Project Officers: J. Bright**Location: Katherine Research Station

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**Objective:*****To evaluate the performance of asparagus cultivars in the Katherine Region.***

Currently UC157 F<sub>1</sub> is the standard asparagus cultivar grown in Northern Australia. The commencement of the 2nd International Asparagus Cultivar Trial provided an opportunity to obtain a wide selection of genetic material for comparison with UC 157 F<sub>1</sub> at Katherine.

**Materials and Methods:**

Seed of 18 cultivars were sown and transplanted to the field in March 1998 (Table 1).

**Table 1.** Cultivars selected for evaluation at KRS

UC157F <sub>1</sub>	Apollo
Grande	Boonlim
Tainan1	Cipres
Tainan 2	PLA-2232
Tainan 3	Atlas
JACQ MA 2004	JACQ MA 2014
Andreas	Venlim
Val Prima	PLA-2132
Larac	Dariana

**Progress Report:**

Labels were inadvertently removed from the trial and as a result have made it difficult to identify several of the cultivars. This trial was only an observation trial and due to unexpected events will be phased out.

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**PROJECT: VEK005 Management of Annual Crops and Asparagus****Project Officers: J. Bright**Location: Growers' properties in the Katherine region

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**Objective*****To develop management strategies for annual crops and asparagus.***

The project VEK002 provided DPIF Katherine horticulture staff with the valuable opportunity through extension work to listen to growers' issues first hand. During this process, the false wireworm (*Cadius* sp) problem was again brought to the attention of the horticulture staff. The issue was seen by the growers as being a very dominant one and a solution was needed urgently.

The usual practice for the growers around the Venn area is to plant out their seed and replant seed where false wireworm had taken the new plants. Other treatments in the past have included the use of chlopyrifos injected through the drip lines. Nema-cur was trailed by the department several years ago but was unsuccessful. Growers have mentioned that chlopyrifos was an effective control measure but tended to dwarf the plant. This was clarified by Strickland and Collins (1987) who confirms that chlopyrifos will cause severe reductions in rockmelon seedling growth.

#### **Progress Report:**

Bayer recommended Mesurol® snail and slug bait. The product was included in a planting at a Venn farm as a comparison against Chlopyrifos and a control strip. Preliminary observations have shown numerous dead wireworm and weevils where the Mesurol was applied. All seedlings had germinated. The chlopyrifos strip also had some kills of wireworm but some plants had not emerged at the time this report was written. Many of the plants were obviously stunted when compared to the Mesurol® and control strips. The control strip has had numerous replants in sites where wireworm had infested.

Other interesting observations include:

- The use of black plastic mulch appears to assist in deterring wireworm as it absorbs heat and creates a hot surface for the seed.
- Mesurol® has an anti fungal agent and so is capable of being effective for several weeks i.e. until the plant has emerged and is growing.
- Chlopyrifos is only effective while it is in the soil, i.e. until washed out by the next irrigation.
- Mesurol® is an attractant i.e. bait not a deterrent as are the other systems.
- Cost works out to approximately \$10/ha.

The trial is still in progress and will be reported on in the 2000/2001 Technical Annual Report.

Reference:

Strickland, G. R. and Collins, S. G. (1987). Chemigation with chlorpyrifos (Lorsban 50 E. C.) a potential hazard of rockmelon production. Proceedings of Tropical Agricultural Entomology 4<sup>th</sup> Workshop, Darwin 10-15 May pp 34-35.

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**PROJECT: VEK006 Asparagus Colletotrichum Control**

**Project Officers: J. Bright**

**Location: Katherine Research Station**

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**Objective:**

***To screen fungicides for the control of Colletotrichum gleosporioides f.sp. on asparagus.***

#### **Progress Report:**

Work is suspended as commercial planting has been removed and no further asparagus is growing in the region. There is some interest in the region to trial a small plot of asparagus under buried drip tape in the future. This may justify reviewing fungicide screening.

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**PROJECT: VEK007 Provide Assistance to the Vegetable Industry and Assist with its Future Expansion**

**Project Officers: J. Bright**

**Location: Katherine Region**

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***Objective:***

***Assist the vegetable industry in the Katherine region.***

**Progress Report:**

**Vegetable Discussion Group Meeting**

During 1999 and 2000, a vegetable discussion group was formed to identify the needs of the Katherine vegetable growers. Initially the group would form for a one off meeting each year, but this year it appears the group would like a follow up meeting. The items raised from the 2000 discussion group included:

**Nutrition:**

- Soil sampling.
- Sap analysis nutrition guide.
- Trials comparing different fertilisers (slow release, organic, fertigation, foliar, soil applied).
- Sap analysis brix (as indicator of plant health).
- Fertiliser requirements and application methods for region all crops.
- Fertiliser rates and timing for sweet potato in the region.

**Irrigation:**

- Efficiency of overhead/pivot.
- Tape systems-surface, sub surface, use of plastic mulch.
- Watering requirements for sweet potato in the region.

**Cultivars:**

- Cultivar trials for a range of crops.

**Post harvest:**

- Quality of fruit from the region – standards quality charts.
- Cool chain in transport.
- Freight –consolidation (central trucking and cooling point) in the region.
- Coop (group buying power- making up transport loads).
- Fungicides post harvest.
- On farm cold storage.

**Entomology:**

- False wire worm-use of Lorsban® registration/alternative.

**Pathology:**

- Etching of butternuts.
- Fungicide pre harvest.

**Management:**

- Alternatives to plastic mulch e.g. shredded cardboard jute.
- Plant densities for melons.

**Weeds:**

- Herbicide trials.
- Weed control using organic products and methods i.e. products - pine oil methods, steam, heat.

**Land and water:**

- More information from water resources on why they are assessing Katherine river water usage.

The above items were voted on (in a ranking type system) and several of the items were seen as being not so important, even by the people that raised them. It was pointed out to the growers that several of the issues raised were in fact items that the grower could look at himself ie: on farm research, with the assistance of DPIF. This has happened in a few of the cases and has resulted in departmental staff being freed up. It is planned to have a follow up meeting in late 2000 as a forum for the grower to report on the season and to determine whether the needs and wants of the growers were achieved.

**Progress Report:****Helen Springs vegetable trial**

Helen Springs station is situated 20 km south of Renner Springs. The property is in its second year of screening various vegetable varieties for their suitability to the Barkly region environment. Initially it was believed that rock melons would be successful, as the latitudinal location of Helen Springs appeared to be suitable. This project has been a very difficult one to oversee, due to the distance between KRS and the actual trial site (550 km). Due to this vast distance, we are only able to visit the site every two weeks. This means that if a problem eventuates, it is not taken care of for at least 14 days. To produce good quality rock melons the grower needs to be informed and up to date on the crops status on a daily basis. As this is not possible for us, it makes it difficult to determine the performance of such a crop in this region. Other crops being reviewed include pumpkin, corn, watermelons and honeydews.

The work is continuing and will be reported on in 2000/2001.

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**PROJECT:            Temperature Logging of Cut-flowers During Transport and Handling**

**Project Officers:    J. Kirk, NTU, M. Gosbee and S. Marte**

**Location:            BARC**

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***Objective:***

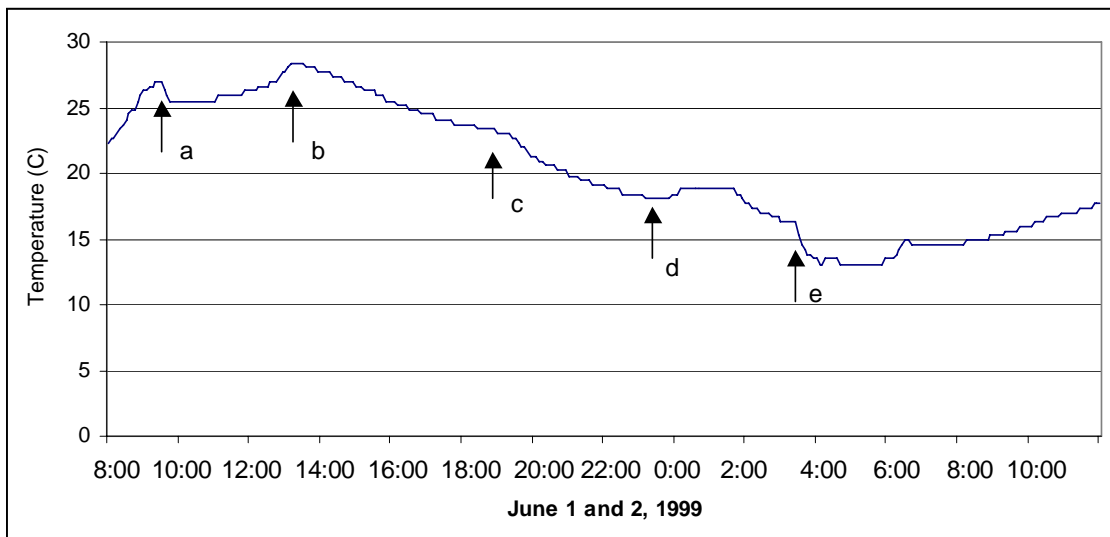
***To investigate the temperatures that cut flowers are exposed to during handling.***

Flowers leaving the Northern Territory experience a range of temperatures. This study was undertaken to determine the handling practices of the grower and at the airport, and the temperatures of the flowers during transit. The dry season was chosen as growers were concerned low temperatures in southern markets would cause damage to the flowers.

Temperature extremes were determined by enclosing data loggers inside flower boxes which were being air freighted interstate. This was undertaken with the cooperation of local flower growers, Ansett Airlines and interstate flower buyers/wholesalers. Heliconias and gingers packed in large boxes between shredded, moistened paper were used in the study. This was done five times during 1999.

**Results:**

Temperature data is summarised in Table 1. Temperatures during a 'typical' trip are shown in Figure 1. Initial temperatures at packing were 20.5 to 29.5°C. In most instances, these increased slightly prior to departure. The increase was usually in the order of 3 to 5°C, which is in the magnitude of increases experienced by the flowers during packing. All temperature during the flight decreased, some by as much as 10.7°C. Overnight, or early morning temperatures at interstate destinations were lower than expected, reaching 6.9°C in Sydney. Temperature data from the five trips is summarised in Table 1.



**Figure 1.** Temperature recorded during a trip from Darwin to Sydney on 1 June 1999. Points of interest are: (a) loggers placed in boxes with flowers, (b) plane leaves Darwin airport, (c) approximate time plane arrives in Sydney, (d) period over night in some temperature controlled environment such as a coolroom, (e) flowers at open air markets

**Table 1.** Summary of temperatures recorded during transport in June to October , 1999 (°C)

	Darwin - Sydney			Darwin – Perth	
	1 June	8 July	10 August	25 September	3 October
<b>Average temperatures<sup>1</sup></b>					
Monthly maximum temperature - Darwin	30.6	30.4	31.3	32.4	33.1
Monthly minimum temperature – Destination	10.5	9.4	9.7	8.3	8.0
<b>Datalogger temperatures</b>					
Maximum temperature	28.4	25.6	27.3	31.1	32.6
Temperature at packing	25.6	20.5	25.2	28.8	29.5
Temperature prior to flight	28.4	25.6	23.9	31.1	28.8
Temperature after flight	23.2	23.0	18.8	20.4	28.0
Minimum temperature recorded	13.1	9.4	6.9	11.6	16.0

<sup>1</sup>Bureau of Meteorology Climate and Consultancy Section, Darwin.

**Conclusion:**

Monitoring temperature was a useful exercise in determining what really happens to flowers once they are harvested. High temperatures at the airport were equivalent to ambient temperatures in Darwin. These would also be equivalent to shed temperatures if the flowers were left in the shed for a day prior to packing. There was no evidence indicating that flowers were left in the sun and got excessively hot. This is occasionally reported by growers, and renders the flowers unsaleable. Low temperatures in southern markets were cooler than expected, and cold enough to potentially cause chilling damage. However the flowers were at these temperatures only for short period and damage is unlikely.

Quality and vase life may be increased by cooling flowers prior to packing. It may also be beneficial to educate wholesalers and florists to keep flowers between 15 and 20°C.

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**PROJECT:           The Effect of Low Temperatures on the Vase Life of *H. psittacorum***

**Project Officers:   J. Kirk (NTU) and M. Gosbee**

**Location:           BARC**

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**Objective:**

**To determine the optimum storage temperature for two *H. psittacorum* cultivars, 'Golden Torch' and 'Petra'.**

**Introduction:**

Temperature control is the single most effective method for prolonging the shelf life of horticultural produce. This experiment aimed to demonstrate the effect of low temperatures on the storage life of *H. psittacorum*. This species is one of the most commonly produced in the Darwin region. Two cultivars were chosen to detect any possible differences. These were *H. psittacorum* hybrid 'Golden Torch' and *H. psittacorum* cv. 'Petra'.

**Materials and Methods:**

Thirty-two stems of each variety were harvested at 7.30am on Wednesday 9 September 1999. Flowers were loaded into an air conditioned vehicle and transported to laboratory. Twenty-four uniform stems were selected on the basis of flower maturity (bract opening), damage and stem length. Poor quality stems were discarded. Stems were cut between 80 – 100 cm and randomly allocated to treatments. They were kept in large upright cylinders filled with tap water. Cylinders had been sterilised using hypochlorite solution. Stems of 'Golden Torch' had all leaves stripped, while one leaf was left at flower height for 'Petra'. This is current industry practice for these cultivars. Stems were then placed in one of four treatments. Actual measured temperatures of the coolrooms are presented in brackets:

- 20°C (21-23°C)
- 16°C (15-17°C)
- 12°C (10-12°C)
- 8°C (7-9°C)

Measurements of flower quality were taken every third day. A scale of 1 to 5 was used to record quality, 1 = excellent, 2 = good, 3 = saleable (first signs of aging), 4 = would still look alright in a vase, 5 = dead, too damaged to keep in a vase. Records were also kept of the opening stage of bract, the condition of bracts and leaf blades and spots on bracts and leaf blades. Bract blackening was measured in millimeters. Dayflower number and condition was also noted, particularly if they blackened and dropped from the stem.

Flowers were removed from the low temperature treatments to 20°C at weekly intervals and further deterioration recorded. This was done to detect chilling damage, which often manifests after removal to warmer temperatures.

**Results:**

**'Petra'**

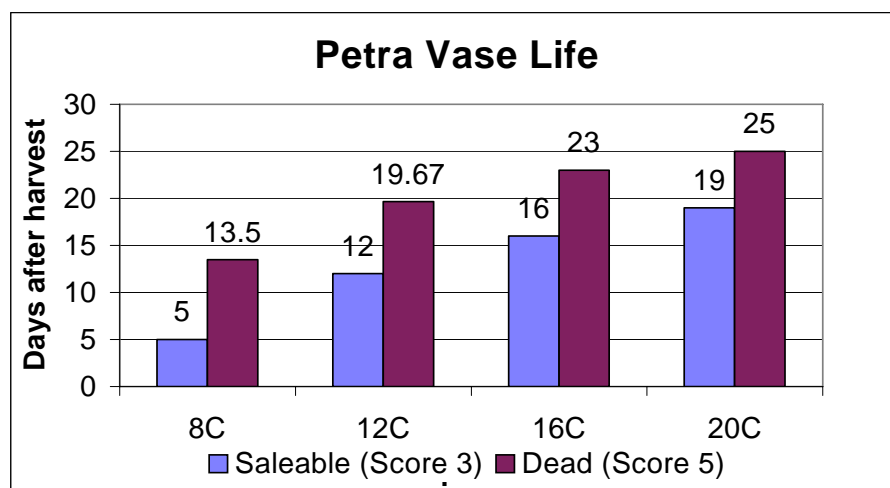
'Petra' stored at 8°C showed first signs of chilling injury after five days. Temperatures of 16°C or 20°C gave 'Petra' the longest vase life; 20°C slightly longer (Figure 1). On day 12, two thirds of the

flowers stored at 8°C had reached a score of 5. Bracts had shown severe blackening and loss of turgor. The tips of bracts along the keel had curled and day flowers were black and hanging and dropping. The edges of leaf sheaths had started to curl and blacken along edges.

'Petra' stored at 12°C first showed signs of deterioration on day 7 but this was minimal. By day 12, all flowers except for 1 had reached the point where they would not be able to be sold (score of 3). By day 19, all but 2 flowers were unsuitable to be left in the vase.

At 16°C slight flower deterioration first showed on day 7 for two of the six flowers. On day 12 one of the flowers which had been at this initial temperature for one week and then removed to 20°C had reached a rating of 4 ½. One flower lasted for 37 days. This illustrates the variability in vase life which is common with these flowers.

Once flowers were removed from 8°C and 12°C to 20°C they showed more blackening. This is common with chilling damage that the symptoms appear when the plant is placed at warmer temperatures.

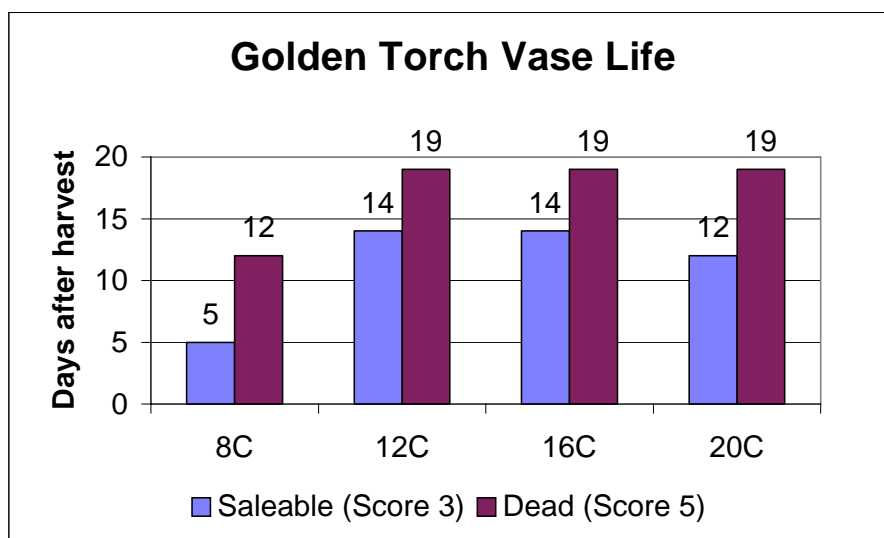


**Figure 1.** Vase life of *H. psittacorum* 'Petra' stored at various temperatures

#### 'Golden Torch'

A similar response to 'Petra' was recorded when 'Golden Torch' were stored at 8°C, with reduced shelf life due to chilling damage. On day 12, all six flowers stored at 8°C had reached a score of 5. Bracts showed severe blackening and loss of turgor. The tips and edges of bracts along the keel had curled and day flowers were black and hanging and dropping. Signs of exuding sticky pollen droplets appeared externally on unopened bracts.

Temperatures of 12, 16 and 20°C gave 'Golden Torch' vase life of 19 days in this experiment. This lack of response to temperatures above 12°C was quite different to 'Petra'.



**Figure 2.** Vase life of *H. psittacorum* 'Golden Torch' stored at various temperatures

**Conclusion:**

This experiment has shown that both 'Petra' and 'Golden Torch' suffered chilling damage at 8°C. Those flowers that remained at their original temperature for three weeks were more stable and took longer to deteriorate than those removed after one and two weeks to 20°C. Chilling injury was more obvious when flowers were removed from low temperatures to 20°C. The measure of vase life to score of 3 is important as it represents the saleable life of the flowers. 'Golden Torch' ceased to be saleable after 14 days while 'Petra' had a minimum vase life of 12 days. Interestingly, the vase life of 'Petra' increased with increasing temperature while 'Golden Torch' remained nearly identical, even slightly declining at 20°C. Blackening was, however, greater at 12°C. If one temperature had to be selected to store these two cultivars, it would be about 18°C.

Thanks to Kai and Lucy Hansen for donation of the flowers used in this experiment.

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**PROJECT:**            **Vase Life Extension for *C. australasica***

**Project Officers:**    **S. Marte and M. Gosbee**

**Location:**            **BARC**

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**Objective:**

***To determine whether sucrose solutions are suitable for increasing the vase life of Curcuma australasica and other new cut flower species.***

During vase life screening of *Curcuma australasica*, it was observed that the flowers were taking up much more water than other species recently evaluated for vase life. A series of small trials were conducted when stems were available to determine how much water was used by the cut flowers, and whether a 2% sucrose solution would increase vase life.

## 1. Water uptake of *Curcuma* sp.

Ten stems of *C. australasica* and five stems of *C. alismatifolia* stems were picked on the morning of January 19, and kept in water. To each vase 350 mL of water was accurately added. Empty vials were set up in a similar fashion to measure water loss due to evaporation. Length, maturity and weight of each stem was recorded, and then it was placed in a vase. Weight of water and stems was measured three times a week and quality recorded. Quality was recorded as a score of 1 = excellent, 2 = good, 3 = saleable (first signs of aging), 4 = would still look alright in a vase, 5 = dead, too damaged to keep in a vase. Weight loss per 100 g of stem tissue was calculated as there are large differences in the weight of a single stem.

### Results:

Water uptake of *C. australasica* averaged 40 g in three weeks after harvest. An additional 35 g was lost to evaporation. On average, this represented up to 60% of the plants initial fresh weight. The initial fresh weight of the stems decreased by almost half by the time they had completely deteriorated, which was 16.4 days (range 12-26).

*C. alismatifolia* did not last as long as *C. australasica*: 9.4 days (range 5-12). As these stems are so much lighter than *C. australasica* differences were not as easily detected. Still, water uptake was over 20% of the initial fresh weight of each stem.

These results indicate that vase solutions may be a possibility for *Curcuma* sp, as they do take up large amounts of water relative to their fresh weight.

## 2. Vase life increase with 2% sucrose solution

A second experiment was conducted on 11 February 1999. Four stems of *C. australasica* were placed in water and another four in a 2% sucrose solution. These flowers were very mature with many day flowers. The stems in sucrose lasted an average of eight days until first signs of aging were observed, compared to those in water which lasted only five. Both flowers were considered not suitable for a vase at 12 days after harvest (range 10 to 14).

More flowers were harvested on 1 March. Several species of *Curcuma* were available as well as some *Globba* sp. These are named in Table 1. Again, half the stems from each species were placed in either tap water or a 2% sucrose solution. Vase life was evaluated as described. Heavy rain for several days preceding the experiment may have affected vase life.

Unfortunately the increase in vase life with the sucrose solution was not repeated in the second experiment. For the three *Curcuma* species trialled, those kept in water lasted a maximum of one day longer than those in sucrose. The addition of sucrose to the vase water of *G. winitii* reduced their vase life considerably. This was evident at the first signs of ageing, and the difference increased when the flowers were judged unsuitable for a vase. 'Mauve' again had a longer vase life than 'Large white'.

**Table 1.** Vase life of flowers in water or 2% sucrose solutions

	Stems	Days to first ageing		Not suitable for vase	
		Water	Sucrose	Water	Sucrose
<i>C. australasica</i>	6	10	9	11	10
<i>C. cordata</i>	2	5	5	7	6
<i>C. alismatifolia</i>	2	6	5	7	6
<i>G. winitii</i> 'Large White'	4	9	8	19	10
<i>G. winitii</i> 'Mauve'	4	23	15	33	20

**Conclusion:**

The lack of available stems and variation in the maturity of individual stems for each experiment limits the interpretation of the results. This work will be continued as more material becomes available to investigate differences in maturity of the stems in these treatments and also to determine whether other additives to vase water may increase the life of cut flowers.

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**PROJECT:           Improving Heliconia Productivity NCD001****Project Officers:   M. Hout, M. Connelly and D. Marcsik****Location:           Growers Properties**

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Two meetings were held with the cut-flower growers group to identify the issues influencing their understanding of heliconia nutrition. At the first meeting, some 25 growers identified issues which highlighted the need for knowledge on how nutrition and nutrient balance influenced yield, flower quality and plant health. These main areas accounted for nearly 70% (50 listed issues) of all grower responses with the remaining responses spread over seven other areas such as colour, vase life, cost, etc (Table 1).

**Table 1.** Industry needs analysis of heliconia nutrition

**YIELD**

- healthy plants with good yield;
- high yield;
- maximum potential production;
- better production e.g. more flowers for a longer period;
- good flowering – hence production;
- higher yield;
- good yield;
- increased yields - reduction in wastage of fertilisers and residues;
- good yield;
- quantity;
- high production;
- max production out of minimum space.

**QUALITY**

- top quality;
- good quality;
- quality;
- quality flowers;
- quality;
- top quality;
- improvement in flower size and strength;
- colour and strength.

## **BALANCE**

- how do I reduce calcium levels in soil;
- perfect balance of nutrients especially for heliconias;
- a balanced fertiliser suitable for heliconia and gingers alike with more trace elements;
- how much nutrition and when;
- how little is enough fertiliser;
- basal application of fertiliser to foliar application of fertiliser – determine application needs of the plant;
- to be able to know at a glance what your plant requires and how to fix it.

## **HEALTHY PLANTS**

- healthy plants – long lasting flowers;
- regular growth;
- good growth;
- healthy plants;
- effect of elements on productivity and disease resistance;
- optimum plant growth.

## **VASE LIFE**

- better vase life;
- longer vase life;
- is nutrition related to vase life.

## **GROWTH/PHENOLOGY**

- quicker flower growth;
- promote flowering on set weeks of the year;
- good to be able to time fertiliser with critical growth phases.

## **COSTS**

- minimum cost for maximum production;
- consistent cashflow.

## **COLOUR**

- is there any type of nutrition to increase colour depth;
- rich colour.

## **ORGANIC**

- organic to improve soil;
- how to provide an effective nutrition program using sustainable organic products in the main i.e. to keep soil organisms balanced and diverse.

## **RECIPE**

- I buy what I am told;
- nutrition program to follow as the base rule.

## **WATER**

- good water supply.

## **SAMPLE**

- what do we sample – nice to know.

## **ISSUES OTHER THAN NUTRITION**

- new plant releases;
- varieties for Territory conditions;
- new varieties;
- local market conditions.

At a second meeting, seven growers from the first meeting formed a heliconia best-practice group and prioritised the issues identified previously. Four key areas that interact with nutrition, namely irrigation, yield, growth and nutrient balance, were determined. For each of these key areas, the group identified influencing parameters, how these parameters could be quantified and who would be responsible for quantifying them (Table 2).

Data collection has commenced from each of the sites and for three cultivars, namely Golden Torch, Petra and Claw 2. It is important to note that while the process of identifying industry needs and issues proved very fruitfull, it would have been prudent to have further prioritised the issues and variables (Table 2), to a more manageable level. As it has turned out, we have not been able to address the majority of the irrigation component of this project.

**Table 2.** Industry derived variables that influence heliconia productivity

<b>Issue</b>	<b>Variables</b>	<b>How quantified</b>	<b>Who to monitor</b>
<b>Irrigation</b>	<ul style="list-style-type: none"> <li>• Quantity</li> <li>• <i>Water Quality</i></li> <li>• Delivery</li> <li>• <i>Soil type</i></li> <li>• Soil moisture</li> <li>• Environment</li> </ul>	<ul style="list-style-type: none"> <li>• Record application and timing</li> <li>• Chemical analysis</li> <li>• Irrigation method</li> <li>• Chemical/physical analysis</li> <li>• Tensiometers</li> <li>• Neutron probe</li> <li>• Temp. loggers</li> <li>• Record rainfall</li> </ul>	<ul style="list-style-type: none"> <li>• Growers</li> <li>• DPIF</li> <li>• Growers</li> <li>• DPIF</li> <li>• Growers</li> <li>• DPIF</li> <li>• DPIF??</li> <li>• Growers</li> </ul>
<b>Yield</b>	<ul style="list-style-type: none"> <li>• <i>No. flowers</i></li> <li>• Environment</li> <li>• <i>Soil structure</i></li> <li>• <i>Fertiliser</i></li> <li>• Plant health</li> </ul>	<ul style="list-style-type: none"> <li>• Flws/ linear metre?</li> <li>• Flws/sq. m ?</li> <li>• As above</li> <li>• Record amendments</li> <li>• Chemical/physical analysis</li> <li>• Record what, when and amount</li> <li>• Visual inspection roots etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Growers</li> <li>• As above</li> <li>• Growers</li> <li>• DPIF</li> <li>• Growers</li> <li>• Growers/DPIF</li> </ul>
<b>Growth</b>	<ul style="list-style-type: none"> <li>• <i>Varieties</i></li> <li>• <i>Age</i></li> <li>• Environment</li> <li>• Plant health</li> <li>• <i>Fertiliser</i></li> <li>• Phenology</li> </ul>	<ul style="list-style-type: none"> <li>• Petra. Golden Torch, Lady Di, Claw 2</li> <li>• Record plant date</li> <li>• As above</li> <li>• As above</li> <li>• As above</li> <li>• Develop later in project</li> </ul>	<ul style="list-style-type: none"> <li>• Growers</li> <li>• Growers</li> <li>• As above</li> <li>• As above</li> <li>• As above</li> </ul>
<b>Nutrient balance</b>	<ul style="list-style-type: none"> <li>• <i>Monitoring</i></li> <li>• <i>Fert. rates</i></li> <li>• <i>Fert. type</i></li> <li>• <i>Application</i></li> <li>• <i>Soil pH</i></li> <li>• <i>Water pH</i></li> </ul>	<ul style="list-style-type: none"> <li>• Leaf, Soil &amp; Sap levels</li> <li>• As above</li> <li>• As above</li> <li>• As above</li> <li>• As above</li> <li>• As above</li> </ul>	<ul style="list-style-type: none"> <li>• Growers/DPIF</li> <li>• Growers/DPIF</li> <li>• DPIF</li> <li>• As above</li> <li>• As above</li> <li>• As above</li> <li>• As above</li> <li>• As above</li> </ul>

(Note: variables in italics have been addressed)

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**PROJECT: Heliconia Cultivar Improvement NCD002**

**Project Officers: D. Marcsik, M. Hault, M. Gosbee and P. Albano**

**Location: Growers Properties**

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Twenty five new Heliconia accessions were introduced for evaluation. Only a limited number have commenced flowering with two *Heliconia orthotrica* out of possibly eight accessions, showing promise. From 130 open pollinated seedlings of *Heliconia* species, all *H. psittacorum* seedlings have flowered with 10 seedlings showing early promise for colour and good vase life i.e. 14 days.

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**PROJECT: Ornamental Ginger Breeding NCD004**

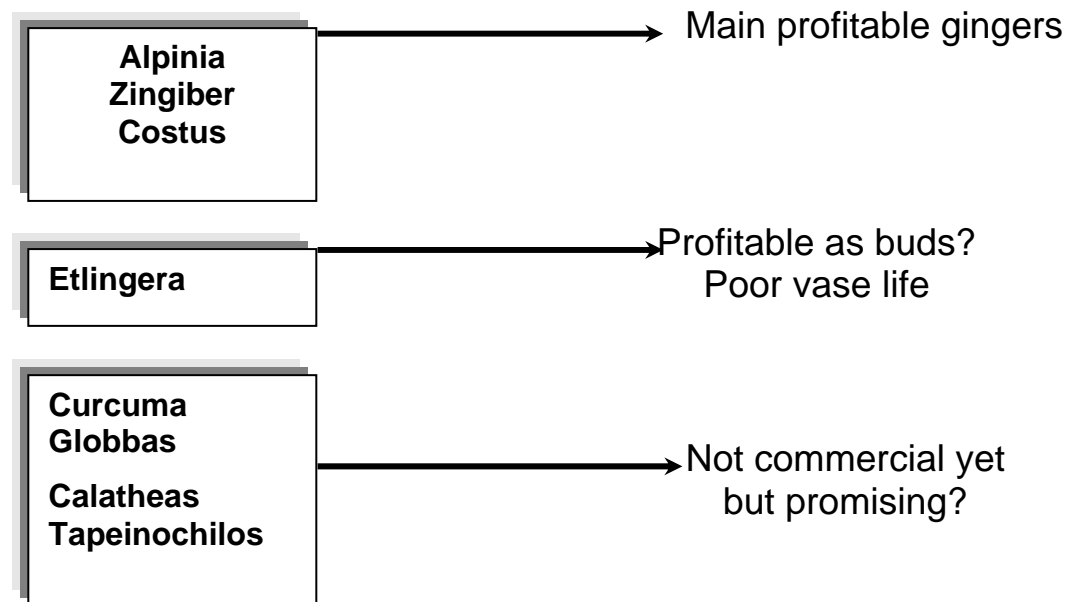
**Project Officers: D. Marcsik, M. Hault, M. Gosbee and P. Albano**

**Location: CPHRF**

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### Industry View of Gingers

Industry involvement was paramount in ensuring a commercial focus was maintained through this project. A number of meetings were held with the cut-flower growers group to determine the direction and planning of this project. From these meetings the important commercial ginger species were determined (Figure 1) and positive and negative attributes for each species identified (Table 1). These attributes form the basis of the selection criteria.



**Figure 1.** Commercial status of Ginger cut-flowers

**Table 49:** Industry analysis of commercial cut-flower ginger types

**ALPINIA**

**“Pink/Red gingers”, “Princess gingers”**

**Positive aspect**

- Attractive form
- Colour range
- Promising flower
- Unlimited market potential
- Vase life good

**Negative aspect**

- Hard to see flowers
- Dwarf ‘em
- Slow growth
- Stem thickness, weight

**Growth habit**

- Flowers/leaves scorch
- Deformed flowers
- Flowers sunburn/bleach

**Adapted to environment**

- Nematodes

**ZINGIBERS “Beehives”**

**Positive aspect**

- Vase life
- Vase life
- Vase life
- Produce lots
- We are earlier than Qld. by 6-8 weeks
- Colour change too red

**Negative aspect**

- Mushy shoots/leaves
- Not strong, bacterial rots?
- Rhizome rots

**Disease**

- Stem length
- Hard to harvest especially young
- When Qld. comes on, price crashes

**COSTUS**

**Positive aspect**

- Structure in arrangements
- Attractive
- Easy to grow
- Produce well
- Good for foliage
- Easy to pick
- Good price same as psitts

**Negative aspect**

- Do not last with leaves
- Leaves wilt
- Post harvest wilting
- Insect attacks e.g. grasshoppers
- Cold sensitive = colour fades

**Wilting leaves**

**ETLINGERA “Pearl, torch or tulip gingers”**

**Positive aspect**

- Better vase life as buds
- Flowers, flowers, flowers = productive
- Lots of colour
- Lots of forms, shapes
- Market as closed buds “candlesticks”

**Negative aspect**

- Vase life
- Vase life
- Price and market
- Market education

**Vase life**

- Impenetrable
- Heaps of shoots
- Hard to work in
- Bracts bruise
- Hard to pack
- Flower/bract rots

**Growth habit**

## Zingiber hybrids

As part of the Ginger Breeding Project, DPIF have undertaken a series of crosses with promising parents. Hybrid seedlings resulting from the 1998 Zingiber crossing program were established in a field trial at CPHRS in October 1999. Severe waterlogged conditions were encountered due to a heavy 1999-2000 wet season and this resulted in losses of some hybrids and parents. In addition, losses were experienced due to the heat from the sun. Early flowering of some Zingiber hybrids started in June, eight months from the time of establishment. A growers' project group was formed and a successful evaluation and selection process was held to assess the first of the early flowering hybrids. Further evaluation and selection will be undertaken with the group to assess the remainder of the Zingiber hybrids as flowering proceeds. Promising hybrids selected from the trial will be later evaluated commercially on grower's properties and market-tested. It is anticipated that selected hybrids will be protected under plant breeder rights and bulked up in tissue culture prior to release.

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**PROJECT:           Cut-Flower Product Diversity NCD005**

**Project Officers:   D. Marcsik, M. Gosbee and M. Hout**

**Location:            BARC**

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New cultivars and species of the genera *Curcuma* and *Globba* were assessed in a field trial at BARC. Thirty *Curcuma* and four *Globba* accessions were assessed during the reported period. For most *Curcuma* accessions, plants were evaluated under the full sun and 70% shade conditions while all *Globba* accessions were evaluated under 70% shade only.

Three *Curcuma* species did not perform well under the full sun, namely *C.roscoeana*, *C.parviflora* and *C.cordata*. However, *C. alismatifolia* cv. "Pink" performed well under the full sun and there was an obvious increase in stem length of this accession when grown under 70% shade, however these stems had a tendency to lodge easily after heavy rains or winds. *C. rubescens* grew well under the full sun and shade but plants did not flower. *C. elata* grew and flowered well in full sun and shade.

The following *Curcuma* species warrant further evaluation: two accessions of *C.elata*, seven accessions of *C.australasica* and *C.alismatifolia* cv."Pink". Accessions found unsuitable were *C.rubescens* and *C.domestica* due to poor flower production. Two *Globba* accession showed promise vis. *Globba winitii* cv. "Large White" and "Mauve". Further introductions of *Curcuma* and allied genera continues.

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**PROJECT: Nursery and Flower Industry Promotion NCD009**

**Project Officers: M. Connelly, J. Thomas and M. Hoult**

Location: BARC

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Assistance was provided to NIAANT for the Nursery Industry Association of Australia National conference held in Darwin in April, 2000. Over 300 delegates attended this national event. DPIF assisted with workshops and seminars during the conference. Development of a "expression of interest" package for potential investors in the NT nursery industry was also undertaken to coincide with the conference.

A cut-flower poster on the Top End industry was developed in collaboration with the cut-flower growers group. This was exhibited at the National Flower conference in Gosford where NT growers were represented.

An *Alpinia purpurata* hybrid named "Federation Lady" was developed by DPIF in collaboration with the NT Centenary of Federation committee. This Territory developed flower was to represent the Northern Territory at all major events marking the Centenary of Federation celebrations throughout the country.

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**PROJECT: Implementation of NIASA – Nursery Industry Accreditation Scheme Australia NCD010**

**Project Officers: M. Connelly, A. Daly and M. Hoult**

Location: Nurseries

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Two wholesale nurseries maintained full accreditation under NIASA. In addition to these nurseries, one new business was accredited. Five nurseries are proceeding with accreditation and are developing their businesses to a standard that will ensure accreditation. Funding for NIASA implementation was received from HRDC to allow for workshops to be held on growing media management and "Waterworks", the national learning module for irrigation management in nurseries.

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**PROJECT: Nursery Product Diversity NCD011**

**Project Officers: M. Hoult, D. Marcsik and C. Ford**

Location: BARC

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Approximately 120 *Euphorbia x milli* hybrid accessions from Thailand were imported during the reported period. More than 70% of these accessions were destroyed in the post entry quarantine phase, principally due to bacterial soft rot infections. A number were also screened for possible virus infection following suspect leaf symptoms. None of the material showed evidence of viral infection.

Forty five accessions have been released and represent a broad range of colours and flower types. These are currently being bulked up for release to industry. NIAN T has indicated an interest in trade marking some accessions as they represent a new product for the Australian ornamental market. Assistance was also provided to a number of NIAN T sponsored imports of a range of ornamental plants.

## INTERSTATE AND OVERSEAS VISITORS

### July 1999

- Peter Schofield (Schofield and Robertson) – AZRI
- Malcolm Smith (QDPI Bundaberg) – KRS
- Philip Toy (Pivot) – KRS
- Jim Peacock (Director CSIRO) and Steven Sykes (CSIRO Merbein) – KRS
- Shane Mahany (ABC Melbourne) – KRS
- Doug McCullum (Crop Care) – KRS

### August 1999

- Graham McGreggor (QDPI, Bowen) and Gavin Berry (QDPI, South Johnstone) – BARC

### September 1999

- Ken Matthews (Director General of AFFA) – CPHRF
- Jeremy Garland (interim Chairman of the Australian Mango Industry Association) – KRS

### October 1999

- Ian Bally (QDPI) and Peter Johnson (AgWA) – National Mango Breeding Project – CPHRF
- Lynton Vawdrey (QDPI – Plant Pathology) – BARC
- Peter Fahley (former Director of Colly Cotton) - KRS
- Ian Bally (QDPI) and Peter Johnson (AgWA) – National Mango Breeding Project – CPHRF

### November 1999

- Raul Hernandez (Philippines-Australian Business Council) – KRS

### December 1999

- Dr Terry Sheales (Chief Commodity Analyst ABARE) – TTRF

### January 2000

- David Leng (and members of the consortium Advinco Group) – KRS
- Peter Gillette (mango nurseryman from North Queensland) – KRS

### February 2000

- Lee Farrell (Wheatbelt Computer Systems Pty Ltd) – KRS
- John Daly (Scotts Australia) – KRS
- Orville Hildabrand and Peter Tandy (Fertico) – KRS

### March 2000

- South African Banker/Investor – CPHRF

### April 2000

- Yan Diczbalis (QDPI) and Nick Richards (AgWA) – Cocoa Production Workshop – BARC
- Judy Noller (QDPI Marketing) – BARC
- Mark Napier (Australian Horticulture Corporation) and Les Baxter (HRDC) – BARC
- Yan Diczbalis (QDPI) – BARC
- Prempre Na Songkhla (editor of Kehakankaset Magazine) – KRS

### May 2000

- Sandy Pate (AgWA) – KRS

### June 2000

- Dr Vong Nguyen (Special Research Horticulture, NSWAg) – BARC
- Dr Wendy Morgan, Mangy Chew (AgVic), Samantha Bray (QFVG) – BARC
- Anne Frodsham (Nursery Industry Office, SARDI)
- David Survery (Chief Quarantine Officer (Plants) for Papua) – PEQ BARC
- Ashley and Bradley Dawson (Rockmelon growers from Victoria) - KRS

## STAFF VISITS

### July 1999

- Chris Wicks and Niranjan Dasari – North Australian Cocoa Development Alliance and RIRDC meeting. in South Johnstone Qld.

### September 1999

- Paul Albano – Farm Injury and Prevention Conference in Cairns Qld.

### October 1999

- Geoff Kenna and Nagarajah Sellappah – 5<sup>th</sup> National Table Grape Conference in Mildura Vic.
- Melinda Gosbee – RIRDC Asian Food Program 5-Year Plan Meeting in Canberra ACT.

### November 1999

- Geoff Kenna – Australian Vine Improvement Association Meeting – Mildura Vic.
- Melinda Gosbee – ASEAN and APEC Post-harvest Seminar in Vietnam.
- John Mansfield and Jeremy Bright – National Citrus Field Day in Yanco.

### December 1999

- David Hamilton – National Mango Breeding Program – Mereeba Qld.

### January 2000

- Vinod Kulkarni – National Mango Breeding Program Field Day - Southedge Qld.
- Chris Wicks – North Queensland Longan and Rambutan Growers Meeting in South Johnstone Qld.

### February 2000

- Greg Owens and Jeremy Bright – Mango Growers Trip to North Queensland.
- Melinda Gosbee – RIRDC Asian Vegetable Meeting in Sydney, NSW.

### April 2000

- Matt Darcey – North Australian Vegetable Development Workshop – Brisbane Qld.
- Francene Brown – Australian Mango Conference in Cairns, Qld.
- Vinod Kulkarni - Australian Mango Industry Association Conference Cairns Qld.

### May 2000

- Francene Brown – Australian Horticulture Export Development Network in Shepparton Vic.
- Geoff Kenna – Central Land Council Study Tour of Israel.
- Doris Marcsik – Molecular Marker Course, Lismore NSW.

### June 2000

- Francene Brown – Mango Growers trip to the Zespri Kiwifruit Export Operations in New Zealand.
- Chris Wicks – Trip to Thailand (Longan, Durian and Rambutan production), Vietnam (Mid-Term Review of ACIAR Program – Phytophthora in Durian)

## ORGANISATION OF SEMINARS, WORKSHOPS AND FIELD DAYS

### August 1999

- Soil Assessment Workshops in Darwin and Katherine by Geoff Kew (Kew/Wetherby)
- Mango Nutrition Workshop in Darwin and Katherine by Ted Winston.
- Panama Disease Workshop in Darwin by Drs Natalie Moore, Suzie Bentley and Mr Ken Pegg.
- Produce Supplier Scheme Workshop in Katherine by Ian Golding

### September 1999

- Cocoa Workshop in Darwin by Tony Lass (Cadbury-Schweppes) and David Lim (Consultant).
- Endosulfan Label Changes by Greg Bowering (NTU)

### October 1999

- Citrus Irrigation Workshop in Darwin and Katherine by Chris Wicks.
- Rambutan Nutrition Workshop by Chris Wicks.
- Vietnamese Vegetable Growers Field Day on Min Bang's Property at Buckley Road, Humpty Doo by Kevin Blackburn, Mark Traynor and Greg Owens.

### November 1999

- Water Works in Darwin by Chris Rolfe NSW Ag.
- Heliconia Nutrition by Mark Houlton and Doris Marcsik

### December 1999

- Mango Nutrition Workshop Follow-up in Katherine

### January and April 2000

- Rambutan Nutrition Workshops by Chris Wick

### February 2000

- Potting Media Workshop in Darwin for Nursery Industry by Keith Bodman
- Potting Media Workshop in Darwin for Allied Industry by Keith Bodman
- MYBO Workshop for horticultural/agricultural/pastoral producers by NTU - KRS
- Rambutan IPM Workshop by Chris Wicks

### April 2000

- Workshop Planning Cocoa Production by Chris Wicks, Yan Diczbalis, Nick Richards, John Orchard and Gerry McMahon – BARC
- Katherine Farm and Garden Day – KRS
- Nursery Industry Association of Australia National Conference in Darwin

### May 2000

- Citrus Field Day in Katherine by John Mansfield and Greg Owens
- **Strategic Planning Meeting for Horticulture Development on Aboriginal Land in Tennant Creek**
- **Cut-flower Irrigation Workshop by Chris Wicks**

### June 2000

- Pests and Diseases Workshop in Alice Springs
- **R&D Seminar in Aileron**

## INTERSTATE AND OVERSEAS SEMINARS/WORKSHOPS/PRESENTATIONS

### November 1999

Quality Assurance in Agricultural Produce

19<sup>th</sup> ASEAN/1<sup>st</sup> APEC Seminar on Postharvest Technology - Ho Chi Minh City Vietnam.

## PUBLICATIONS, CONFERENCE PAPERS AND LECTURES

Mark D. Hoult and Doris Marcsik (2000). From Rainforests to City Florists: A Breeding Strategy for Cut-flower Gingers. *Heliconia Society International Bulletin* 5(1-2) : p8-11.

Gosbee MJ and Lim TK (1999). Postharvest handling of 'Asian vegetables in the Northern Territory'. *ACIAR Proceedings* 100:456-460.

Geoff Kenna (1999). The use of dormancy breaking agents for early table grape production in the Northern Territory; Murray Valley Table Grape Growers Council 5<sup>th</sup> Australian Table Grape Technical Conference Proceedings; *Table Grapes Into The Next Century*: p17-24.

Geoff Kenna (1999) The commercial table grape industry in Central Australia: Murray Valley Table Grape Growers Council 5<sup>th</sup> Australian Table Grape Technical Conference Proceedings: *Table Grapes Into The Next Century*: p115-118.

V. Kleinhenz, M. Gosbee, S. Elsmore, T.W. Lyall, K. Blackburn, K. Harrower and D.J. Midmore. (2000). Storage methods for extending shelf life of fresh, edible bamboo shoots [*Bambusa oldhamii* (Munro)]. *Postharvest Biology and Technology* 19(3):253-264.