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**HORTICULTURE
DIVISION TECHNICAL
ANNUAL REPORT
1996/97**

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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 who have worked on horticulture-related projects.

The Horticulture Division provides research, development and extension services to horticultural industries in the Darwin, Katherine and Alice Springs regions of the NT. Activities of the Division cover most of the fruits, vegetables, nursery and cutflower crops. The following strategies are used to satisfy the goal of the Division:

- Provide appropriate genotypes of commercial species through varietal trials for all crop categories.
- Develop optimum production systems for selected crops, encompassing irrigation, nutrition and post harvest aspects.
- Support expansion with an orientation towards export through information services and participation in land use planning and other infrastructure development.

Work reported in this report will be 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 V Kulkarni
Banana	Mr K Blackburn
Table Grapes	Mr G Kenna
Tropical Exotics	Dr T K Lim
Dates	Mr G Kenna
Citrus	Ms D Jaensch
Sub-Tropicals	Mr G Kenna
Cashew	Dr V Kulkarni

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>
Annual Crops	Mr M Smith
Asparagus	Mr M Smith
Tropicals	Mr M Hoult
Australian Natives	Mr G Kenna

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

	1992	1993	1994	1995	1996
MANGO					
Production (Tons)	3984	3810	5715	5598	5472
Value (\$M)	10.92	13.73	15.83	19.67	19.41
Average Price (\$/Kg)	2.75	3.61	2.77	3.51	3.55
BANANA					
Production (Tons)	2800	2381	3154	2957	3798
Value (\$M)	3.47	2.62	3.56	2.97	4.35
Average Price (\$/Kg)	1.24	1.10	1.13	1.01	1.15
TABLE GRAPES					
Production (Tons)	1310	1149	1130	1600	1326
Value (\$M)	4.54	4.42	4.63	6.40	6.10
Average Price (\$/Kg)	3.47	3.84	4.10	4.00	4.60

The value and production figures for bananas increased significantly this year, up 28% and 46% respectively. This can be attributed to one major grower, who has planted 75ha of bananas during the past 2 years.

Whilst the production and value of table grapes decreased this year, the average price per kilogram increased by 15%.

Table 2. Production and value of fruit and vegetables for 1995 and 1996

	CROP PRODUCTION		VALUE	
	(Tons)		(\$M)	
	1995	1996	1995	1996
FRUITS				
Mango	5598	5471	19.671	19.410
Melons	2633	2599	2.916	3.691
Table Grapes	1600	1326	6.400	6.100
Banana	2957	3798	2.973	4.351
Others	768	595	2.184	2.925
Sub-total	13556	13790	34.144	36.477
VEGETABLES				
Asian vegetables	678	797	1.718	2.269
Cucurbits	1248	1014	1.021	0.925
Other	682	1307	1.272	1.745
Sub-total	2608	3118	4.011	4.939
TOTAL FRUITS & VEGETABLES	16164	16908	38.155	41.416

As mentioned in the 1995/96 Technical Annual Report, the data presented in Table 2 is incomplete as most of the Asian vegetable trade is vertically integrated and goes into southern markets without going through traditional marketing chains.

HIGHLIGHTS FOR THE YEAR

- The Division organised, under the auspices of the Horticulture Advisory Committee (HAC), a strategic planning workshop from which a Northern Territory Horticulture Industry Strategic Plan was developed.
- The Division provided substantial input into the development of a poster for Asian vegetables.
- The Division conducted a survey of the nursery and the cutflower industry to identify areas of work the Department should conduct in future.
- The Division identified a new mango variety on a grower's property and assisted the grower to register the variety.
- Together with the Commercial Development Division, the Division assisted rambutan growers in trialing the new packaging method (punnets) in the markets.
- The Division set up an 'Exotic Pests & Diseases Working Group' with industry representation, to formulate strategies to effectively deal with future incursions of insect and disease problems.
- Through the Division's active participation, a number of blocks for horticultural development were released at Lambells Lagoon.

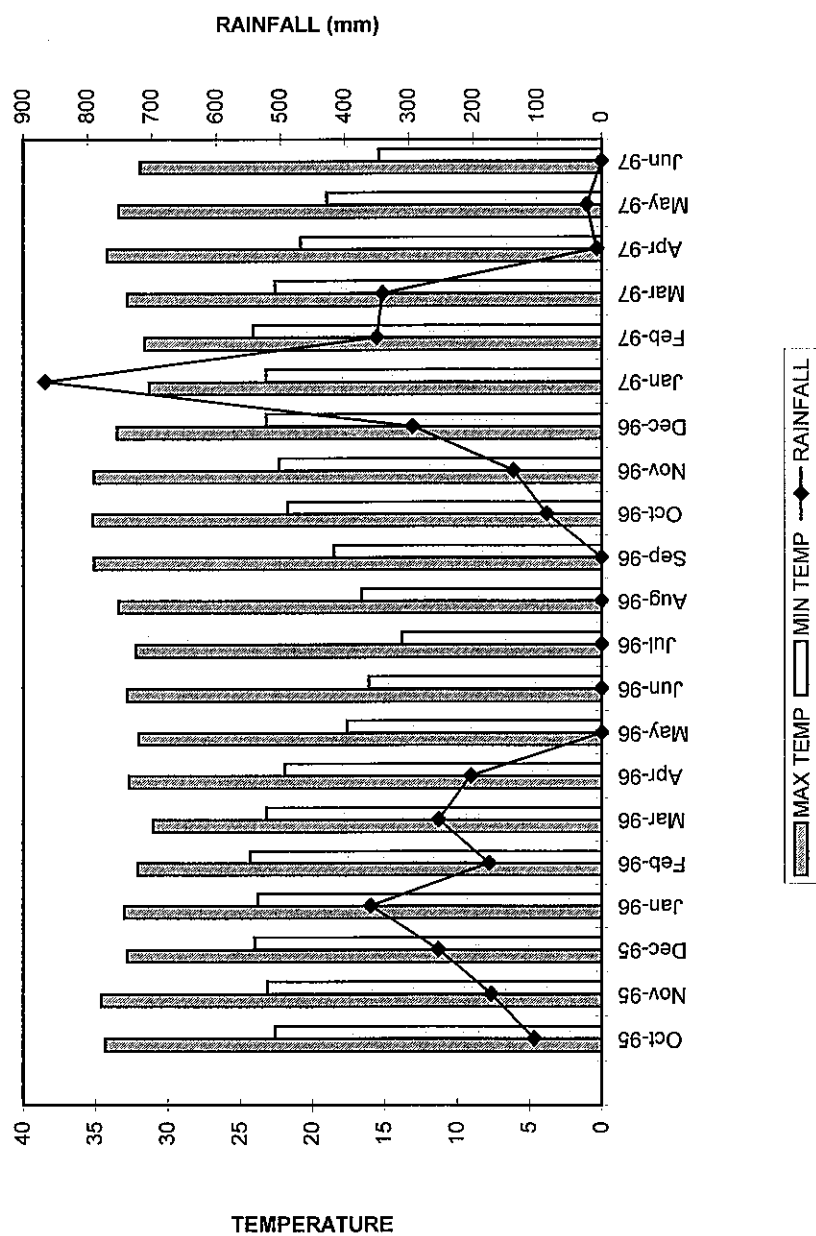
ACKNOWLEDGMENTS

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 research conducted and optimised our resource utilisation.

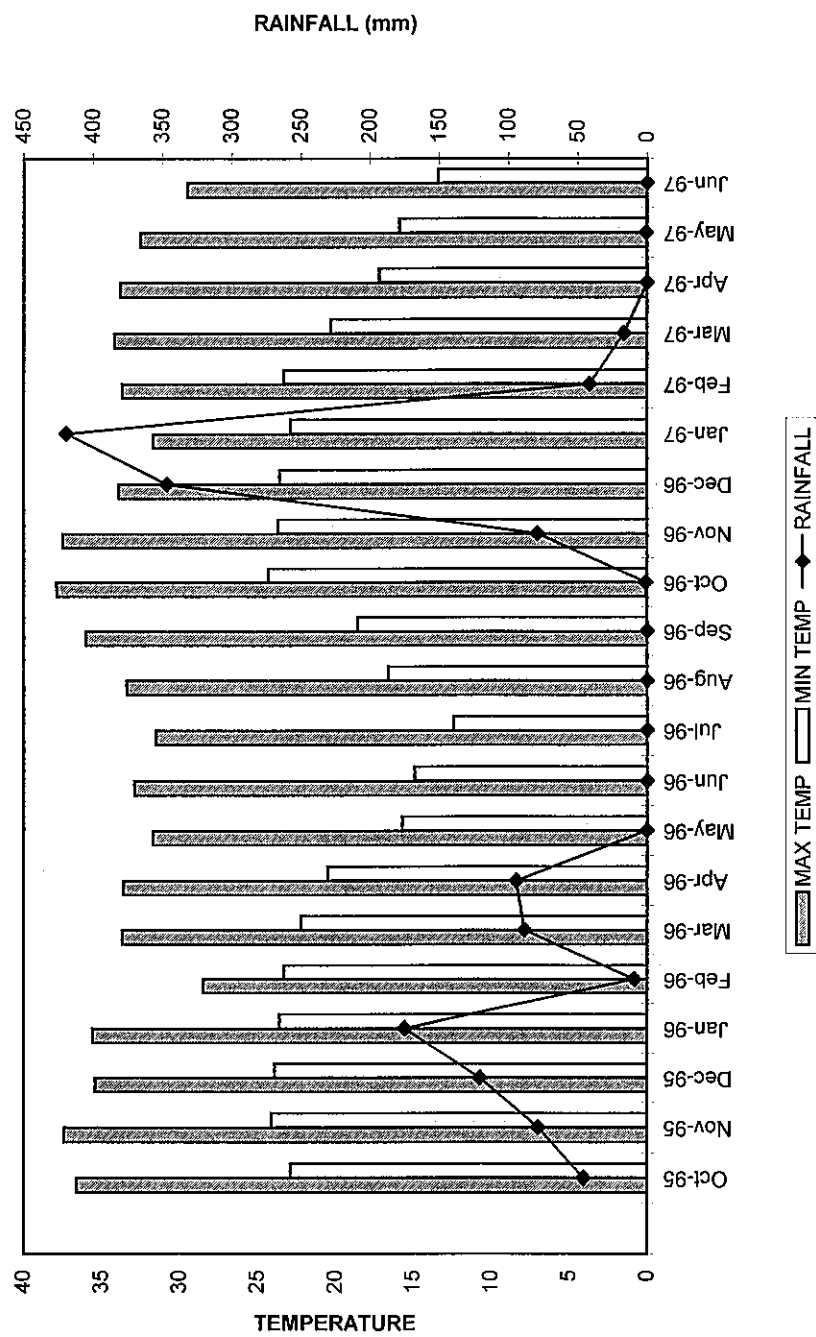
Assistance provided by the Rural Industry Research and Development Corporation is also appreciated.

Dr Niranjan R Dasari
Director, Horticulture Division

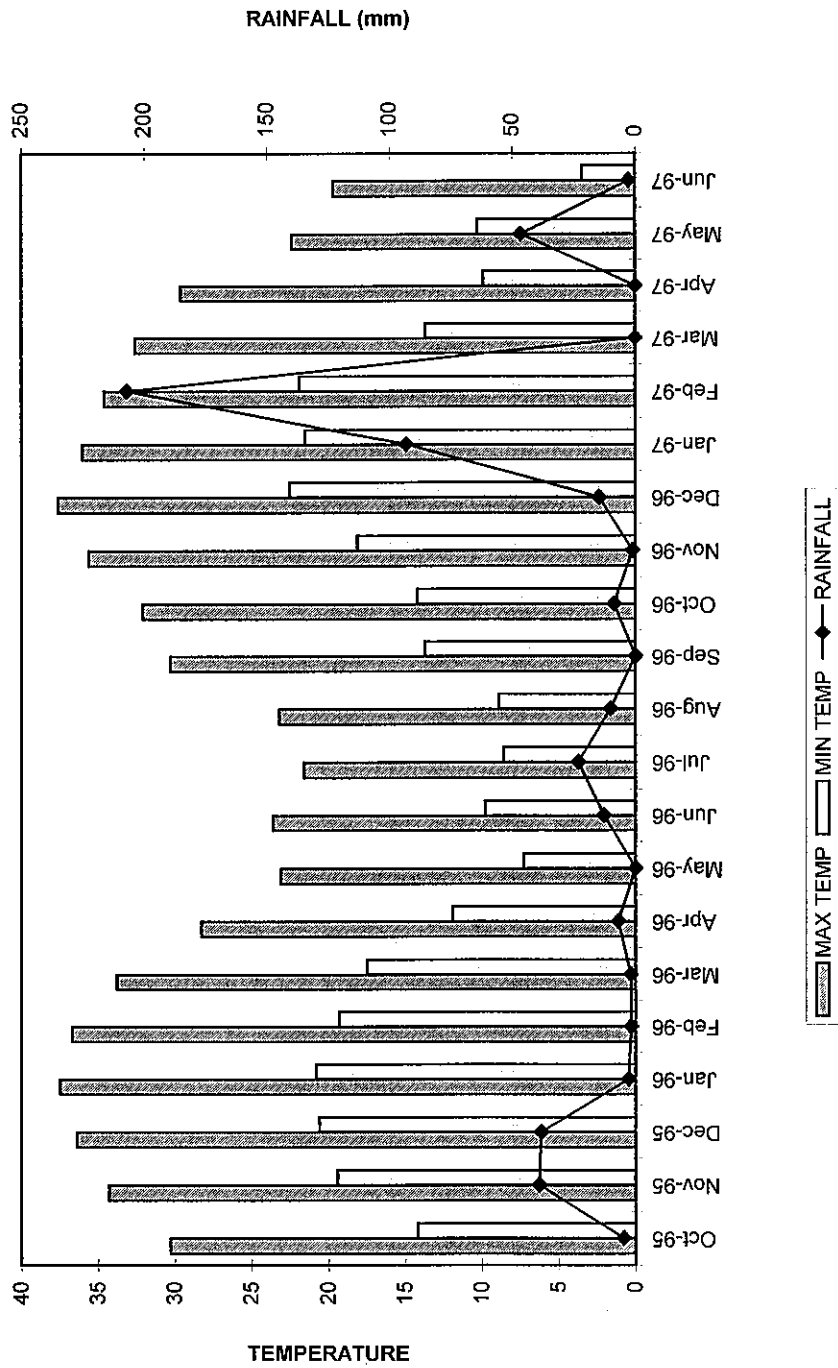
COASTAL PLAINS HORTICULTURE RESEARCH FARM



KATHERINE CLIMATIC INFORMATION



ALICE SPRINGS CLIMATIC INFORMATION



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¹ Left January 1997

⁴ Left September 1996

⁷ Joined January 1997

¹⁰ Joined February 1997

² Joined May 1997

⁵ Left October 1996

⁸ Joined February 1997

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ABBREVIATIONS USED THROUGHOUT REPORT

ABGC	Australian Banana Growers Council
AQIS	Australian Quarantine and Inspection Service
AZRI	Arid Zone Research Institute
BARC	Berrimah Agriculture Research Centre
CPHRF	Coastal Plains Horticulture Research Farm
CSIRO	Commonwealth Scientific Industrial Research Organisation
das	days after sowing
DDRS	Douglas Daly Research Station
DPIF	Northern Territory Department of Primary Industry & Fisheries
GA	Gibberellic Acid
HRDC	Horticultural Research and Development Corporation
hwd	hot water dip
IPM	Integrated Pest Management
KRS	Katherine Research Station
map	modified atmosphere packaging
NIAA	Nursery Industry Association of Australia
NIANT	Nursery Industry Association of the Northern Territory
NTHA	Northern Territory Horticulture Association
NTU	Northern Territory University
PBZ	Paclobutrazol
QDPI	Queensland Department of Primary Industries
R&D	Research and Development
RIRDC	Rural Industries Research and Development Corporation
TTRF	Ti Tree Research Farm
UCQ	University of Central Queensland
WAAG	Western Australia Department of Agriculture

4.1.1 MANGO VARIETAL TRIALS

V Kulkarni and D Hamilton

The Australian mango industry is based on a single cultivar, Kensington Pride. The need for diversification into other cultivars can be justified on two grounds. Firstly, Kensington Pride has some major limitations, such as erratic flowering and fruiting, severe sapburn, excessive tree vigour and lack of consistent attractive red blush on fruit. In the tropical environment of the Top End, these problems are further accentuated. While research in productivity improvement has given very encouraging results, introducing and evolving promising cultivars is yet another approach. In a national mango breeding project commenced in 1994, improvement of Kensington Pride is being attempted by crossing it with other donor cultivars (See 4.1.2). This project has two components (1) Introduction and multilocation testing of promising cultivars from overseas and (2) Evolving superior seedling types from monoembryonic seedlings and multilocation testing of clonally propagated progeny of the selection.

Introduction and multilocation testing of new introductions: The new introductions from India and species introduced from S.E. Asia were planted out at CPHRF and/or BARC. It is proposed to test some of the most promising types, such as Badami Model, Vanraj, Kesar, Mahmuda, Himayatpasand, Nam Dok Mai selection T5 on grower properties. Response from growers to volunteer their properties has been very encouraging. It is proposed to propagate the outstanding cultivars for evaluation on grower properties under a testing agreement. Conditions for such an agreement have been prepared.

Evolving superior seedling types from monoembryonic cultivars: From a large number of monoembryonic seedlings planted at CPHRF in 1983, one selection was found to be most promising. Tentatively named S-113, the selection from 'Glenn' seedling is similar to Kensington Pride in taste and fruit shape but has more attractive fruit with little fibre in the flesh. Time of fruit maturity is on par with Kensington Pride. It is proposed to test its performance on grower properties along with the introductions mentioned above.

One more selection identified on a grower's property is being registered with Plant Breeder's Rights. The selection has outstanding fruit quality especially fruit appearance, and has been bearing regularly for the last three years. It has been named 'Celebration'. The selection is being described on guidelines used for international registration of mango cultivars. 'Celebration' is likely to be registered by 1998.

4.1.2 MANGO BREEDING

NATIONAL MANGO BREEDING PROGRAM

V Kulkarni and D Hamilton

Although the supply of the Kensington Pride mango in Australia far exceeds that of any other mango cultivar, Kensington Pride has several inherent problems related to both production and quality which have a significant impact on producers and the market. Some of these problems can be controlled through the use of sound cultural practices and the use of plant growth regulators, but evolving superior genotypes to suit the needs is perhaps a more tangible approach.

To address this, a national mango breeding program was initiated in 1994 between CSIRO, QDPI, DPIF and WAAG. The primary aim of the program was to improve the performance of Kensington using the conventional breeding method of transferring pollen from Kensington to other cultivars with certain superior characteristics such as

- * Dwarf growth habit
- * High productivity
- * Early maturity (NT)
- * Fruit size (400g)
- * Fruit colour (blush)
- * Retention of the Kensington flavour
- * Reduced fruit internal disorders
- * Reduced sap burn and post harvest problems
- * Disease resistance
- * Longer shelf life

Other commercial cultivars of lesser importance, but with good potential and in need of improvement, such as Irwin, R2E2 and Nam Dok Mai were also included in the program. In addition to generating promising genotypes, the project also provides an excellent opportunity to study inheritance of various characteristics in mango.

Materials and Methods

Donor cultivars with the desired characteristics were selected in 1994 when the collaborative project was initiated. Sites of crossing work were decided on, taking into account the availability of sufficient number of trees in the parent cultivars. It was decided that at least 50 crosses would be generated in each combination so as to provide a reasonable chance of obtaining at least one promising hybrid per cross. The technique involved emasculation of the female parent and hand pollination with the male parent. Panicles were selected and bagged to obtain at least eight open flowers on the following day when all other flowers except the selected hermaphrodite flowers were removed before dehiscence of the anther. Stamen and bold staminodes were also removed from the selected flowers. Male flowers from the male parent were collected and left in partial shade in Petri dishes to dehisce. After examining pollen for dehiscence, pollen was carefully transferred to the stigma of the flowers of the female parent. The crossed flower was immediately covered with a small gelatine capsule to prevent further cross pollination. The capsule was removed after two days. Kensington Pride and other polyembryonic parent cultivars were used as male parents. The

successful crosses were protected against insect pests and diseases. Well developed fruits at 'late egg' stage were bagged in onion bags. After fruit maturity and ripening, kernels were sown to raise seedling progeny of the crosses. Staff and temporary assistants were trained in the method of hand pollinating mango and the preparatory work involved.

Progenies are being tested at two sites, one at South Edge Research Station in Queensland and the other at CPHRF in NT. Plant material of the successful crosses is to be sent by all the participants to the two sites. Original seedlings are to be planted in the NT, whereas grafts from these seedlings are to be planted in Queensland. After the initial evaluation, promising progenies will be further tested using clonally propagated material.

Results and Discussion

This year, the maximum number of successful progenies was generated by DPIF (173 as compared to 158 by CSIRO, 64 by QDPI and 83 by WAAG). Fruitset was better in early crosses in June and early July than in late July and August. This may be attributed to the speedy dehiscence and senescence of the pollen later in the season. Graftsticks of these will be sent to Queensland and seedlings will be planted in 1997-98 at CPHRF. Seedlings of 1994 progenies were planted at CPHRF. The total number of crossed progenies from 1994 until 1996 was nearly 1200. By the 1997 and 1998 seasons, this number is likely to reach the 1500 mark.

4.1.3 REGULATION OF VEGETATIVE GROWTH, FLOWERING AND FRUITING

V Kulkarni and D Hamilton

Improvement of productivity continues to be the foremost issue for the mango industry. The interaction between the vegetative and reproductive growth is an important factor significantly affecting productivity and seems to be acting in a somewhat opposite way in tropics and subtropics. In subtropical environments, the inability of commercial cultivars to sustain reproductive and vegetative growth in an annual cycle has been held responsible for alternation of fruiting, whereas in the tropics, excessive and intermittent growth acts as a strong counterproductive force. This difference can be explained on the basis of a crucial dual role played by the leaves in flowering, by being the sites of synthesis of a phloem- and graft-transmissible floral stimulus (Reece et al. 1949; Kulkarni 1986, 1988), as well as an inhibitor which interferes with the stimulus (Kulkarni 1988). The hypothesis, in simple terms, implicates cyclic synthesis of a floral stimulus from leaves which, on reaching an active meristem, induces flowering as long as the flower inhibitory factors are overcome. Besides the scientific significance of this evidence, there is considerable unexploited scope to apply these findings in establishing situation-specific approaches towards improving productivity.

In the tropical conditions of Darwin, the commercial cultivar Kensington Pride suffers from intermittent and pre-flower flushing. Three to four flushes are produced from harvest to flowering, the last one usually through the floral cycle, which plays a key

role by (a) preventing flowering, (b) delaying flowering and (c) staggering flowering. The resultant reduction in yield and delay of fruit maturity has a direct impact on productivity and profitability for an industry which relies heavily on the early domestic market. Soil application of paclobutrazol has been found to be an effective tool for improving flowering and yield and for advancing fruit maturity. Observations over the last five years have indicated that efficacy of paclobutrazol is diminished with untimely vegetative flushing. Prevention or removal of such untimely vegetative flush should then improve flowering and response to paclobutrazol. Preliminary trials have indeed shown that pre-flower pruning to mature flush resulted in flower induction on sub apical buds and that this response was significantly high in Cultar® (paclobutrazol)-treated trees. Post harvest pruning, although very important for training and removal of inner wood, was of little use in improving production. These findings suggested that pre-flower pruning can be used together with post harvest skirting for improving yield and quality in a higher density situation.

Material and Methods

Grafted trees on Kensington Pride seedling rootstock planted at 10 x 5m in a private property were used. Trees were initially trained for two years to form a strong framework and were three years old when the trial commenced. Treatments included pre-flower pruning, pruning in combination with paclobutrazol (PBZ), pruning alone, PBZ alone and control. For the annual pre-flower pruning treatments, whole tree pruning was undertaken manually every year in the first week of June to prune to the last mature flush. This was in addition to the post harvest removal of lower branches, selective pruning of vigorous growth which had failed to fruit in the previous season and removal of inner wood in all treatments. In between the post harvest and pre-flower pruning, there were generally three to four flushes. Pre-flower pruning left at least two of these mature flushes. Shoots were pruned below the whorl of buds. PBZ (Cultar®) was applied in the first week of January after post harvest pruning as collar drench by diluting the required volume of 25% aqueous suspension in one litre of water. Depending on tree age, rates of application varied from 2 g a.i. to 5 g a.i. per tree. Management practices were applied uniformly to all treatments. As PBZ was applied in the wet season, there was no need for irrigation following application. However, if a dry spell followed, a light irrigation was given. During the dry season, trees were irrigated from flowering to harvest. Rates of irrigation varied with tree age. Soil moisture status was monitored from May to October (flowering to maturity) with 'Enviroscan' to a depth of 10, 30, 50 and 80cm.

Observations on flowering were recorded on 20 to 30 shoots randomly tagged soon after pruning.

Results and Discussion

Observations on flowering and yield for the four years are summarised in Table 1. Maximum flowering was generally obtained in PBZ + pruning treatment followed by the PBZ alone treatment. Flowering was also early and synchronous in these treatments and was completed within six to seven weeks after pruning, whereas in the other two treatments, it was distributed between six to ten weeks. Of the four years, two (year 3 and year 6 in Table 1) were 'off' years. In these two years, the PBZ + pruning and PBZ alone treatment showed much greater promise than in the 'on' year. In PBZ + pruning treatment, profuse bud activity was noticed extending up to six buds

on the shoot giving a multiple panicle effect. In year 5 ('on' year), flowering was slightly better in pruning alone than in PBZ alone and occurred along with PBZ and PBZ + pruning treatments.

1996 (year 6) was a strongly 'off' year. Flowering and yield were low in all treatments. PBZ + pruning and PBZ alone however recorded significantly higher yields than pruning alone and the control which produced negligible yields.

As a result of the significant improvement in flowering and yield, the cumulative yield was highest in the PBZ + pruning treatment followed by PBZ alone. In year 5, PBZ alone was marginally better than PBZ + pruning perhaps because of larger tree size and also because of the 'on' year conditions. When yield was related to the canopy size, yield efficiency was highest in PBZ + pruning. By this time, control trees had attained significantly large canopies overlapping within the rows which adversely affected flowering and fruiting. Visual pest monitoring also showed higher incidence of white scales not found in the well-lit canopies of the pruned trees.

One consistent observation was poor flowering on the south west aspect of the unpruned trees. Terminal buds on these shoots remained dormant through the floral cycle and emerged later as vegetative shoots. This effect was overcome by the pruning treatment as long as flowering was ensured either by PBZ treatment or in the 'on' year. The aspect effect was not as pronounced in year 5 ('on' year) as in the previous two years.

These investigations have shown that the flower-inhibiting effect of immature vegetative flush can be overcome with pre-flower pruning and that such removal of unwanted growth during the reproductive cycle significantly improves the yield of Kensington Pride. These results need to be elucidated with our existing knowledge of promotory and inhibitory mechanisms in operation.

This approach was initiated on the basis that flowering in mango occurs as a result of cyclic synthesis of a floral stimulus in leaves in the floral cycle. The hypothesis was based on a series of grafting, deblossoming and defoliation experiments. The graft transmission experiments have also shown that leaves ironically play an equally crucial flower-inhibitory role if they are in a vegetative phase during the floral cycle and are located between the inductive leaves and the site of evocation i.e., the terminal bud (Kulkarni 1988). In addition to the presence of inductive leaves and absence of inhibitory leaves, one more requirement is the meristematic activity at the terminal bud in synchrony with the floral cycle, without which it escapes the signal from the inductive leaves.

The identity of the floral factor is not known but gibberellins seem to be the most likely candidates for the inhibitory component. The flower-promotory activity of PBZ has been attributed to its anti-GA property. The new, rapidly expanding vegetative flush is known to be a more potent source of gibberellins. The emergence of pre-flower flush almost certainly results from non-synchrony between the floral cycle. Both PBZ and pre-flower pruning seem to achieve the objective of overcoming the inhibitory role of the vigorous vegetative flush. However, pre and post emergence of vegetative flush indicates that there are different grades of inhibition operating

simultaneously in a tree. In terms of availability of the floral stimulus, the cycle perhaps commences much earlier (generally in May in Darwin) but flowering is held up on account of preponderance of inhibitors. PBZ seems to be acting on a long term basis to counteract the inhibitor and pre-flower pruning seems to be eliminating the immediate effect of new flush to turn the balance in favour of the promoter providing a favourable situation for activating the buds at the proper time. There also seems to be a link between the floral condition and bud activity. In the pruned-alone treatment, bud activity in pruned trees was resumed within a few days, whereas in 'off' years shoots on the pruned-alone trees remained dormant for a long time to come out later as vegetative shoots. Comparison of response of pruned-alone in years 3 and 4 with year 5 in Table 1 elucidates this point.

Consistent observations of poor flowering on the south west aspect was a very unique feature and operated almost certainly through some dormancy mechanism imposed by the pale green leaves on this aspect. This effect was completely overcome by pruning. Interestingly, most of the sun scald also occurred on this aspect. It is therefore tempting to attribute the 'aspect effect' to some photo-inhibitory effect, similar to synthesis of ABA-like inhibitors on photo-oxidation of xanthophylls in high light intensities (Taylor and Smith 1967).

The combination approach has perhaps opened a way for higher density planting systems in the tropics. Experience has shown that heavy pruning after harvest and hedge row systems may not be advantageous in the tropics because of reinstatement of vigour and uncontrolled return growth. It is proposed to test the application of these findings in higher density planting of Kensington Pride. A high density trial was planted at CPHRF with three spacing treatments of 10 x 10m, 7 x 7m and 7 x 5m (0.3ha in each treatment). Treatments of tip pruning and PBZ will be imposed in 1998 in the third year of the trial.

Mechanical pruning is an area that needs to be looked into. The option of mechanical or manual pruning will depend upon other factors such as tree size and number of trees. One option is a combination of mechanical pruning of the top and manual pruning of the sides.

Table 1. Promotion of flowering and fruiting in Kensington Pride mango with pre-flower pruning and PBZ

Treatment	Year 3				Year 4				Year 5				Year 6		Cumulative Performance
	Flowering %	Days to Flower	Yield (kg/tr)	Flowering %	Days to Flower	Yield (kg/tr)	Flowering %	Days to Flower	Yield (kg/tr)	Flowering %	Days to Flower	Yield (kg/tr)	Flowering %	Yield (kg/tr)	
PBZ + Pruning	81.3 ^a	41 ^a	22.9 ^a	91.8 ^a	42.5 ^a	50.0 ^a	95.6 ^a	41 ^a	72 ^a	38 ^a		21 ^a		166	
PBZ Alone	66.6 ^b	44 ^a	17.1 ^b	64.3 ^b	48.2 ^b	40.6 ^b	72.0 ^b	42 ^a	75 ^a	30 ^a		21 ^a		154	
Pruning Alone	12.6 ^c	64 ^b	2.2 ^c	49.3 ^c	54.7 ^c	30.1 ^c	78.0 ^b	43 ^a	60 ^b	1 ^b		1 ^b		93	
Control	7.3 ^c	69 ^c	0.4 ^c	41.8 ^c	59.7 ^c	20.1 ^d	52.4 ^c	54 ^b	63 ^b	1 ^b		1 ^b		84	

Different letters in superscript following the values indicate statistical significance. Data on yields is from 8 trees/treatment and on flowering from 20 to 30 shoots randomly tagged after pruning. In year 6, flowering was assessed visually as percentage of canopy.

4.1.4 PROPAGATION AND ROOTSTOCK/INTERSTOCK TRIALS

V Kulkarni and D Hamilton

Together with and possibly likened to erratic flowering and fruiting, excessive tree vigour is another major limitation with our commercial cultivar Kensington Pride. The tropical environmental conditions of the Top End further accentuate the problem of excessive tree vigour and low productivity. Strategies towards vigour control in this situation can be mediated through (1) management practices such as pruning and nutrition, (2) chemical means such as plant growth regulators like paclobutrazol, (3) breeding and (4) use of rootstocks and interstocks. Post harvest pruning alone has been found to be of little use in tree vigour control and is mainly aimed at removing unwanted growth. Recent findings with a combination approach of paclobutrazol and pre-flower pruning have given promising results. Tip pruning works well only in combination with paclobutrazol (See 4.1.3). Breeding is a long term approach and holds some promise. Tree vigour control through rootstocks offers a long term and non-chemical alternative for improvement of productivity. It is one area which has shown great promise in temperate tree fruits and has remained unexplored in tropical tree fruits, including mango. Initial work on the use of clonally propagated rootstocks and interstocks of dwarf cultivars has provided some evidence of vigour control through rootstocks (Kulkarni 1991). Recent reports from India and Israel also suggest that some seedling rootstocks such as Vellaikolamban (from India) and 13/1 (from Israel) could be useful.

Material and Methods

Two types of rootstock material are proposed to be used:

- (1) Use of seedling rootstocks which have shown promise in other cultivars. These include Vellaikolamban, 13-1 and Sabre in comparison with Kensington Pride as control.
- (2) Clonally propagated marcots of dwarf and ready to root cultivars such as Mahmuda Vikarabad introduced from India.

Results and Discussion

(1) Rootstock trial using seedling rootstocks: It is now proposed to undertake the rootstock trials on grower properties under testing agreements similar to the agreements for varietal testing. Grower reaction to a call for volunteering their properties was very positive. Rootstock material of cultivars mentioned above is being raised to lay out trials using completely randomised design on grower properties with Kensington Pride as scion. It is proposed to include Vellaikolamban, 13/1, Sabre and Kensington Pride as the rootstock treatments.

(2) Use of clonally propagated rootstocks: It is important to standardise and simplify the technique for clonal propagation of marcots as rootstocks. In preliminary attempts, excellent rooting was obtained in marcotting in January-March. The polystyrene 'stubby holders' were found to be ideal as containers for marcotting. Rooting was very profuse in Mahmuda Vikarabad and satisfactory in Kensington Pride. Further work is in progress to prepare grafted material on the marcotted shoot directly on the parent tree without any need to use nursery beds. Initial results seem encouraging. If

this technique is successful, it is proposed to test the performance of the clonally propagated rootstocks on grower properties.

4.1.5 ROOTSTOCKS FOR KENSINGTON PRIDE MANGOES

M Smith, M Hout, J Bright, G Foord, S McAlister, C Brown, E S Smith and M Langdrigan

Research work is underway to identify rootstocks that will increase the commercial profitability of mango growing.

Materials and Methods

Two rootstock experiments, with Kensington as the scion, were harvested in the 1996 season. The oldest of these experiments planted at Manbulloo Mangoes, contains nine stock treatments and has been reported on extensively in the past.

Results and Discussion

Results from this experiment in the 1996 season (Table 1) were largely consistent with those obtained over the past five seasons. The rootstock Sg. Siput again outyielded (124kg/tree) all other stocks by a large margin, whilst Sabre was the poorest (27 kg/tree) yet again.

Table 1. Rootstock effects on tree yield, tree size and yield efficiency in the 1996 season.

Rootstock	Yield (kg/tree)	Canopy Silhouette (m ²)	Yield Efficiency (kg fruit/m ² canopy)
Sg. Siput	124	28.1	4.04
Strawberry	75	21.2	3.47
J.Common	72	25.0	2.86
M.Telur	61	19.0	3.32
Lemon D2	56	21.1	2.70
Pineapple	54	18.4	2.91
Teluk Anson	45	19.1	2.13
Kensington	44	17.3	2.43
Sabre	27	22.0	1.15

Sg. Siput has clearly emerged as a superior rootstock, resulting in significant commercial interest.

Quality assessments in the other Kensington rootstock experiment showed that stock influenced fruit maturity time, with Red Harumanis giving the earliest maturing fruit while Batavi delayed maturity.

4.1.6 MANGO VARIETAL/ROOTSTOCK EVALUATION

M Smith, J Bright, M Hoult, G Foord and S McAlister

This work involves the evaluation of seven different scion cultivars (Glenn, Haden, Kensington Pride, Kent, Tommy Atkins and Zill) on two different rootstocks (Sabre and ARC Common).

Materials and Methods

Data collection in this experiment was completed during the 1997 season. Yields of most combinations were poor for the age of the trees. This is believed to be due, in part, to inadequate nutrient additions in the latter years of the experiment.

Results and Discussion

Overall, the experiment revealed a number of interesting trends. For example, Kensington was found to give yields comparable (on a per tree basis) to most of the other cultivars, contrary to the belief that it is a 'low yielding' cultivar. However yield efficiency was lowest with Kensington. This cultivar also compared favourably with the others in terms of consistency of production from year to year.

Haden produced very well during the early years, but had slumped in the last few seasons. Conversely, Tommy Atkins was quite slow to come into production and had produced good yields in the latter years of the experiment.

In terms of rootstocks, all cultivars when grown on Sabre produced markedly smaller trees than on ARC Common. However yields were also very poor on Sabre, and it is not recommended for commercial use. One notable exception is the combination of Kent on Sabre, which not only resulted in smaller trees, but also produced high yields. This combination would be well suited to high density planting.

Many of the problems in mango production that are often blamed on the Kensington cultivar, appear to be common to many other cultivars. It would seem that overcoming these problems requires more than simply changing to a 'better' scion cultivar.

4.1.7 MANGO RESEARCH IN CENTRAL AUSTRALIA

CULTIVAR EVALUATION

J Mansfield, G Kenna and S Marte

The objective of this experiment is to evaluate the commercial production of mangoes in the southern region of the Northern Territory for the lucrative late season domestic market.

Materials and Methods

In 1990, twelve cultivars were planted in a single row running north-south at a spacing of 3m between trees. For nine of the cultivars there are two trees of each cultivar

planted adjacent to each other. For the other three cultivars (Davis Haden, Keitt and Manzanillo Nunez) there is only one tree of each. All the trees are on Kensington rootstock except for the Manzanillo Nunez which is on Adelaide River Common rootstock.

Mature fruit were harvested and weighed. The date and tree from which this fruit was removed were recorded. From this information it is possible to compare the cultivars for differences in harvest patterns, fruit size and total yield (kg fruit/tree).

Results and Discussion

Fruit was harvested from 11 December 1996 to 1 April 1997. The cultivars which produced the earliest fruit were Irwin, Lippens, R2E2 and Sensation, while the cultivars which produced the latest fruit were Keitt and Kent (Figure 1). In addition to Davis Haden, Keitt and Kent were also the highest yielding cultivars producing around 50 kg per tree (Figure 2). This is based on estimated yield (number of fruit collected by average fruit size) and not marketable yield, as due to the wet summer in the Ti Tree area some fruit was damaged by fruit piercing moth. The fruit of the cultivar R2E2 averaged 720 g and this was much greater than the other cultivars, with most of these averaging between 440 and 570 g (Figure 3).

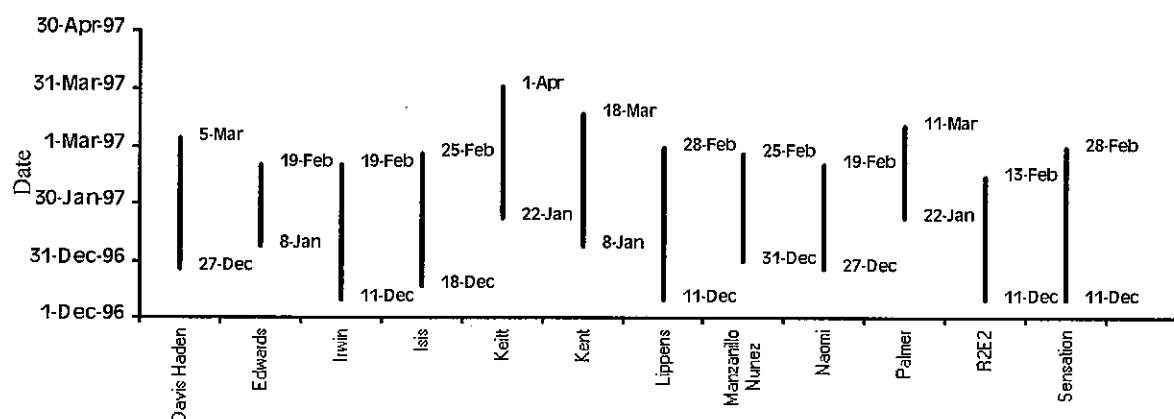


Figure 1. Cultivar differences in harvest range.

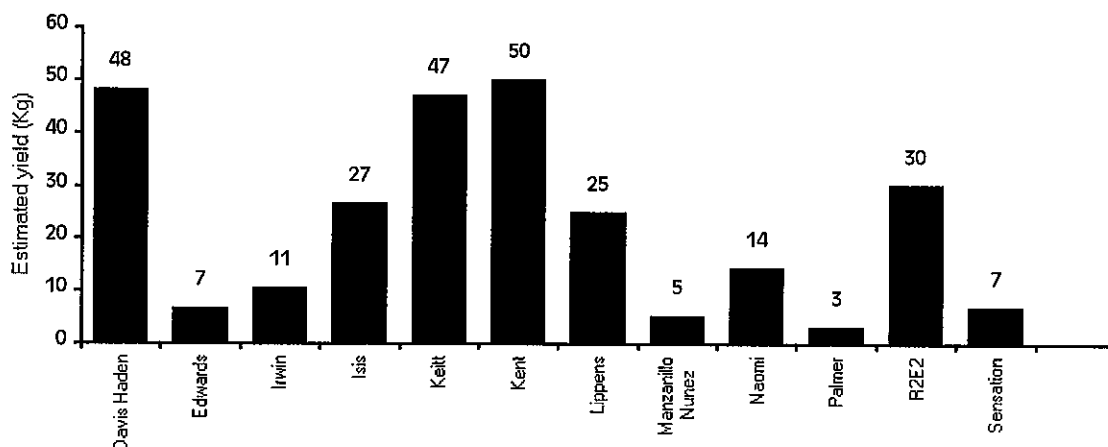


Figure 2. Cultivars differences in yield per tree.

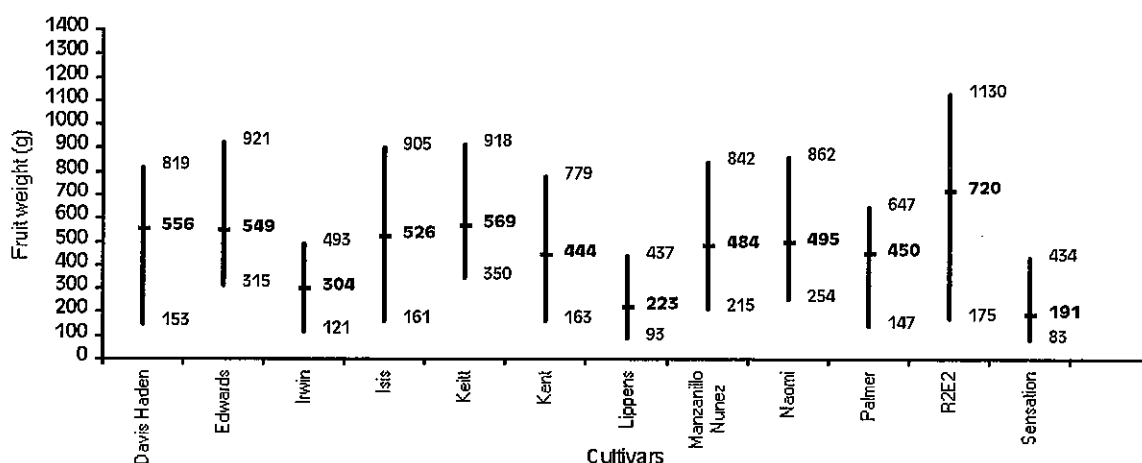


Figure 3. Cultivar differences in average and range of fruit weight.

4.1.7 MANGO RESEARCH IN CENTRAL AUSTRALIA

HIGH DENSITY PLANTING

G Kenna, J Mansfield and S Marte

Due to the slower growth of mango trees in the Central Australian region compared to those further north some research has been directed at maximising the yield per unit area by examining various high density planting designs.

Materials and Methods

In 1990, a high-density planting trial was established by planting six plots in an east-west direction. Two plots are single row plantings of five trees each of Kent and Naomi at 2 m spacings between trees. Another four plots are double row plantings at a spacing of 2 m within rows and 2 m between rows. The two rows are offset to each other by 1 m. One row contains five trees and the other contains four. The cultivars grown in these plots are Palmer, Keitt, Kent and Springfels. All the trees are on Kensington rootstock.

Mature fruit were harvested and weighed. The date and tree from which this fruit was removed were recorded. From this information it is possible to compare the cultivars for differences in harvest patterns, fruit size, and total yield (kg fruit/tree).

Results and Discussion

The trees of the cultivar Kent planted in the single row plot showed a difference to the trees of the same cultivar in the double row plot. The single row planting produced mature fruit slightly later (Figure 1), had almost twice the yield per tree of the double row planting (31 kg compared to 18 kg) (Figure 2), and also had larger fruit (average of 505 g compared to 433 g) (Figure 3). In Figure 2, estimated yield (number of fruit collected by average fruit size) and not marketable yield is presented, as due to the wet summer in the Ti Tree area some fruit was damaged by fruit piercing moth. The cultivar Springfels had an average fruit size of 669 g which was higher than for the other cultivars (Figure 3).

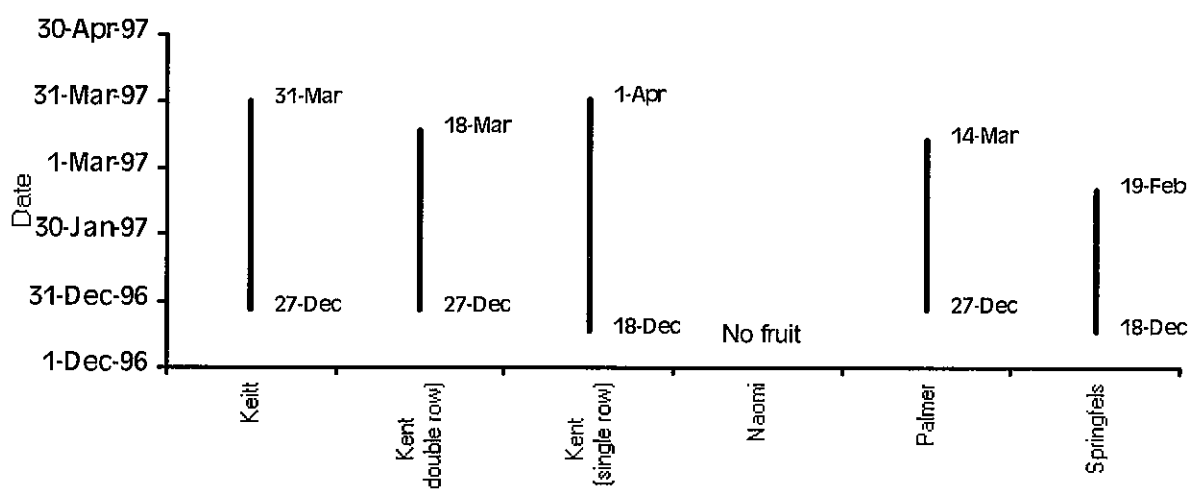


Figure 1. Effect of different plantings arrangements on the harvest range of different cultivars.

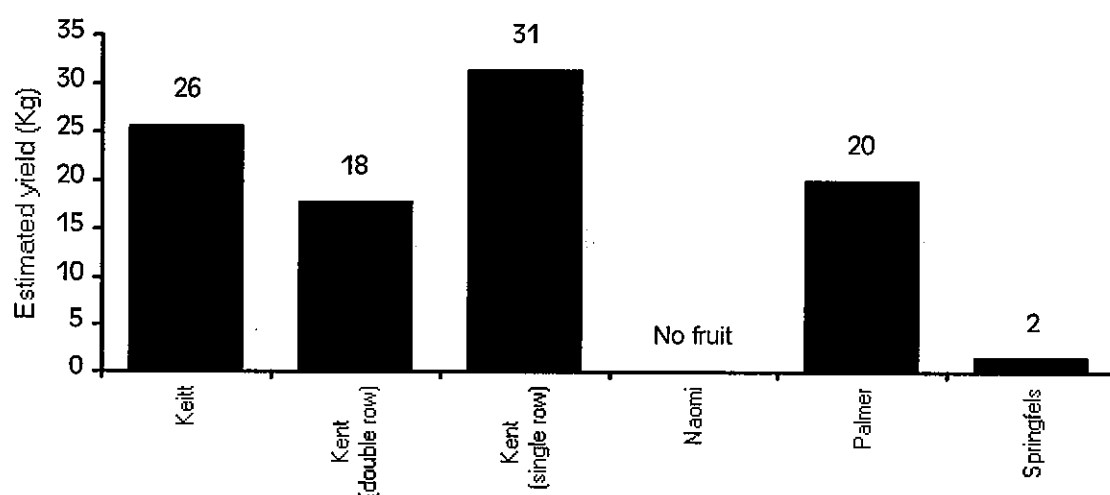


Figure 2. Effect of different plantings arrangements on the yield per tree of different cultivars.

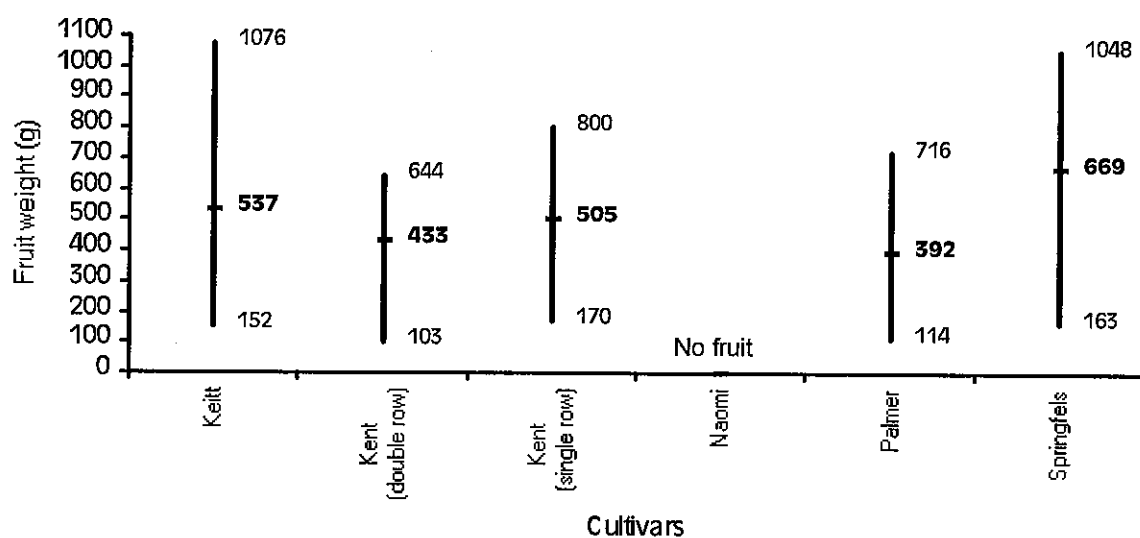


Figure 3. Effect of different plantings arrangements on the average and range of fruit weight of different cultivars.

4.1.8 IMPROVEMENT OF FRUIT QUALITY IN MANGO

4.1.8.1 IMPROVEMENT OF EXTERNAL FRUIT COLOUR AND FRUIT FIRMNESS BY CONTROLLING VEGETATIVE VIGOUR

V Kulkarni and D Hamilton

Besides affecting flowering and fruiting, excessive and frequent vegetative growth (flushing) in mango in the warm growing conditions of the Darwin region is implicated in problems associated with internal and external quality of fruit.

Material and Methods

Fruit from the pre-flower pruning trial (See 4.1.3) was used for this purpose. Fruit maturity was assessed using flesh dry matter percentage of freshly-harvested fruits as an indicator. A minimum level of 14% dry matter is currently required for market acceptance. Fruits were sampled randomly from four aspects of the tree. Approximately 10g of grated pulp was dried for 18 to 20 hours at 65°C to a constant dry weight. At harvest, fruit dry matter generally was above 15%. External fruit colour was judged visually as well as quantitatively with a 'Minolta' chromameter (Model CR 300, Minolta Camera, Ltd., Osaka, Japan). For visual assessment, percentage blush on fruit surface was estimated using a diagrammatic chart. The Minolta Chromameter measures light reflected in three coordinates L*, a* and b* giving a three dimensional colour space. L* corresponds to brightness (0, dark, 100 white), a* to a green-red scale (negative value, greenness; positive redness) and b* to a blue-yellow (negative value, blue; positive value, yellow). The a* value was found to be most useful in evaluating the red blush on the shoulders. The chromameter was calibrated with a white reference. Two measurements were made on each sample fruit, one near the stalk end and another one on the shoulder with maximum blush. Fruit firmness of ripe fruits was assessed with a visual firmness index on a point scale of 1 to 6 (1-very hard; 6-very soft). Firmness was also measured quantitatively with a 'EFFEGI' penetrometer using an 8 mm plunger. The manually operated device measures pressure to penetrate the peel. In 1995, the third year of the experiment, the impact of the treatments PBZ + pre-flower pruning, PBZ alone, pruning alone and control on fruit quality was assessed to confirm visual observations made in the previous two years. A total of 48 fruits were taken randomly (six/tree) from each treatment, ripened at 20°C, and were assessed for external colour and internal quality when they were ripe to eat.

Results and Discussion

Observations on fruit colour and firmness are summarised in Table 1.

Table 1. Effect of Pre-flower pruning on fruit quality in Kensington Pride mango

Treatment	Fruit colour			Fruit firmness		TSS
	Blush Rating (% of fruit surface)	Proportion of Fruits with >10 % blush	a* Value in Chromameter	Fruit Firmness Index	Penetrometer Test	
PBZ + Pruning	26.9 ^a	79.1 ^a	15.9 ^a	3.5 ^a	9.2 ^a	16.2
PBZ Alone	6.0 ^b	24.9 ^b	7.4 ^b	4.8 ^b	6.0 ^b	16.0
Pruning Alone	24.0 ^a	77.0 ^a	15.8 ^a	3.4 ^a	9.7 ^a	16.1
Control	5.0 ^b	18.7 ^b	6.7 ^b	4.9 ^b	7.0 ^b	15.1

Different letters in superscript following values indicate statistical significance. Observations on fruit quality are mean values of randomly selected 40 fruits (5/tree/treatment) from all sides of the canopy. Data from year 5 of the trial.

Pre-flower pruning had a dramatic promotory effect on development of red blush on the fruit. Average colour rating of the fruits, proportion of fruits with noticeable blush and quantitative measurement of the blush were significantly higher in the PBZ+ pruning and pruning alone treatments than in the unpruned treatments. There was no significant difference in fruit weight (540 to 585 g).

Field observations suggested that fruits in the pruning treatments not only appeared more attractive, but were also more firm than those from the unpruned treatments. Manual assessment with a fruit firmness index (FFI) and with a penetrometer to test pressure required to penetrate the fruit supported these observations. TSS values in treatments PBZ + pruning, pruning alone and PBZ alone, were similar almost certainly because of similar time of flowering in these treatments whereas fruits from the control trees which flowered later recorded lower TSS.

Dramatic improvement in external fruit colour was obtained with pre-flower pruning. Differences were clearly visible in the field. To a large extent, this difference can be attributed to better light interception in the pruned trees and the shading effect in the excessively vigorous trees. Pre-flower pruning also significantly improved firmness. Excessive flushing during flowering and fruiting is reported to effect fruitset and retention and its removal improves fruit retention. From studies in avocado, it has been proposed that this could be mediated through calcium translocation. (Cutting, et al. 1990). It is therefore tempting to attribute the ubiquitous quality-related problems in mango in the tropics to the excessive tree vigour and intermittent flushing during flowering and fruiting. It is proposed to investigate this aspect more closely.

Vegetative growth also seems to play a similar dual role in fruit quality (Cutting et al, 1994) on one hand by being a source for the energy and on the other, by being a sink for nutrients and other metabolites during the course of fruit development and possibly through a hormonal pathway.

4.1.8.2 EFFECT OF LOCATION AND CULTURAL PRACTICES ON MANGO QUALITY

V Kulkarni, M Landrigan, D Hamilton and G Foord

Currently there is considerable interest in pre harvest nutrition effects, particularly calcium on fruit quality. We decided to look at four sites in Darwin, experiencing perceived fruit quality differences. To gather some objective data, leaf samples and soil samples were collected to build up profiles of inputs at each location. Samples of mature fruit were also assessed for quality and mineral content.

Materials and Methods

Four grower properties under different management systems were chosen. Fruits were tagged (at 'egg' stage) on four trees in each orchard. About 30 fruit on each tree were tagged around the tree. At this stage, soil and leaf samples were taken.

Soil samples were taken from 10 -20 cm depth and leaf samples from the youngest mature leaf (second to fourth leaf) from the latest terminal flush. Fruits were harvested at commercial maturity (using visual observation and dry matter) and desapped for 30 minutes in the lab. No post harvest treatments were applied. Half a tray of fruit (~7 fruit) from each tree (2 trays/grower) was stored under each of the following conditions:

1. 22°C & 70%RH until ripe
2. 10°C & >90%RH for four weeks

The following fruit measurements were taken at harvest:

1. fresh weight (% weight loss)
2. colour (PCI; 1=fully green, 6=fully coloured)
3. blush (% surface area of skin affected)
4. firmness (FFI; 1=fully firm, 5=oversoft)
5. decay (1=0% skin area affected; 2=1-5% skin area affected; 3=6-15% skin area affected; 4=16-30% skin area affected; 5=31-100% skin area affected).

When ripe, in addition to the above, the following observations were made:

1. Internal colour (FCI; 1=white, 5=orange)
2. TSS (Brix)
3. Calcium and other minerals of the skin and flesh (Chemistry section).

After four weeks storage:

1. Internal colour (FCI; 1= white, 5 = orange)
2. TSS (Brix)

Results and Discussion

With the fruit stored at 22°C there were some slight differences in quality of fruit from the Darwin growers (Table 1). Fruit from Katherine was noticeably better in quality than the Darwin fruit. No decay and rots were observed in Katherine fruit during the four week duration as compared to a much higher incidence in the Darwin fruit. Katherine fruit also took longer to ripen. Differences in the Katherine and Darwin fruit was even more significant when fruit were stored at 10°C. G4 from Darwin had the highest incidence of decay and rots. Weight loss in fruit during ripening was also highest in the fruit from G4. Fruit from this property failed to develop any red blush.

Table 1. Quality parameters of ripe fruit from five locations after storage at 22 °C

Parameter	G1	G2	G3	G4	Katherine
Dry Matter (%)	15.32	15.41	15.69	-	-
Weight Loss (%)	6.09	7.8	6.37	10.58	8.25
Days to Ripen	12.0	12.0	9.3	10.0	13.3
PCI	5.8	5.5	5.9	4.7	5.6
FFI	4	4	4	4	4
Decay	1.2	1.3	1.1	2.5	0
FCI	4	4	4	4	4
TSS (°Brix)	16.5	16.5	17.5	16.7	17.0
% Blush	15.5	12.3	17.5	0	0

Table 2. Quality parameters of ripe fruit from five locations, after storage at 10°C for four weeks

Parameter	G1	G2	G3	G4	Katherine
Weight Loss (%)	4.80	8.22	6.65	10.27	10.52
PCI	6	6	6	4	6
FFI	4	4	4	3.2	4
Decay	4	3	4	5	0
TSS (°Brix)	16.2	16.2	16.8	14.9	14.1
% Blush	19.6	9.7	8.4	0	4

Mineral analysis of fruit: A perusal of Tables 3 and 4 on mineral analysis of fruit shows that calcium content of the peel was much higher than that of the flesh. Calcium and potassium content of the peel and flesh of fruit from Katherine was noticeably high as compared to the Darwin samples. Fruits from G4 which recorded higher incidence of rots and lack of blush also recorded lowest calcium in the peel.

Table 3. Mineral concentrations in the skin

Element	Katherine	G1	G2	G3	G4
P%	0.066	0.055	0.052	0.052	0.085
K%	1.05	0.75	0.73	0.76	0.46
Ca%	0.193	0.088	0.112	0.069	0.066
Mg%	0.118	0.123	0.136	0.120	0.092
Zn mg/kg	4.10	4.20	5.00	5.08	6.43
Mn mg/kg	11.8	11.0	26.1	11.5	15.8
B mg/kg	14.5	14.7	14.9	12.9	11.8
N%	0.377	0.334	0.363	0.278	0.462

Table 4. Mineral concentrations in the flesh of Kensington Pride mango

Element	Katherine	G1	G2	G3	G4
P%	0.093	0.072	0.071	0.071	0.102
K%	1.263	0.969	0.856	0.873	0.589
Ca%	0.081	0.036	0.044	0.025	0.033
Mg%	0.0700	0.069	0.079	0.060	0.056
Zn mg/kg	11.1	5.45	4.67	4.67	6.21
Mn mg/kg	7.80	5.90	11.33	5.00	8.29
B mg/kg	8.20	8.4	7.67	9.08	8.07
N%	0.403	0.353	0.398	0.306	0.471

Mineral analysis of soil and leaf: Data on soil and leaf nutrient levels in the four Darwin properties is summarised in Tables 5 and 6. Interestingly, property G4 which recorded a relatively high rate of rots and low levels of calcium in fruit recorded the lowest soil levels of calcium but unexpectedly higher levels of calcium in the leaves as compared with the other three properties. It is clear that the issue of nutrition and fruit quality needs long term research so that a suitable explanation can be found for these observations. There may be a need to evolve alternate ways to improve calcium levels in fruit *per se*.

Table 5. Mineral analysis of the soil and fruit quality of Kensington Pride mango

Element	G1	G2	G3	G4
EC mS/cm	0.09	0.03	0.03	0.04
pH	5.9	6.7	6.4	7.1
K ppm	100	<25	45	<25
Ca ppm	440	500	420	120
P ppm	50	28	120	96
TKN%	0.10	0.08	0.06	0.11
Zn ppm	0.6	0.6	0.6	1.5
OC %	2.68	1.83	2.21	1.94
B ppm	<2	<2	<2	<2

Table 6. Mineral concentrations in the leaves of Kensington pride mango

Element	G1	G2	G3	G4
P%	0.08	0.09	0.07	0.10
K%	0.60	0.71	0.49	0.21
Ca%	0.80	0.75	0.79	1.45
Mg%	0.55	0.58	0.56	0.55
Zn mg/kg	36	26	39	11
Cu mg/kg	74	8	6	6
Mn mg/kg	140	261	128	446
B mg/kg	36	31	58	76
Fe mg/kg	65	50	125	79
N%	0.89	0.98	0.82	0.93

4.1.9 MANGO RIPENING RESEARCH

MODIFIED ATMOSPHERE STORAGE OF MANGOES

M Landrigan

Over the last few seasons LifeSpan has been working in conjunction with the WA Department of Agriculture and the WA mango industry to come up with some options for modified atmosphere packaging (MAP) of mangoes to prolong shelf life. With the development of a successful package and promising results after eight weeks storage with WA fruit, it was suggested that trials be conducted with NT fruit to ascertain if they would perform similarly.

Materials and Methods

Two trials were conducted. The first with fruit from Katherine and the second with fruit from the Darwin region.

1. Fruit from Katherine was harvested on 24 October 1996. Fruit had an average dry matter of 16.5% (a dry matter of >14.5 % is considered desirable for commercial maturity).
2. Fruit from Darwin was harvested on 20 November 1996. Fruit had an average dry matter of 16.6%.

Fruit from both trials were desapped for a couple of hours after being harvested and washed in water and then dried prior to packing in the LifeSpan bags. Fruit from the Darwin region was dipped in a fungicide (Sportak®; 0.55 mL/L for two minutes) to reduce post harvest disease.

Fruit were then stored at 10°C and removals made at four, six and seven weeks. Assessments of fruit quality were made when the fruit had ripened, usually after three days at 22°C.

Assessments were made on skin colour using a rating scale (1=fully green; 6=fully coloured) and flesh firmness (1=hard; 5=oversoft). Disease was assessed using a five point scale (1=0% skin area affected; 2=1-5% skin area affected; 3=6-15% skin area affected; 4=16-30% skin area affected; 5=31-100% skin area affected).

Internal measurements on flesh colour (rating scale 1=white flesh; 5=orange flesh) and total soluble solids were also recorded.

Results and Discussion

The carbon dioxide and oxygen concentrations inside the bags were measured weekly (Table 1).

Table 1. Mean Carbon Dioxide and Oxygen concentrations inside the MAP.

Trial	Carbon Dioxide (%)	Oxygen (%)
1. Katherine	7.5±0.4	15.3±2.0
2. Darwin	4.6±0.3	17.8±0.1

These values differed from those experienced in WA. One possible reason for this may have been the reduced weight in each bag (about 5 kg instead of the usual 7 kg) (Table 2).

Table 2. Mean fruit weights in each box

Region	Mean Fruit weight (kg)
Katherine	5.33±0.37
Darwin	5.02±0.31

With the fruit from Katherine, peel colour and fruit firmness were assessed immediately after removal from storage. Initially (after four weeks) fruit stored in MAP were less coloured and more firm upon removal. By six weeks, all fruit irrespective of MAP, had coloured to a rating of 5 (60-90% skin area fully coloured) and all fruit was at the edible ripe stage (rating 4). After 3 days at 22°C all fruit had coloured and was edible ripe.

Weight loss was significantly greater at all storage times for fruit not stored in MAP.

The rating for disease increased with time. At the first removal (four weeks) the incidence of decay was lowest (Table 3) and had an average rating of 1.3 (<1% area affected). Whilst the percentage of fruit effected was similar for the six and seven week storage with MAP stored fruits, the rating increased from 2.5 (1-5% skin area affected) to 3.5 (6-15% skin area affected).

Table 3. Katherine - % Fruit with Disease.

Time (weeks)	% Fruit with Disease	
	MAP	No MAP
4	20	33
6	93	53
7	100	100

With the fruit from Darwin, fruit were only assessed when ripe. The incidence of decay was high for all removals (Table 4), whether the fruit were MAP stored or not.

Table 4. Darwin - % Fruit with Disease

Time (weeks)	% Fruit with Disease	
	MAP	No MAP
4	87	70
6	90	100
7	100	100

This high incidence of disease may explain the reduced colour and softening compared to the Katherine fruit. That is, fruit may have been assessed earlier because of rots. The colour and firmness changes at week six and seven were similar being a

colour rating of 4 (>40% and <60% coloured 0 and a softness of 3, ie. moderate softening).

Weight loss again was significantly greater at all storage times for fruit not stored in MAP.

In both trials there were no differences between the MAP and non-MAP fruit flesh colour and total soluble solids. It should be mentioned that some possible chilling injury was seen in fruit from Katherine stored without MAP for longer than six weeks. No noticeable chilling injury was seen in the MAP fruit. The chilling injury was expressed as a slight discolouring of the skin and a darkening of the flesh next to the skin.

These results suggest that under the conditions created in this trial, fruit could only be stored for about four weeks. Obviously care should have been taken to adhere strictly to the recommended weight and temperatures for these bags. Also it is interesting to note the poorer outturn of the Darwin fruit compared to the Katherine fruit. One reason for this may be the lower incidence of disease on the Katherine fruit due largely to environmental conditions.

4.1.11 MANGO SAPBURN AND BROWNING AMELIORATION

MANGO SKIN BROWNING I

M Landrigan and M Hearnden

Mango skin browning refers to the types of skin blemishes (excluding sapburn) which appear on mangoes during post harvest handling and marketing. This research is part of the HRDC Mango Skin Browning project coordinated by Rowland Holmes of QPDI. Last year QPDI put out an excellent guide to identify the different types of skin browning. Correct identification is essential to determine the cause of skin browning. For the last three seasons we have been working with staff at QPDI to elucidate the causes of skin browning and initiate strategies for alleviating the problem.

A range of experiments were conducted this season that looked at the following aspects;

- 1) Effect of a range of concentrations of Mango Wash® on skin browning and sapburn
- 2) Inducement of skin browning
- 3) Effect of temperature differences on skin browning.

1) Effect of a range of concentrations of Mango Wash® on skin browning and sapburn.

Last season the induction experiments performed in Queensland, showed Mango Wash® not usually associated with the occurrence of skin browning. However, Mango Wash® is used by about two-thirds of the NT industry and high skin browning levels have been seen in the markets. Also no extensive studies have been carried out

on the efficacy of Mango Wash®. For these two reasons it was decided to look at the efficacy of a range of Mango Wash® concentrations and the application of sap, in the one experiment.

Materials and Methods

Fruit were harvested from a grower's orchard in the Darwin rural area and dipped in one of the following Mango Wash® concentrations, 0.0, 1.0, 2.5, 5.0, 10.0 & 20 g/L. Within each concentration, half of the fruit were dipped for 30 minutes and the other half for five minutes. Fruit were allowed to dry and sap was applied to one cheek of each fruit. Both skin browning and sapburn were assessed when fruit ripened;

- 1) Peel colour was scored on a scale of 1 = green through to 6 = full colour change (Joblin-Decor 1988).
- 2) Lenticel intensity was scored using a rating suggested by Scott Ledger, 0=nil, 1=faint, 2=light and 3=dark.
- 3) Lenticel area was reported with a rating scale corresponding to 0=nil, 1=<10% of surface area affected, 2=>10% but <25% of surface area affected, and 3=>25% of surface area affected.
- 4) Other skin browning scores used a rating system the same as for the lenticel scoring as outlined above.

This scoring system was used for all the experiments, except where stated otherwise.

A modified version of this experiment was repeated later in the season with fruit from the CPHRF harvested after a week of heavy rain. The following Mango Wash® concentrations were used 0.0, 0.25, 1.00, 5.00, 10.00 & 50 g/L and neither sap nor detergent solutions were applied to the cheeks of the fruit after dipping. Dip times were one or 15 minutes. Fruit were assessed when ripe.

Where appropriate, analyses of variance were performed on the data sets. Where data was not normally distributed, a Kruskal-Wallis ANOVA on Ranks was performed. (ns=not significantly different at $p<0.05$, * =significantly different at $p<0.05$, **=significantly different at $p<0.001$)

Results and Discussion

For the fruit from the grower's property, there were no significant differences between the 30 and five minute dip times, therefore results presented have been combined.

The area where the absorbent pad was applied was assessed for damage and only lenticel injury was seen. The area where sap was applied was also assessed separately. No sapburn was experienced, only a combination of abrasion and etching (skin browning score; Table 1).

Table 1. Effect of Mango Wash® concentration and sap on skin blemish.

Mango Wash® concentration (g/L)	Peel Colour (1-6)	Lenticel injury (0-3)	Skin Browning (0-3)
0.0	3.8	0.2	0.1
1.0	4.4	0.5	0.9
2.5	4.0	0.3	1.1
5.0	4.4	0.1	0.4
10.0	3.6	0.5	0.4
20.0	3.8	0.1	0.1
	ns	ns	**

Colour development was unaffected by Mango Wash® concentration. The results, however, illustrate the random effect of Mango Wash® concentration on both lenticel injury and skin browning. Lenticel injury was not significantly different among the different Mango Wash® concentrations and levels recorded were low (<1). Where sap was applied, there were significant differences with the amount of etch and abrasion recorded among the different detergent concentrations. However these differences do not necessarily provide a guide to the grower for the most effective concentrations. The lowest rates of Mango Wash® (1.0 and 2.5 g/L) gave the highest skin browning scores whilst the water and 20 g/L had the least skin browning. This suggests that rates of Mango Wash® up to 50 g/L are no more detrimental to mango skin than water. No other forms of skin browning were experienced in this trial.

Fruit from CPHRF showed significant differences between the two dip times, unlike the fruit from the grower (Table 2). This was probably due to sap accumulation in the dip solutions when preparing the fruit from CPRHF. Thus, fruit dipped in the solutions for a longer time had more damage.

Table 2. Effect of Mango Wash® concentration on skin blemish. (Browning score used 1=nil, 2=trace, 3=moderate, 4=severe and 5=very severe).

Mango Wash® Concentration (g/L)	Mean Browning Score (1-5)		% Fruit affected	
	1 min	15 min	1min	15 min
0.00	1.7	2.5	53	73
0.25	1	2.4	0	100
1.00	1.1	2.4	7	80
5.00	1.5	2.3	47	73
10.00	1	2.5	0	100
50.00	1.3	2.2	27	100
	ns	ns		

The skin browning symptoms consisted mainly of pronounced lenticels and occasional smear and blotch, most likely because sap was allowed to accumulate in the detergent solution. The mean browning scores showed no significant differences among any of the detergent concentrations. Increasing the Mango Wash® concentration (up to 50

g/L) does not necessarily increase the likelihood of lenticel injury or skin browning. Similarly when looking at the percentage of fruit affected there are no logical differences. What appears important is the length of time fruit spent in the dip. At 15 minutes, more fruit were more severely affected than those fruit dipped for only one minute. This confirms thoughts that fruit held too long in contact with detergent solution that contain sap increases the chances of skin blemish.

From these experiments, no upper limit for Mango Wash® concentration was established. Lenticel injury, etch and abrasion can be induced by water alone as well as by Mango Wash®. Concentrations up to and including 50.0 g/L (20 times the recommended rate) all can result in similar levels of injury. More important is the length of time fruit are in contact with the solution and the quantity of sap present.

4.1.11 MANGO SAPBURN AND BROWNING AMELIORATION

MANGO SKIN BROWING II

M Landrigan and M Hearnden

The following experiments were designed to test the effect of a range of post harvest chemicals on skin browning. Three separate experiments were conducted. The first with fruit from Katherine and the second and third with fruit from CPHRF with the Hamilton staff. The third experiment examined the effect of time after harvest and fruit turgor as well as skin browning.

Materials and Methods

Fruit were harvested from KRS early in the morning, desapped for 30 minutes on racks then transported to the laboratory within six hours of harvest. The fruit were randomly distributed among the following treatments, resulting in 15 fruit per treatment; 1)water, 2)Mango Wash® 2.5 g/L, 3)Mango Wash® 5.0 g/L, 4)Mango Wash® 50.0 g/L, 5)Agral 1.0%, 6)Coldpower 1%, 7)Rogor® (a.i. Dimethoate; Rhone-Poulenc) 1mL/L, 8)Lebaycide® (a.i. Fenthion; Bayer) 0.75 mL/L and 9)Sportak®(a.i. Prochloraz; Hoechst & Schering) 0.55 mL/L. The last three are post harvest insecticides and a fungicide. A further three groups of fruit were held at 22°C & 70 %RH for 24 hours before being treated with the following solutions, 10)Mango Wash® 50.0 g/L, 11)Agral 1.0%, and 12)Coldpower 1%. Each fruit was placed cheek side down on an absorbent pad saturated with 2 mLs of the treatment solution and incubated for 24 hours at high RH. Injury was assessed when fruit had ripened at 22°C & 70 %RH. Both the treated area and the remainder of the fruit surface were assessed. This was to record the background level of lenticels that developed as a consequence of ripening.

The second experiment used fruit from CPHRF, involving a repetition of that at KRS with the Hamilton staff. The only difference was the use of petri dishes to contain the solution and saturate the absorbent pad and skin. A few extra chemicals were included: DCTron (Ampol) and Bioshield (Spraytech) at 0.1/mL/L and LOC (Amway)

at 1% and a range of times fruit were left in contact with the solutions used. These were four, six, ten and 17 hours. Only the treated area was assessed for damage.

Results and Discussion

Experiment 1

Colour development of the peel was not affected by any of the treatments in this experiment (Table 1).

Table 1. Effect of postharvest chemicals on skin browning. Fruit harvested at KRS

Solution	Peel Colour (1-6)	Skin Browning (0-3)	% Fruit affected	% Area affected ¹	Intensity ² (0-3)
Water	4.8	0.6	20	18.0	0.8
Mango wash 2.5 g/L	5.1	1.9	73	14.7	1.1
Mango wash 5.0 g/L	5.4	1.1	47	10.7	1.1
Mango wash 50.0 g/L	5.7	1.7	67	6.7	0.7
Agral 0.1%	5.2	3.0	100	4.7	0.3
Coldpower 1%	5.7	1.8	80	22.7	1.5
Rogor	5.9	1.0	67	18.7	1.3
Lebaycide	5.9	1.7	73	20.0	1.5
Sportak	5.5	2.0	80	27.3	1.7
+24h Mango Wash 50.0 g/L	5.2	0.2	13	2.0	0.1
+24h Agral 0.1%	5.5	3.0	100	5.7	0.8
+24h Coldpower 1%	5.3	2.3	100	18.0	1.0
	ns	**		**	**

¹ % Area of whole fruit with lenticels (excluding treated area).

² Intensity of Lenticel injury on whole fruit (excluding treated area).

The only skin browning seen here was an enhancement of the lenticels. There were significant differences among the treatments with respect to skin browning. The Agral and the Coldpower, as experienced last season, gave the most intense lenticels and this injury was not reduced by leaving fruit for 24 hours to allow the skin to become less turgid. Also 100% of the Agral fruit were affected at both times and for Coldpower the numbers were 80% immediately after harvest and 100% with time. The Mango Wash results were again puzzling, with both the lowest and highest rates resulting in pronounced lenticels (~2). However this effect was reduced after 24 hours after harvest treatments (0.2). The percentage of fruit effected was also reduced 24 hours after harvest treatment. The reduced effect of Mango Wash® with time probably reflects its weaker penetrating power compared to Agral, a chemical specifically designed to be active as an interface.

In this experiment the surface of the fruit not treated was also scored for area covered by lenticels and their intensity (using rating scale as in previous experiments). These results are interesting in that there are significant differences with both lenticel area affected and intensity on the untreated surfaces. This result may have biased the results for the treated area. For example, the water treatment caused a lenticel score of 0.6 but the background level was similar (0.8), indicating, perhaps a lack of treatment effect.

The inability of the post harvest chemicals to induce skin browning may also be due to the fruit themselves. Fruit grown in Katherine are known for being 'tougher' fruit due to the harsher growing conditions.

For the fruit picked from CPHRF the results were reduced to not marketable and marketable and analysed the percent of fruit in each solution time combination, that were not marketable. The cut off for marketable fruit was fruit with an area score of 1 (< 10% area effected) and / or an intensity score of 1 (faint) (Tables 2, 3 and 4).

Table 2. Percent of fruit that were unmarketable due to lenticel injury

Solution	2 hours	6 hours	10 hours	17 hours
Water	20	10	25	20
Coldpower 1%	85	20	95	100
Agral 0.1%	70	65	85	100
Mango Wash 2.5 g/L	60	60	80	35
DCTron 0.1 mL/L	40	65	55	79
Bioshield 0.1 mL/L	65	50	45	15
LOC 1%	60	60	70	100
Sportak	20	30	25	20
Rogor	5	63	15	45
Lebaycide	5	42	90	90

Table 3. Percent of fruit that were unmarketable due to etch

Solution	2 hours	6 hours	10 hours	17 hours
Water	0	0	25	5
Coldpower 1%	5	28	75	45
Agral 0.1%	5	45	55	35
Mango Wash 2.5 g/L	5	0	10	5
DCTron 0.1 µL/L	50	50	55	0
Bioshield 0.1 µL/L	5	15	45	35
LOC 1%	0	40	30	42
Sportak	10	0	5	5
Rogor	0	5	10	15
Lebaycide	0	0	0	25

Table 4. Percent of fruit that were unmarketable due to smear

Solution	2 hours	6 hours	10 hours	17 hours
Water	0	0	20	0
Coldpower 1%	0	0	0	5
Agral 0.1%	10	0	5	0
Mango Wash 2.5 g/L	0	0	0	0
DCTron 0.1 µL/L	5	5	15	0
Bioshield 0.1 µL/L	0	10	5	0
LOC 1%	0	5	20	0
Sportak	10	0	5	0
Rogor	0	0	0	0
Lebaycide	5	5	25	0

Two hours in contact with the solution appears long enough to cause damage and as seen in earlier experiments, as little as 15 minutes may result in damage. Lenticel damage was the main form of injury with some etch occurring and a small percentage of fruit showing smear.

It is possible to rank the ability of the solutions to cause injury irrespective of duration of application. For lenticel injury Coldpower, Agral, Mango Wash, DCTron, LOC, and Lebaycide all had median values of greater than 50 % of fruit with lenticel injury, whilst water, Sportak and Rogor effected less than 30% of fruit with lenticel injury. With respect to the occurrence of etch, Coldpower, Agral, DCTron and LOC all affected greater than 30% of fruit. And for smear, the levels were too low to highlight differences.

These experiments highlight the random nature of the response of fruit to postharvest chemical treatment. It would appear that all post harvest chemicals, including water, are capable of causing injury. The most consistent form of injury able to be produced in these experiments was lenticel injury, but damaged lenticels are also a result of 'natural' ripening processes, so these results should be interpreted with caution. It would also appear that not so turgid fruit are also susceptible to damage and that skin turgor is not the only thing predisposing the fruit to skin browning.

The fact that no other skin browning (aside from lenticel damage) was seen on the 'tougher' fruit from Katherine, perhaps provides evidence for regional differences in susceptibility.

4.1.11 MANGO SAPBURN AND BROWNING AMELIORATION

MANGO SKIN BROWING III

M Landrigan and M Hearnden

Due to speculation about the practice of dipping hot fruit into cooler dips and vice versa, a small trial was undertaken to confirm the symptoms, if any, from this practice.

Materials and Methods

Fruit was harvested early in the morning at CPHRF. The fruit was uniformly distributed among six groups, resulting in ten fruit per treatment. One third of the fruit were placed in the sun for two hours to increase the core fruit temperature, another third was placed in the coolroom to reduce fruit core temperature and the remaining third was treated immediately. Two dips were prepared of Mango Wash® (2.5g/L) and fruit were dipped for ten minutes. Fruit were assessed for skin browning when ripe.

Results and Discussion

The injury seen on these fruit was a type of sapburn/scald. There was a significant difference between the fruit dipped in the hot and cool dip. Fruit dipped at 29.7°C had more injury than fruit dipped at 38.3°C. The effect of fruit core temperature on skin browning was not significantly different (Table 1).

Table 1. Effect of temperatures on skin browning.

Dip Temperature (°C)	Fruit Temperature (°C)	Skin Browning (0-3)	% Fruit Affected
38.3	36	1.2	20
	31	0	0
	14	0	0
29.7	36	1.4	20
	31	1.6	30
	14	1.6	40
		ns	

It would appear that temperature of the dip may have an important role to play in the amount of skin browning that occurs.

Measurements of turgor may prove a useful guide to identify fruit predisposed to skin browning, though much further work would be needed.

4.1.14 PRE-FLOWERING MANGO IRRIGATION TRIAL

HOW PRE-FLOWERING IRRIGATION, CULTAR AND SEASON INFLUENCE MANGO YIELD

Y Diczbali and C Wicks

In the NT, irrigation is traditionally withheld from the end of the wet season until flowering. This period of stress is imposed to improve the flowering response. Questions were being asked by growers and researchers as to whether this stress period had a negative influence on fruit set. A three year trial was initiated in 1995 to determine whether irrigation through the dry period prior to flowering influenced flowering, fruit set and hence yield. The work was carried out on untreated and Paclobutrazol (Cultar®) treated trees.

Materials and Methods

The trial was designed to allow an investigation of the effects of pre-flowering environmental conditions (soil moisture and temperature) and the growth regulator Paclobutrazol on flowering.

In mid December 1994, 96 four and a half year old trees on a commercial farm were lightly pruned. Paclobutrazol as Cultar® was applied to half the trees at conventional rates in late December 1994 following pruning. An irrigation system was installed which allowed four pre-flowering irrigation treatments (50, 25, 13 and 0 mm/week) to be imposed from the end of the wet season (late April) until flowering (June-July). Following flowering, trees were fully irrigated (approximately 40 mm/wk) through to harvest. Measurements undertaken at the site included, weekly soil tension and total soil moisture (Neutron Moisture Probe and EnviroScan), daily maximum and minimum temperature, weekly photosynthesis and tree phenology (flushing, flowering etc) recording, flowering panicle number per tree and harvest measurements such as fruit number and total tree yield.

Results and Discussion

In 1995 Paclobutrazol-treated trees flowered approximately a week earlier in mid July. Pre-flowering irrigation treatments decreased flowering in the untreated trees and increased flowering in the Paclobutrazol-treated trees (Table 1). Similar yields (38 kg/tree) occurred in the non-irrigated untreated trees and the Paclobutrazol-treated trees irrigated at 25 mm/week (Table 2). Paclobutrazol increased the number of flowering panicles per tree but there was no evidence of a similar increase in yield as fruit set was reduced. There was no evidence to suggest that dry conditions pre-flowering substantially reduced fruit set for either Paclobutrazol-treated or untreated trees, in fact the reverse may be said to have occurred. This suggests that tree yield may be limited by tree physiological factors, as yet unknown, and hence the tree can only support a certain number of fruit regardless of the number of flowers produced.

The trees were well pruned in December of 1995 and Paclobutrazol applied. Flush number and length were monitored during the period prior to flowering. In 1996 the flowering was extremely poor. For all practical purposes there was no fruit on the trees in the trial block. However, as in 1995, the best yields were obtained in the untreated, 0 mm/wk irrigation treatment and in the Paclobutrazol plus 13 mm/wk irrigation treatment.

Growth measurements suggested that Paclobutrazol-treated and untreated trees had the same number of flushes, but the average length of flushes were smaller for the treated trees (Table 3). Photosynthesis measurements showed that as soil moisture declined after the wet season so did leaf photosynthesis. Temperature measurements show that the 1996 season was colder than the 1995 season. Despite this, the flowering response in the trial block was poor. Continued work this season and perhaps next season will hopefully allow us to pick up a pattern which helps explain the flowering behaviour of Kensington in the Top End of the NT.

Table 1. Average number of flowering panicles per tree in the 1995 and 1996 season

Irrigation Treatments (mm/wk)	Untreated		Cultar®	
	1995	1996	1995	1996
50	48	0	252	11.5
25	134	1.2	245	12.8
13	142	1.3	186	32
0	152	5.5	148	6.8

Table 2. Average tree yield (kg/tree) in the 1995 and 1996 season

Irrigation Treatments (mm/wk)	Untreated		Cultar®	
	1995	1996	1995	1996
50	7	0	23	1.1
25	29	0.2	38	0.7
13	28	0.2	22	7.8
0	37	1	21	1.2

Table 3. Average flush number and average length (cm) from pruning until flowering in 1996

Irrigation Treatment (mm/wk)	Untreated	Cultar®
50	4.4 (188)	4.2 (162)
25	3.5 (183)	4.0 (155)
13	3.9 (178)	3.5 (158)
0	3.5 (182)	3.8 (172)

The trial, which is continuing in the 1997 season, has raised a number of issues which need to be carefully considered by researchers and growers alike. In the NT's Top End environment:

- Does the use of Paclobutrazol increase yields or just the flowering response?
- If using Paclobutrazol, small amounts of water pre-flowering may be beneficial to production.
- In trees not treated with growth regulators, pre-flowering irrigation reduces yield potential by reducing the flowering response.

4.1.16 FOLIAR NITROGEN NUTRITION OF MANGO

M Smith, S McAlister, C Brown, G Foord, J Bright, M Hoult, and D Jaensch

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. The aim of this project is to determine any effects of foliar nitrogen application on the yield and quality of mangoes.

Materials and Methods

The experiment was established in January 1996, with four different rates of nitrogen (80, 40, 20 and 0 g N/tree) applied at four different phenological stages (post harvest flush, pre-flowering, fruit at golf-ball size, and all three of these stages). These treatments were arranged in a factorial design with five replicates and individual tree plots. Two additional treatments (of potassium nitrate pre-flowering; and window pruning in August) were included.

Results and Discussion

Harvest in the 1996 season showed no effect of treatment, as was to be expected so early in the experiment. However, measurements of vegetative activity (flush number, length, number of leaves etc.) made in April 1997, showed interesting trends, suggesting that the treatments were starting to have an effect. Furthermore, leaf measurements taken from the two extreme treatments in May 1997 (Table 1), confirmed that significant effects ($p=0.004$) were present.

Table 1. Comparison of leaf size from trees: 1. treated with 80 g N/tree in January 1996 and December 1997 or 2. receiving no nitrogen.

Block	Leaf Size (mm ²)*	
	80 g N/tree	0 g N/tree
1	80 303	58 156
2	86 096	59 789
3	80 397	66 919
4	88 708	62 723
5	86 729	67 163

* sum of 30 leaves sampled 14 months after the start of the experiment

Effects on yield and quality will be examined over the next three to four seasons, with treatments applied annually.

4.1.17 MANGO BREEDING AT KATHERINE

M Smith, M Hoult, S McAlister and C Brown

Despite a strong preference for Kensington Pride in the Australian market, this cultivar exhibits a number of attributes that might be improved through breeding and selection. Hand pollination in mango is time consuming and therefore expensive. An alternative approach is to collect and propagate seed from a tree growing in close

proximity to the desired pollen parent. This approach enables the rapid establishment of large progeny populations, and has been employed with some success elsewhere.

Materials and Methods

A population of 550 seedlings of the cultivar Glenn, were field planted in May 1994 from seed collected in December 1993, from different orchards in the Katherine area. Seeds were collected from Glenn trees growing at six different pollination distances from Kensington Pride trees. These pollination distances make up the six treatments being examined in the experiment.

Preliminary observations were made on the first of the trees that had flowered and carried fruit in the 1996 season, just two years after planting.

A time budget was also prepared in order to help calculate the cost of this approach to mango breeding. In this budget, full account was taken of all time input into the experiment during the first two and a half years.

Results and Discussion

Of the 550 seedlings planted, 32 died and 87 flowered during the 1996 dry season. This means that 17% of the population flowered after two years. Of the 87 flowering trees, 65 went on to carry fruit through to maturity. This represents 13% of the population fruiting after two years growth. These figures are important because they show that it is possible to obtain early fruiting of monoembryonic seedlings even in a low-land tropical environment. Furthermore climatic conditions during the 1996 dry season were not particularly conducive to good flowering in mango.

The trees that fruited, carried between one and 36 pieces of fruit. Seed from these fruit were extracted and examined to determine whether they were mono or poly embryonic. Based on this examination, it was found that 32 of the 65 trees produced polyembryonic seed. Given that polyembryony in mango is controlled by a single dominant gene (Aron *et al.* in print), these results suggest that almost 50% of the trees that fruited in 1996 were a natural hybrid between Glenn and a polyembryonic pollen parent (possibly Kensington Pride given that it was the dominant source of pollen in most of the orchards from which Glenn seed was collected). If this proves to be the case when more trees fruit in the 1997 season, then it has important implications for any future approach to mango breeding.

Seed from 19 of the trees that were polyembryonic have been included as rootstock treatments in an experiment due to be planted in 1997. Seed from trees that were monoembryonic have also been planted, as it is hoped that these seedlings may show a shorter juvenile period. That is, we hope to be able to select for a short juvenile period (assuming this trait is heritable in mango) and therefore speed up future breeding work with this species.

In terms of time allocations, it was calculated that the first two and a half years of the experiment required 412 person hours (49 minutes per seedling). This included land preparation, irrigation installation and maintenance, seed collection and dehusking, nursery growing, and all field maintenance. The nursery phase consumed over 70 hours, and would appear to be an area where improvements in efficiency can be made.

It is anticipated that the final time input into this experiment (which is programmed to finish in 1999) will be around one hour per seedling. This figure needs to be considered with the relative success of the program (in developing suitable genotypes) when comparing this approach to other methods of mango breeding.

4.1.17 DIRECT SEEDING MANGOES

M Smith, S McAlister and M Houlst

A time budget of inputs into current mango breeding work at KRS showed that major improvements in efficiency could be achieved if it were possible to direct-seed mangoes in the field. This would avoid the time consuming nursery phase (>70 hr / 550 trees) as well as the expense of field planting trees from pots (>90 hr / 550 trees). By decreasing plant spacing from 3 * 4 m to 1.5 * 3 m and with the use of plastic mulch and a seedling planter, it was estimated that the time costs for the first two and a half years of a project could be reduced from 49 minutes per tree to 11 minutes per tree. A preliminary experiment was undertaken to investigate the possibility of direct seeding mangoes.

Materials and Methods

Ripe Irwin fruit were collected and planted through small holes punched into plastic mulch which had been laid over a cultivated seed-bed. Fruit were either: 1. planted whole (green mature); 2. planted whole (ripe); 3. planted after removing the flesh; or 4. the flesh and husk were removed and just the kernel planted. These four treatments were replicated three times, with four fruit in each plot. Planting occurred on 18 October at a spacing of 1.5 m between plants in the row, and 3 m between rows. Emergence and survival of seedlings were recorded.

Results and Discussion

For two weeks after planting, climatic conditions were very hot, dry and with bright cloudless days (mean daily max. air temp. 38.2 °C; mean daily max. grass temp. 56.4°C). Seedlings that emerged showed necrosis of the stem at the level of the plastic mulch. Plants in the dehusked treatment were the first to emerge, and without exception showed obvious signs of stress. Emergence in treatments 1 and 2 was particularly poor, with less than 10% of seeds emerging in each case. Where the kernel alone was sown (treatment 4), around 42% emergence was achieved. The highest rate of emergence (58%) was achieved by only removing the flesh and leaving the husk around the kernel (treatment 3).

None of the four treatments were satisfactory in terms of establishing a population of mango seedlings. However the prospect of direct seeding mangoes should not be abandoned, as our observations point to areas where modifications may lead to increased success. In particular, seeding should take place as late in the season as possible, when there is a higher probability of cloudy conditions and increased humidity. Seed should be defleshed but not dehusked. A tall grass, such as sorghum, planted between the beds may help to keep temperatures down and provide shade for newly emerging mango seedlings. A north-south row orientation may also reduce stress on emerging seedlings.

4.1.17 POLLINATION DISTANCE EFFECTS ON GLENN SEEDLING VEGETATIVE CHARACTERS

M Smith and L Granger

This trial was established in order to determine if seedlings from Glenn trees, growing close to a Kensington pollen source, were any different in vegetative characters from seedlings derived from Glenn trees located far from a Kensington pollen source.

Materials and Methods

The vegetative characters of tree height, trunk circumference, number of branches, length of the longest branch, and average length of branches were measured on three year old mango seedlings of the cultivar Glenn. A total of 473 trees were measured consisting of six different treatments. These six treatments were the distance between the Glenn seed parent tree, and the closest source of Kensington pollen.

Results and Discussion

The character of 'number of branches' showed poor correlation with other measurements, and likewise the correlation between 'trunk circumference' and 'branch lengths' were poor. The six treatments had little influence on the correlations between vegetative characteristics (Table 1).

Table 1. Correlation coefficients for selected vegetative characteristics in mango seedlings where values >0.25 (in all cases $p < 0.05$).

Correlation Between	Correlation Coefficient for different populations						
	1 (closest)	2	3	4	5	6(furthest)	Combined
Tree Height/ Trunk Circ.	0.63	0.67	0.61	0.76	0.74	0.61	0.67
Tree Height/ Av. Branch	0.28	0.39	0.46	0.42	0.30	0.15	0.34
Tree Height/ Longest Branch	0.30	0.43	0.47	0.40	0.30	0.19	0.36
Longest Branch/ Av. Branch	0.91	0.87	0.81	0.92	0.82	0.87	0.87

Clearly there is no evidence for a pollination distance effect on any of the characteristics measured (Table 2).

Table 2. Means of five vegetative measures, for six different pollination distances in Glenn seedlings.

Characteristic	Mean of the Population						Sig. Level p
	1 (closest)	2	3	4	5	6 (furthest)	
Tree Height (cm)	354	345	368	358	348	353	0.56
Trunk Circ. (cm)	28.0	27.2	28.5	26.2	27.0	27.1	0.20
No. Branches	5.56	5.50	5.17	5.83	5.04	5.56	0.55
Longest Branch (cm)	108	121	122	125	107	116	0.41
Av. Branch (cm)	79.3	83.6	81.6	91	71.9	79.1	0.40

Whilst within treatment variation is undesirable in terms of detecting significant differences between treatments, high levels of variation can be desirable in terms of breeding for a particular characteristic. Where large variations are the result of genetic variation (rather than seasonal or environmental) and heritability are high, then there exists considerable opportunity for genetic gain in response to selection. With this in mind, Table 3 shows the mean and variance for each of the vegetative characteristics measured.

Table 3. Mean and variance for five vegetative characteristics measured on 475 Glenn seedlings.

Vegetative Measure	Statistic	
	Mean	Variance
Tree Height (cm)	352	4243
Trunk Circ. (cm)	27.4	38.6
No. Branches	5.47	5.73
Longest Branch (cm)	114	3750
Av. Branch Length (cm)	79.4	2310

These results confirm visual observations on the enormous variation that exists within a monoembryonic seedling population of mangoes and supports much evidence that mangoes are a highly heterozygous species. Future measurements will concentrate on reproductive characteristics of the six different seedling populations.

4.1.18 VARIATION IN MANGO PRODUCTIVITY

G Foord, J Bright, M Smith, M Hout, S McAlister, L de Souza and M Landrigan

In 1996 the large variation in the productivity of Kensington Pride mango trees, between orchards and between trees within the same orchard continued. DPIF Horticulture staff are attempting to identify why such variations exist. This will help in the development of a 'Local Best Practice' model for the Katherine region. Other related projects will compile a record of the size and productivity of the industry and develop a model to predict productivity for the region.

Materials and Methods

In 1996 the data set for this project extended to include an additional property on the Katherine River Levee soil type. There are now 11 groups of three trees in orchards on three different soil types of different bearing ages and management practices. Data collection of phenology, nutrient status (at flowering and after harvest), fruit yield and fruit quality continued in the 1996 season.

Results and Discussion

As in 1995, 1996 data showed that productivity does not directly relate to orchard age, tree size (Figure 1) or a number of other parameters.

Analysis of the data showed that the relationships between yield and leaf nutrient levels were different for young trees and mature trees (Figures 2 and 3). Leaf nutrient

levels were generally unchanged from 1995 to 1996, despite changes in fertiliser inputs.

Sporadic flowering led to an extended harvest season in 1996. Yields were generally lower than in 1995, which may be attributed to the mild dry season and highlights the need to collect data for a number of seasons as well as from a number of orchards. Most trees with relatively high yields in 1995, again yielded well in 1996, however, some improved dramatically when compared to the rest of the data set. Further collection and analysis of data is required to identify what, if any, management practices influenced this improvement.

Growers involved in this project are generally very interested in its progress and are modifying their management, particularly their nutrition program, based on data we collect.

This project seems to have provided us with more questions than answers. High leaf nitrogen levels had a positive impact on the marketable yield and yield efficiency of mature trees (seven years and over). However the negative trend displayed in young trees (four and five year old trees) poses a whole new set of questions. It is somewhat surprising that the young trees with relatively low leaf nitrogen were larger and higher yielding than those with higher leaf nitrogen.

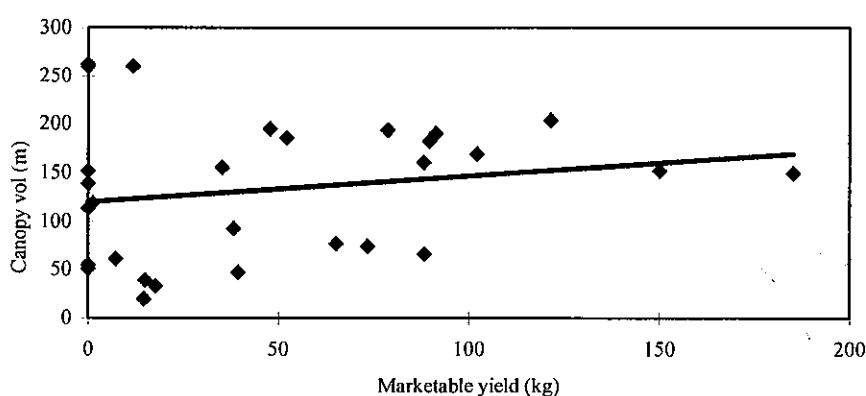


Figure 1. Comparison of tree size and marketable yield (not significant) for mango trees.

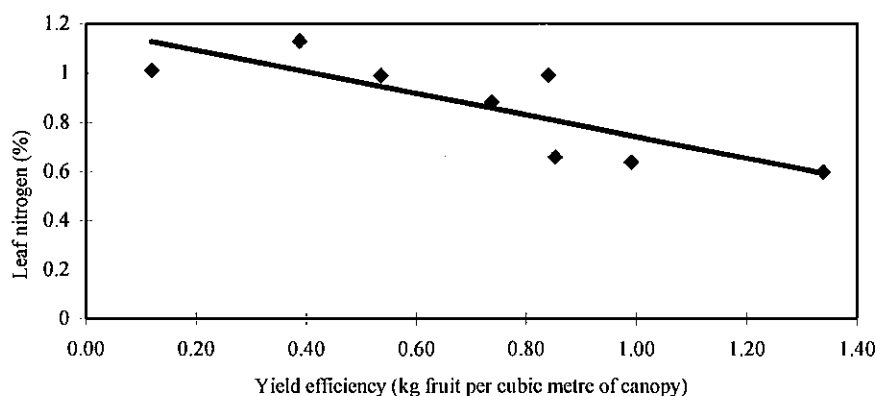


Figure 2. Comparison of tree yield efficiency and leaf nitrogen levels ($P=0.009$) in mature mango trees (>7 years).

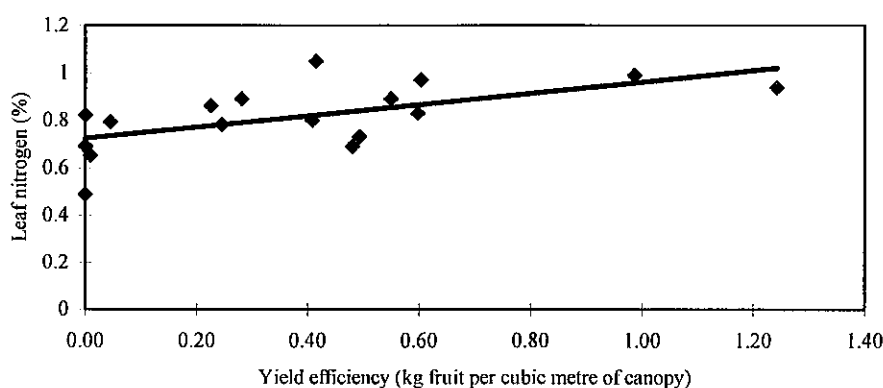


Figure 3. Comparison of tree yield efficiency and leaf nitrogen levels ($P=0.013$) in young mango trees (<6 years).

4.1.19 NEW ROOTSTOCKS FOR KENSINGTON PRIDE

M Smith, M Hoult, G Foord, L Granger, J Bright and S McAlister

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 stocks for Kensington Pride. The influence of soil type on rootstock performance also requires evaluation.

Materials and Methods

An experiment with 64 different rootstocks was planted in mid 1996 on a Tippera clay loam, while the second experiment with 97 different rootstocks is due to be planted in mid 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 spacial variation.

Results and Discussion

Whilst differences between stocks in terms of vigour are already obvious, it will be some years before any meaningful data on yield and quality can be generated from this work.

4.1.19 MORPHOLOGY OF POLYEMBRYONIC MANGO GENOTYPE SEEDLINGS

M Smith, L Granger and S Eastburn

More polyembryonic mango cultivars exist than can ever be evaluated as rootstocks in field experiments. Furthermore, the general absence of pest and disease problems makes the elimination of genotypes on the basis of pot screening (such as is done in citrus) inappropriate as a way of reducing material warranting field evaluation. Ideally we require a way of relating a genotype's performance as a rootstock to its performance as a seedling. Attempts have been made to relate vigour as a rootstock to root bark percentage, and to screen for salt tolerance in seedlings, but direct comparison between seedling performance and performance as a rootstock in the field seems to be lacking.

Materials and Methods

Prior to grafting and planting the new rootstock experiments discussed in this Technical Bulletin, we decided to record some morphological characteristics of different polyembryonic seedlings in the hope that these may later correlate with results obtained from the field.

Trees used at the Tippera site were from seeds sown in December 1994 and 1995, and were measured in February 1996. Measurements were taken from four to six seedlings of each genotype. The measurements included: seedling height; stem diameter; leaf number; leaf area; leaf biomass; bark thickness; bark density; wood density; and internode length. In total, 28 variables were generated for 276 seedlings.

Trees used at the Blain site were from seeds sown in December 1996, and were measured in May 1997. Six seedlings of each genotype were measured for tree height.

Results and Discussion

There was a wide spread in measurements for the morphological characteristics across the genotypes (Table 1). It is also worth noting that what are referred to as 'commons' are obviously not all the same genotype.

Table 1. Three morphological characteristics of 46 mango genotypes, destined for the Tippera site.

Rootstock	Characteristic		
	Seedling Ht. (cm)	Internode Length (mm)	Bark Thickness (mm)
Florigon	868	20.9	0.57
Saigon	847	15.9	0.55
R2E2	800	23.5	0.60
Carabao	800	14.4	0.73
Phoenix	787	15.2	0.20
Orange	777	14.7	0.41
Early Gold	776	13.4	0.64
Sg. Siput	775	27.8	0.59
Pancho R.H.	735	21.7	0.77
Sabre	728	15.2	0.79
B Berrimah	693	10.3	0.32
Glenn seedlings	677	15.0	0.78
Bappukai	667	19.2	0.80
3 Commons	652	15.5	0.77
Golden Tropic	650	9.4	0.33
Batavi	630	20.8	0.58
Banana Callo	620	24.3	0.55
Kensington	610	14.5	0.52
Top End Rural	607	15.5	0.80
Kalano T.O.	570	16.8	0.73
ExCairns	570	10.7	0.91
Pico	570	3.0	0.12
Rapa	550	41.8	0.63
Common near Sg.	548	14.8	0.74
C Berrimah	542	21.7	0.80
A Berrimah	540	3.8	0.11
Starch	530	11.1	0.56
Kurukan	523	13.0	0.90
Giles St. Fence	518	13.2	0.66
Okrong	508	22.3	0.54
Cathania	467	16.8	0.54
Stuttered St. Common	448	11.0	0.67
NT Grain	443	8.5	0.43
Brodie Common	438	11.1	0.70
Olour	428	11.3	0.55
Giles St. Road	408	8.4	0.41
KRS Watertank	402	9.7	0.35
Manzano	397	6.8	0.25
AhToyLong	390	4.1	0.13
Broad Leaf Common	367	9.9	0.68
Neil Eng. Common	352	11.5	0.62
Black Jamaican	350	2.7	0.16
Pineapple	295	5.9	0.29
Adel. River Common	293	10.9	0.62
J. Common	277	14.4	0.44
Nam Doc Mai	150	5.4	0.11
<i>Sig. Level</i>	$p<0.0001$	$p<0.0001$	$p<0.0001$

Results for this second group of seedlings are largely similar to those for the first group in terms of tree vigour (Table 2). Notable exceptions are ‘Vella Colombar’ and ‘Nam Doc Mai’ which grew poorly in the first planting (Tippera site), but were quite vigorous in the second planting (Blain site). This may be due to the younger age of seedlings when they were measured in the second group.

Table 2. Mean tree height for six seedlings of 87 mango genotypes, destined for the Blain site.

Rootstock	Seedling height (cm)	Rootstock	Seedling height (cm)	Rootstock	Seedling height (cm)
Suvernakuekha	100	Manzano	67	Florigon	54
A Berrimah	97	N6E40	67	Irwin*Kens	54
B Berrimah	93	Neil Eng. Com.	66	N4E48	53
Eddie Special	87	Giles St Road	65	Starch	53
Batavi	86	N6E30	65	N3E7	53
DHC Small	84	Unknown CPHRF	65	N1E44	51
NT Grain	82	"13-1"	64	Chandrukuran	51
Vella Colombar	82	Phoenix	64	Acqua	51
Mylepania	81	Black Jamaican	64	Stuttered St. Com.	51
Saigon	81	Carabao	63	Moovandan	50
Tong Dum	80	Charles	63	N2E6	49
KRS Watertank	79	J. Common	63	N8E13	49
N6E36	79	Glenn seedlings	62	Orange	48
Top End Rural	79	N2E39	62	False Chausa	48
Bappukai	79	Joe Welsh	61	Golden Tropic	48
N9E45	79	Blue	61	Browns Seedling	47
Common near Sg.	76	Manggadol	60	Rosa	47
Teluk Anson	76	Pancho R.H.	60	N8E45	43
Koopa Reva	75	Olour	60	N6E4	42
3 Commons	73	R11T1	60	N10E43	41
Pico	72	N10E53	59	Elephant Tusk	39
Sg. Siput	71	N9E36	59	R2E2	37
Kensington	70	Banana Callo	59	Mylapelian	33
Pineapple	68	Peach	58	N4E13	32
Kimtanya	68	Lemon D2	57	N4E41	32
Okrong	68	Nam doc Mai	57	Broad Leaf Com.	31
Kurukan	67	N9E17	57	N2E19	26
Cathania	67	Rapa	57	Millaroo	25
Sabre	67	Giles St. Fence	56	Rajah	25

Differences between genotypes significant at $p < 0.0001$. Critical value of $T = 1.97$

These measurements will be reviewed again once field performance data becomes available.

4.1.19 GRAFT COMPATIBILITY OF MANGIFERA SPECIES

M Smith, TK Lim and L Granger

In recent years there has been renewed interest in *Mangifera* species other than *Mangifera indica* (which is the species of almost all cultivated mangoes). This interest has been stimulated by presentations at the Fourth International Mango Symposium in Florida, the text of Kostermans and Bompard (1993), DPIF field collection trips to Borneo, and an increasing commitment by the Department to mango breeding and rootstock development.

Of fundamental importance to collecting, maintaining and utilising these different species, is their graft compatibility with *M. indica*.

Materials and Methods

A range of budwood material has been grafted to various *Mangifera indica* cultivars at KRS. The species that have been tried as scions include (as labelled): *M. odorata* R1T6 BARC Pastures; *M. quadrifida*, R1T3 BARC Pastures; *M. laurina* (Depih) R2T2 BARC Pastures; *M. torquenda* R1T4? BARC Pastures; *M. foetida* (Aqua) BF1 R7T3; *M. casturi* (Round), Peter Gillett Qld.; *M. casturi* (long) Peter Gillett Qld.; *M. laurina* R1T1? BARC Pastures; and *Bouea macrophylla*, C. Gustont Darwin. Between three and ten grafts of each were attempted at various times during 1996.

Results and Discussion

Although of very limited scope to date, early indications are that many of the species currently available in the NT are compatible with *M. indica*, at least in the early years. The growth rates of scions such as *M. laurina* and *M. casturi* have been particularly impressive. Although from a separate genus, graft sticks of *Bouea macrophylla* remained green for over two months, and in three cases, the buds started to push. Although none of the grafts were eventually successful, indications were that future success may be possible with this material and more intergeneric grafting would be worth evaluating.

It is important to identify which species are the most difficult to successfully graft, and to evaluate means of overcoming such problems. For example, during grafting, it was observed that species differ in the thickness of their bark. In such cases, it may be worth examining a range of different rootstocks since we have also observed large differences in trunk morphological features within *M. indica*.

Great care needs to be taken when ascribing a species name to a particular tree. Often this material has come with only tentative identification. Hence it is important to identify the individual budwood source trees in case these trees are later found to have been wrongly named. For example the tree in the BARC orchard labelled as *M. foetida*, is certainly wrong, and more likely to be *M. laurina* (still to be confirmed).

The benefits of having a wide range of genetic material available for rootstock and breeding work, may be of great commercial significance in decades to come.

4.1.20 HEAT SUMS TO PREDICT FRUIT MATURITY IN MANGO (CV. KENSINGTON PRIDE)

Y Diczbalis, C Wicks and M Landrigan

Mangoes are a climatic fruit. That is, they can be harvested when mature (hard green) and will successfully ripen into firm but succulent well coloured fruit. The ability to pick at the hard green stage is of considerable advantage to the industry in terms of packaging and transport, however, fruit maturity at harvest and the resultant quality of fruit on the market floor has been an important industry issue since the industry commenced. The maturity of Kensington Pride, the main commercial cultivar, at harvest strongly influences the quality of the fruit at the soft ripe stage.

The current maturity indices used by industry include flesh dry matter percentage, flesh colour, fruit size and shape and to the industry's detriment, price. All of these methods are fallible and can be influenced by season, crop management, picker perceptions and greed. None of the currently utilised maturity indices allow an accurate long term prediction of harvest date to be made, hence orchard management can be chaotic in the weeks leading up to anticipated harvest.

Materials and Methods

Heat Sums are a combination of the time for a particular event to occur and the average temperature experienced during the period monitored. Heat Sums take into account the fact that the rate of development of any biological process is temperature dependent. Hence the objective of this one season (1996) project was to examine the relationship between Heat Sums (Growing Degree Days), other fruit maturity indices, and fruit quality at the soft ripe stage to ascertain whether Heat Sums could be utilised as a mango fruit maturity predictor. Other fruit maturity indices examined at the same time included; dry matter percentage at harvest, flesh colour at harvest (as per the QDPI Mango Picking Guide), total soluble solids (TSS - a measure of sugars - °Brix) at harvest and specific gravity, ie. the ability of the fruit to sink or float in different solutions. Fruit quality measurements made at soft ripe included; peel colour, flesh colour, TSS, and titratable acidity.

The work funded by a commercial mango orchard, HRDC (Project number FR605) and DPIF was carried out at a combined cost of \$8,000. Three commercial orchards in the Darwin area were selected for the project, principally Acacia Hills Farm Pty. Ltd., the commercial contributor to the project. Temperature data was collected by maximum and minimum thermometer and electronic temperature data loggers from early flowering until harvest. Fruit were sampled from each of three flowerings (May, June and August) over a four week period at a range of Heat Sums. Fruit were transferred to the laboratory where they were desapped and divided into two groups with one half being sampled for fruit weight, specific gravity, flesh colour, TSS and flesh dry matter %. The remaining fruit were stored at 20°C and 70 % RH until soft ripe. When soft ripe, fruit were assessed for fruit weight, peel colour, flesh colour, TSS and titratable acidity. Following the completion of data collection, all the ripened fruit were rated on the basis of stringent fruit quality criteria, for different levels of the maturity indices tested.

Results and Discussion

Our data showed that fruit quality, in particular peel and flesh colour, improved as the maturity of fruit at harvest increased. Heat Sum is as good or better a maturity index than dry matter percentage at harvest, with both methods able to account for greater than 90% of marketable fruit at Heat Sums greater than 1500 Celsius degree hours and at dry matter greater than 16%. The best ratings for flesh colour, TSS and specific gravity at harvest were only able to account for 75 to 86% of marketable fruit and hence were not considered as good indicators of fruit maturity. The advantages of the Heat Sum technique for predicting fruit maturity are:

- it can be used as a true predictive tool from flowering, thus allowing for an improvement in orchard management and planning

- calculations are not affected by irrigation management, unlike dry matter percent and TSS
- the method is not affected by the bias selection of fruit prior to harvest.

It is not envisaged that the Heat Sum technique is capable of totally replacing currently used maturity indices, however, when used in conjunction with current methods it will allow for improved orchard management and improve the quality of mangoes on the market floor.

The scope of the experiment did not allow the reliability of the technique to be tested from season to season and over a range of growing environments. However, data already available from other seasons and regions suggests that the technique may be suitable across a wide range of environments and seasons. Immature fruit will continue to be a problem in the 'shed' market, regardless of maturity indicator utilised, hence the development of an inline culling method is also crucial to the improvement of the final product. This study showed that specific gravity may have potential as a post-picking maturity sorter.

The full report to contributing growers and HRDC is near completion.

4.1.21 FRUIT FLY DISINFESTATION

FACTORS AFFECTING SCALD DAMAGE IN HOT WATER TREATED MANGOES

E S Smith, M Neal and H Wallace

This project was undertaken to determine the pre and post harvest conditions which can predispose mango fruit to suffer scald damage when exposed to an on-farm hot water treatment effective against fruit flies and post-harvest rots.

A Hot Water Dipping (HWD) system for mangoes has been developed over the past seven to eight years. The treatment will :

- satisfy quarantine security for fruit flies
- significantly reduce the incidence of post-harvest rots
- eliminate the use of post-harvest chemicals
- accelerate ripening
- give other advantages over the currently accepted methods of marketing mangoes for interstate trade.

The main drawback to general acceptance of the technique by NT growers has been the possibility of fruit suffering heat scald. In the past, this damage has been severe enough to prevent marketing of the fruit. Previous work had shown that scald damage was strongly associated with pre-harvest rainfall and that the damaging effects could be ameliorated by field irrigation practices. Post-harvest conditioning by holding for 24 hours (or longer if harvested after rain) or heating the fruit will also decrease the risk of scalding. Work during the 1996 season was aimed at developing a practical

preconditioning method to carry out the HWD practice on the farm or at the packing shed.

Results

Several areas of work were conducted during the 1996 season.

Conditioning fruit prior to HWD treatment.

The previous season showed that even with rain affected fruit, holding at ambient temperatures for 48 hours eliminated the scald problem. In the 1996 season, we tested the effect of preconditioning fruit at 38-40°C prior to treatment. Mangoes were harvested and held overnight at that temperature before immersion in 47°C water within 24 h of harvest. Preconditioning under these conditions shortened the ripening time; increased the appearance and marketability of fruit and decreased the lenticel score when compared with fruit held for 24 h at ambient temperatures before HWD. There was no scald or disease recorded in preconditioned and HWD fruit. Preconditioning without HWD appeared to improve the appearance and marketability of the fruit, decrease lenticel enlargement and, of course, eliminate the chance of scald compared with those fruit held overnight at ambient temperature and then HWD.

Determination of heat tolerance in immature stages of fruit fly pest species.

A collaborative project between QDPI, Agriculture WA and DPIF will determine the heat tolerance for a range of pest fruit fly species. This work is aimed at identifying the most heat tolerant stage of the most tolerant species of fly to facilitate international trade. The Entomology Branch has undertaken to provide data on *B. aquilonis*. The project commenced in November 1996 and will be completed in 1997.

Heating profile of mango fruit - comparison of temperatures at 10 mm below the skin and at the seed surface.

In early 1996, an NT organic grower queried why core temperatures are specified for heat treatments while the chemical treatment is thought to penetrate only a short distance beneath the skin. Subsequently, the Interstate Plant Health Regulation Working Group requested that the NT provide experimental data on the heating profile of fruit which compares temperatures at 10 mm below the surface with those at the seed surface. The propensity to produce heat damage in mangoes during disinfestation treatment is dependent on the interaction between time of exposure and the temperature.

A series of experiments were conducted and temperature profiles were similar and remarkably consistent for all trials. When mangoes preconditioned to a temperature of >36°C were heated in 47°C water, sufficient heat penetrated through the skin to a depth of 10 mm to raise the flesh temperature to 46°C within 36 minutes. To attain the same temperature at the seed surface in all the fruit tested required exposure for an additional 23 minutes. The major factors affecting the heating times were the initial fruit temperature and the water circulation within the dip tanks. Size of fruit had little effect on heating times.

A heating treatment which raises the flesh temperature 10 mm below the skin of mangoes to 46°C and maintains it at that temperature for ten minutes would significantly reduce the risk of heat damage to the produce. Work currently in

progress (point 3 above) will produce data on the tolerance of immature fruit fly stages to heat exposure. If interstate quarantine authorities are prepared to accept this schedule as a reliable fruit fly disinfestation treatment, the core temperature of preconditioned mangoes should have reached a minimum of 45.5°C.

Repeat of 1994 and 1995 experiment on fruit from different rootstocks.

During 1994, differences were apparent in a Katherine planting but significant differences were not revealed by statistical analysis. The block was originally established to test the effect of rootstock on fruit production and other factors in Kensington Pride mangoes. In the 1995 season, statistical differences in the HWD scalding of fruit from various rootstocks were shown. With little rain during the 1996 season, no differences were apparent. These findings will be assessed by the Horticulture staff at Katherine in relation to other tree and fruit parameters.

4.1.22 BIOLOGICAL CONTROL

ARTHROPOD PROBLEMS ON MANGOES

E S Smith, H Wallace and D Chin

The purpose of this study was to identify potential arthropod problems in mangoes.

Mangoes are the most important horticultural crop in the NT and receive a proportionate amount of the Entomology Branch's resources. New problems appear each year as this relatively new crop continues to expand in area and value, and new growers enter the production phase. Horticultural officers, commercial mango growers and urban backyard producers frequently refer previously unobserved or assumed pest situations to the Branch for advice or comment and these situations may detect a new or potentially damaging pest problem.

Results

During the year, several arthropod species were identified as new or potentially damaging to mango trees in the Top End.

The two species of fluted scales, *Icerya aegyptiaca* (Douglas) and *I. seychellarum* (Westwood) (Homoptera: Margarodidae) previously mentioned (Technical Annual Report 1995/96) continued to expand in distribution and numbers in mango blocks. As described in the next section, the commercially available predatory beetle *Cryptolaemus montrouzeri* Mulsant (Coleoptera: Coccinellidae) has given good control of these pests.

Several reports of large aggregations of chrysomelid beetles on leaves and fruit from both the Katherine and Darwin rural regions were received. On one property, *Agetinus* sp. (Coleoptera: Chrysomelidae) defoliated new flush tissue while elsewhere, two species of *Aphthona* (Coleoptera: Chrysomelidae) were involved but no damage was noted.

Melon aphid *Aphis gossypii* Glover (Hemiptera : Aphidae) was recorded from mango flush in the Katherine area. This is a wide spread species with many hosts throughout the NT. A predatory fly *Leucopsis formosana* Hennig (Diptera : Chamaemyiidae) was collected feeding on the aphid colonies.

As growers examined their trees more thoroughly, more requests for information on thrips were received. During the last year, *Frankliniella schultzei* Trybom (Thysanoptera: Thripidae), *Thrips hawaiiensis* Morgan (Thysanoptera: Thripidae), *T. imaginis* Bagnall (Thysanoptera: Thripidae), *T. coloratus* Schmutz (Thysanoptera: Thripidae) and *Haplothrips* sp. (Thysanoptera: Phlaeo-thripidae) have all been collected from flowers. Only the *T. hawaiiensis* and ? *T. coloratus* detections represented new records for mangoes in the NT. Redbanded thrips, *Selenothrips rubrocinctus* (Giard) (Thysanoptera: Thripidae) was recorded from a second commercial property in the Katherine region.

In addition, more detailed investigations involving several other arthropods on mangoes were conducted. The main investigations were:

Investigations on the insect involvement in mango scab disease and the lenticel blowout syndrome

In collaboration with the Plant Pathology Branch, the Principal Entomologist was heavily involved in investigations to rule out the involvement of insects in these two disorders. In particular, damage by mango scab appeared superficially similar to that of thrips which may feed on very young developing fruitlets.

Fruit fly infestation in mangoes within open trays inside a packing shed

The Interstate The Plant Health Regulation Working Group requested that the NT conduct trials to determine whether flies could oviposit in fruit left on benches or in open boxes in packing sheds following heat disinfestation treatments. Initial observations of flies on fruit stored in plastic picking crates within a packing shed and subsequent experiments on placing fruit for exposure at various locations in the shed clearly indicated that *B. jarvisi* could infest fruit in those situations. It is very likely that the 1995 infestations detected by interstate quarantine inspectors occurred in NT mangoes after hot water disinfestation treatments had been applied and during storage of packed fruit as cartons were placed to build a pallet.

Further investigations on flower caterpillars

Following work conducted previously (TAR 1989/90; 1990/91) a series of emerging flower panicles on several properties were tagged and numbered at emergence. These were then examined at at least weekly intervals for at least 6 weeks to determine the incidence of flower caterpillar infestation, the abundance of natural enemies and the fate of fruitlets which set on these panicles. Although infestation was very patchy due to the uneven spread of flowering during the season, the information collected again indicated that fruit set was probably not affected by flower caterpillars during this period; that caterpillar levels of two to three per panicle could be sustained without yield loss; but that superficial damage to the fruit (enough to cause downgrading at harvest) could be produced when old inflorescences and larval webbing remained on the panicle long after the caterpillars had pupated.

There was also ample evidence that where growers followed the current recommendations of *Bacillus thuringiensis* formulations at a high volume of carrier, wetting agent and high pump pressures, very good control was achieved.

4.1.23 MANGO INDUSTRY LEVY

I Quin

The NT Horticultural Association requested the NT Government to legislate for a compulsory fee for service, as a means of raising funds for developing the local mango industry. The NT Government declined on legal advice that a fee for service may be deemed a levy and therefore a form of tax. Under the Australian Constitution only the Commonwealth has the legal power to raise a tax.

Subsequent approaches to the Commonwealth to raise a mango levy on behalf of the NT have been declined due to lack of support from Queensland mango growers as they are concerned at the loss of control over the funds raised in this manner.

Various industry or marketing groups are legally capable of raising their own revenue by voluntary contributions such as Northern A-Peel.

4.2.24 ECONOMICS OF MANGO PROCESSING IN THE NORTHERN TERRITORY

H Ngo

NT mangoes, mostly Kensington Pride, currently enjoy high prices in southern markets due to the early-in-the-season factor (which is usually from mid-October to mid-November, while the bulk of Queensland mangoes is still not available until late November). However, this may change in the future when production is projected to at least double within the next three to five years as more trees come into bearing. In order to reduce the pressure on the limited fresh fruit domestic market, other market options such as exports and mango processing were, or are being examined by Queensland and the NT in collaboration with the mango industry.

This paper provides some notes on the subject and a preliminary economic analysis on the profitability of the manufacturing of frozen mango cheeks/slices and frozen mango puree.

Processed Mangoes

Mangoes, mostly second grade and in good condition, can be processed into a number of products including frozen mango cheeks/slices, mango puree (concentrated or single strength), canned mango slices, mango chutney, dried mango chips/slices, dried mango puree (mango leather or mango powder); and de-hydrated mango dices/cubes for the muesli markets.

Of particular interest to the NT are quick-frozen mango cheeks/slices and frozen mango puree. Market research from QDPI (Smith 1990) indicates that frozen mango puree, quick-frozen mango slice and mango dice/cubes/balls in syrup appear to be favoured by overseas markets especially in France, Germany, the UK and Canada. Frozen de-skinned whole mango cheek is also reported to be demand in Japan and China. As far as quarantine is concerned, frozen mango products can enter the Japanese market much easier than fresh mangoes due to the current papaya fruit fly problem in Queensland.

Frozen products are relatively easy to produce and do not require high capital outlays as in canning or in the production of aseptic mango puree. The process to produce these is briefly outlined below.

The Processing of Frozen Mango Cheeks/Slices

The mature Kensington Pride mango fruit is ripened, washed, de-skinned, de-cheeked, then vacuum bagged (at six cheeks per bag) before being quick frozen, either by immersing in liquid nitrogen or by blast freezing. The advantage of freezing fresh mangoes (eg. mango cheeks or slices) is that flavour can be maintained, there are no "cooked" flavours as in canned mangoes. The quicker the freezing process can be carried out, the better the quality. Liquid nitrogen can be used to freeze mango quickly, giving good texture retention. The frozen cheeks are packed in suitable carton boxes and stored at -18°C before being exported by shipping. If a mechanical de-cheeker is used, the recovery rate for cheeks is estimated at about 30%-35% of the total mango fruit weight.

The Processing of Mango Puree

The preparation of mango cheeks/slices is usually accompanied by the utilization of the remainder of the fleshy pulp attached to mango seeds for mango puree. This can be carried out with the use of a brush finisher. The rate of recovery is estimated at about 20% of the mango fresh fruit weight.

Mango puree can also be prepared from whole fully matured mangoes. The fruit is washed, sorted and pulped. The recovery rate in this case is up to 55% of the total fresh fruit weight. Freezing of mango puree is probably the simplest way and does not require high capital outlay. Frozen puree is reported to be sold at around \$1.20/kg (net) in southern markets. It is also reported to be in demand in overseas markets such as Germany, France and Canada.

Estimated Financial Returns for Cottage-type Mango Processing in the Northern Territory

Preliminary financial analysis shows that the total capital investment outlay required for a cottage-type mango processing project to produce frozen cheeks (or mango slices) and frozen puree for export would be from \$90,000 to around \$135,000 (depending on the type of freezing equipment used and whether it is leased or owned). It appears that an acceptable rate of return for this type of investment, assumed to be around 25%, can be achieved if raw material mangoes can be obtained at the following prices:

- a) \$0.57/kg (factory door) for projects using liquid nitrogen for freezing. The reason for low profitability (and hence lower price for raw materials) is the high costs of freezing by liquid nitrogen including the hiring of an expensive nitrogen tank for the whole year.
- b) \$1.24 - \$1.28/kg (factory door) for projects using mechanical blast freezing, which is cheaper to operate than liquid nitrogen.

The mango raw material price indicated in (a) at \$0.57/kg (or \$3.70/carton) is much too low to be acceptable to growers. The estimated internal rate of returns (IRR) is either at zero or negative, depending on yield. At this price level, some growers may dispose of their second grade and reject mangoes to processors as a last resort but would not be committed as long term suppliers to processors. Alternatively, prices of frozen mango cheeks need to be higher than \$6/kg to justify the high cost of freezing by liquid nitrogen and subsequently, be able to pay better prices to producers. However, it is not known at this stage, if such a premium exists for whole mango cheeks being frozen by liquid nitrogen compared with blast freezing.

Mango raw material price indicated in (b) at around \$1.24/kg - \$1.28/kg (roughly \$8/carton) is much better than prices currently being offered by local and interstate processors (from \$0.30/kg to \$0.60/kg - farm gate prices). This price level would enable growers to achieve an IRR in real terms, of around 15% for a high density orchard (5m x 7m or 285 trees/ha) with an assumed yield of 25 tonnes per hectare at maturity. For a more conventional lower density planting with an estimated lower yield (15 t/ha), an IRR of around 9% can be expected.

Tables 1 and 2 show the potential returns on investment (ROI) at various mango raw material (factory door) prices and frozen mango cheek/slice prices.

Table 1. Potential returns using own (mechanical) blast freezer

Mango Raw Material Prices (\$/kg)											
Frozen mango											
cheek/slice	price	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
(\$/kg, CIF)											
5		117%	98%	79%	60%	42%	23%	4%	-15%	-34%	-52%
6		183%	164%	145%	126%	107%	88%	70%	51%	32%	13%
7		248%	229%	210%	192%	173%	154%	135%	117%	98%	79%

Table 2. Potential returns using own (liquid nitrogen gas) batch freezer

		Mango Raw Material Prices (\$/kg)							
Frozen mango									
cheek/slice price		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1
(\$/kg, CIF)									
6		41%	32%	22%	12%	2%	-8%	-17%	-27%
7		76%	66%	56%	46%	36%	27%	17%	7%
8		109%	100%	90%	81%	71%	61%	51%	41%

Note: Shaded area indicates price combinations which would give acceptable profitability to the processor.

Outstanding Issues

- i) The markets (both domestic and overseas) for frozen mango cheeks and mango puree are very much unknown at this stage. For the domestic markets, demand for de-skinned frozen mango cheeks (whole or sliced), could be in the tourist trade (eg. up-market restaurants and chain restaurants, market to supply meals for domestic and international airlines etc. Further detailed market research and at a later stage, product promotion is definitely required.
- ii) There are certain unknown technical issues relating to these frozen products at this stage. For example, what would be the quality and acceptance by consumers of these frozen mango products, is there a quality premium for mango cheeks frozen by liquid nitrogen compared with normal mechanical blast freezing, what is the optimum (and least costly) way to process the products under small scale/cottage industry scenarios etc. To answer these questions, further research work is required.

4.1.25 MANGO EXPORTING

S Greenwell

In 1996, a group of mango growers came together to establish an exporting network. Although the group were not able to export in the 1996/97 season, they were able to put all the systems in place which will enable them to export in the future.

Currently actions are being taken to move the group into the actual exporting stage. The NTHA is playing a support role to the network, but the motivation to begin exporting has come primarily from the growers involved. The future of this project now lies with industry's willingness to pursue it to its end.

4.1.26 MANGO QUALITY MONITORING

S Greenwell and T Matthews

The Mango Quality Monitoring Project was initiated in 1996 and by all reports was enormously successful.

In 1997, the quality monitoring will be conducted again, with industry (through the NTHA) playing an increasing role. The assistance of DPIF in 1997 will be limited to data analysis and reporting.

4.1.27 VISIT TO WHOLESALE MARKET

S Greenwell

The interstate markets of Adelaide, Melbourne, Sydney and Brisbane were visited from 11-21 November 1996.

The primary aims of the trip were to:

- gain an appreciation of the wholesale market system for NT fruit and vegetables, seafood and floriculture products;
- determine for wholesale Agents and Retailers, the extent to which NT produce meets customer requirements with respect to quality, packaging, presentation and promotion;
- provide a market presence for NT producers and establish networks in interstate markets;
- create and maintain contact with interstate industry bodies which effect the success of NT primary produce.

The trip proved extremely successful and enlightened the NT Marketing Branch of trends that are happening in the market, which will in turn be fed back to industry.

4.2.1 EVALUATION OF A GROWTH PROMOTING CHEMICAL AND ITS EFFECTS ON TABLE GRAPE QUALITY

G Kenna, J Mansfield, K Young, N Isgro, C Ellis and S Miller

A new generation plant growth regulator is being researched in India. The substance is sold commercially as Combine[®] and is a naturally occurring brassinosteroid.

The chemical Gibberellic Acid (GA) has been used for many years by tablegrape growers to improve the berry size and quality of seedless tablegrapes. There are a number of problems associated with its use such as the accurate timing of spray applications and the effectiveness of the sprays in achieving the desired results. While increased berry size may be achieved, the effectiveness of spray applications for berry thinning and bunch stretching, which is necessary to offset the increase in berry size, is not always possible. The manufacturer of Combine[®] claims that it will increase berry size in tablegrapes independently of GA, yet it also has a synergistic (complementary) effect when used with that product. Research work in India recommends that a small amount of GA be used in combination with Combine[®] for best results. The product can be used on seedless and seeded varieties.

Preliminary work to assess the potential of Combine[®] for the Central Australian tablegrape industry was carried out in 1994. The assessment was carried out at Territory Grape Farm on the varieties Flame Seedless, Menindee Seedless, Sultana and Red Globe, using two methods of application - dipping and hand spraying. Results from this preliminary work indicated that the use of a Combine[®]/GA solution has the potential to improve tablegrape bunch quality in all varieties, particularly when the bunches were dipped. While individually dipping each bunch in solution is the

recommended method of application, this is considered uneconomic under Australian tablegrape production conditions.

Further research on the chemical was considered necessary, and in the 1995-96 season it was trialed again at Territory Grape Farm using two varieties, Menindee Seedless and Red Globe. The use of Combine[®] on the early maturing white grape Menindee Seedless was of particular interest as the use of GA on this variety can cause a severe decline in yield in the season following application of the chemical. The use of Combine[®] with a very small amount of GA may have the potential to increase berry size and bunch quality without compromising future yields. Results from this work indicated that there were no improvements in fruit quality when Combine[®]/GA was applied to the cultivar Red Globe, however there were significant improvements in fruit quality when the same solution was applied to the cultivar Menindee Seedless.

In the 1996-97 season, another field trial was established to investigate two issues which had been identified concerning the use of this chemical in the cultivar Menindee Seedless the previous season:

1. Research in the previous season had indicated that there was a significant increase in bunch weight in those vines treated with Combine[®]/GA however there was no significant difference in berry weight or berry diameter. It was concluded that the treated bunches may have had more berries per bunch which contributed to the increase in weight. This needed to be confirmed.
2. If this chemical is to have a place in modern tablegrape production in this region it must be able to be applied by spray application rather than by dipping individual bunches as is the method of application recommended by the manufacturer.

Materials and Methods

The experiment was conducted in a commercial table grape planting of *Vitis vinifera* cultivar Menindee Seedless located at Territory Grape Farm, approximately 200 km north of Alice Springs. The vines are planted at 3.3 m (between rows) and 2.8 m (between vines). The vines are cane pruned on two cordon wires. All cultural practices are for this cultivar in this region.

The experiment was organised in a randomised complete block design. Treatments were replicated ten times using three vine plots. The middle vine in each plot was used for data collection. Bunches were counted on these vines and were then thinned to 15 bunches per vine on 8 October 1996. Treatments were applied to the bunches on these vines and to any leaves, canes and shoots around these bunches using a hand held spray wand. Each bunch on the treated vines was sprayed to runoff with a Combine[®]/GA solution. Two sprays were applied as per the manufacturers recommendation for hand dipping of bunches. One spray was applied on 8 October 1996 and the second spray was applied on 17 October 1996.

All the data collection vines were harvested on 19 November 1996. All the bunches from each vine were weighed and bunches less than 300 g were discarded. The weight of bunches over 300 g was recorded.

From each vine, two bunches were taken for destructive analysis. All the berries on a bunch were stripped off and then counted. They were then measured for berry diameter using sizing rings and from this the average berry size was calculated. All berries on the sampled bunch were then placed together in a container and weighed and average berry weight was obtained. Following this, these grapes were squashed and the brix reading was recorded.

Results and Discussion

The treated vines had slightly heavier bunches (average of 40 g heavier per bunch) and slightly higher yields per vine (Table 1).

Table 1. Effect of spraying Combine®/GA on bunch weights and vine yields

Treatment	Bunch Weight (g)	Av. Bunches/Vine	Total Weight/Vine (kg)
Control	510	14.80	7.35
Sprayed	550	16.10	8.81

There was no significant difference in the number of berries on bunches between treated and control vines. However, treated vines had significantly larger and heavier berries and thus heavier bunches. The treated vines had a lower Brix reading indicating that the bunches were not as mature as those on control vines, though the Brix readings still met market standards (Table 2).

Table 2. Effect of spraying Combine®/GA on berry characteristics

Treatment	Berries/bunch	Av. Berry Size (mm)	Total Weight of Berries (g)	Av. Berry Weight (g)	Sweetness (brix)
Control	135.8	17.6	488.1	3.6	20.5
Sprayed	133.0	18.8	554.5	4.3	18.2

It appears that the application of a Combine®/GA solution by hand spray to Menindee Seedless does appear to lead to an increase in berry size and bunch weight, although maturity is delayed. However, this increase in size and weight may not be great enough to make an economic difference. While the application of the treatment by hand spray is much more efficient than by dipping individual bunches, applications need to be even more efficient. It is proposed that if this treatment is to be applied efficiently and to be cost effective, further work needs to be conducted to evaluate the effectiveness of the chemical when applied by an airblast spray applicator. The effect that the application of a Combine®/GA solution has on the ability of Menindee Seedless to produce a crop in the following season also needs to be evaluated.

4.2.3 TABLE GRAPE CULTIVAR EVALUATION IN KATHERINE

M Hoult, S McAlister, G Foord, J Bright and D Jaensch

The aim of this trial was to screen various table grape cultivars to determine which ones are suitable to the tropical environment of the Katherine region and to identify suitable management strategies.

Materials and Methods

Various table grape cultivars, such as Ruby Seedless, Flame Seedless, Shtur Angur, Kali Sahebi, Muscat Hamburg, Perlette, Cardinal, Ribier, Queen, Carolina Black Rose, Sultana H5, and Hussiene were planted on their own roots at KRS in July and August 1994.

Other varieties such as Centennial Seedless, Menindee Seedless, and Maroo Seedless were planted in 1995, on Schwarzman rootstock, Teleki 5A rootstock and own roots respectively.

Vines were pruned in late May 1996 with an application of Dormex (4%) applied within 24 hours of pruning. Powdery mildew and black spot levels were monitored through the season and sprayed accordingly.

Irrigations were scheduled according to soil moisture levels monitored using tensiometers.

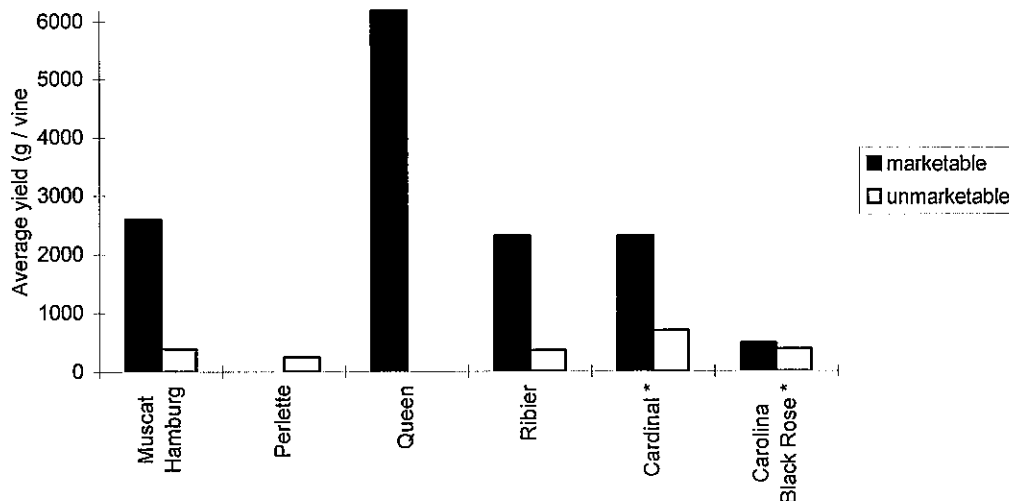
Vine yields at 19-19.8 °Brix were recorded for each variety in the 1996 season.

Results and Discussion

Muscat Hamburg, Queen, Ribier and Cardinal vines cropped reasonably well, with Queen producing the highest yield (Figure 1). Carolina Black Rose vines produced a smaller crop with a large proportion of the bunches being unmarketable due to berry drop and bunch shrivel. Similarly all bunches produced on Perlette vines were unmarketable due to their extremely small size.

Harvest of Carolina Black Rose started on 9 September, Cardinal, Queen and Muscat Hamburg on 20 October and Ribier on 3 October 1996. Management practices and disease control needs to be improved in order to achieve the higher yields required to meet the high production costs.

Vines of Ruby Seedless, Flame Seedless, Shtur Angur, Kali Sahebi, Sultana, Hussiene, Centennial Seedless, Menindee Seedless, and Maroo Seedless vines failed to produce fruit in the 1996 season. The vine vigour and yields will be monitored for these varieties during the 1997 season.



**mean number of bunches for two vines. Other yield readings are for one vine only*

Figure 1. Harvest yield (g/vine) and marketability of various table grape cultivars grown in Katherine, NT 1996.

Vines have been either cane pruned or spur pruned according to their fruitfulness in June 1997. Cultivars that were fruitful at the start of the canes were spur pruned, whereas those cultivars that showed fruitfulness in proximal buds were cane pruned. Many vines were cut back in 1997 at the top of the trunk in order to regain the vine structure. This is expected to greatly reduce the yields achieved in 1997.

4.2.5 ASSIST THE TABLE GRAPE INDUSTRY IN CENTRAL AUSTRALIA TO REALISE ITS FULL POTENTIAL BY THE PRODUCTION OF QUALITY FRUIT FOR DOMESTIC AND EXPORT MARKETS.

G Kenna and J Mansfield

The potential for the development of a tablegrape industry in Central Australia was originally identified when trial plantings were established at the AZRI, approximately 25 years ago. The quality and early maturity of the fruit were identified as a major marketing advantage. In addition, vine growth was excellent and there was a minimal incidence of vine pests and diseases. This resulted in the first commercial planting of table grapes in Central Australia being made by Mr Ian Dahlenburg at Ti Tree, 180 kilometres north of Alice Springs in the early 1970's. The total area planted to table grapes has now reached 172 hectares with approximately 51 hectares of this being planted in the last two years. This is expected to increase significantly with plantings planned for the next two years.

The need to work cooperatively to solve problems during the production cycle is becoming increasingly evident to all involved in this industry. In April 1997, table grape growers in the region met with staff of DPIF to discuss past research and to

determine future research and development priorities. It is intended that these meetings will be conducted on a regular basis.

4.2.6 EXTENSION SERVICES TO HORTICULTURE INDUSTRY

G Kenna and J Mansfield

Table grape growers in the region were visited on a regular basis during the year. Fruit fly traps were checked regularly to maintain area freedom status and plant health certificates issued for interstate market access. In addition, soil sampling was conducted on all properties in the region to generate base information on the nutritional status of the soils. Limited leaf tissue analysis was also conducted and this is expected to be increased to cover all properties in the future. Some farms have also been sampled for nematodes and in future the remaining farms will be sampled. Assistance has been provided to growers with the provision of tensiometers for more efficient irrigation scheduling and with the interpretation of the readings.

4.2.7 ASSESSMENT OF VARIOUS PRUNING METHODS FOR RED GLOBE TABLE GRAPES IN KATHERINE

M Houtt, S McAlister, M Smith, G Foord, J Bright and D Jaensch

Red Globe table grapes remain one of the most popular grape cultivars for both the domestic and Asian market. Although seeded, consumers are attracted to its very large size and good eating qualities.

This project aims to determine whether Red Globe grapes can be successfully produced, as well as identify the optimum pruning method for this cultivar in a tropical environment.

Materials and Methods

Six pruning methods were applied to six single vine replications in a randomised complete block design. Red Globe vines were grafted to Ramsey rootstocks and planted in the field in 1992. Dormex® (4%) was applied to the vines within 24 hours of pruning to promote even budburst.

Vines were harvested early October, and yield data was collected for both marketable fruit and unmarketable fruit in 1995 and 1996.

Results and Discussion

In 1995 there was a general trend of an increase in yield with an increase in the number of buds left on the vine at pruning (Figure 1). For this reason the pruning treatment leaving the lowest number of buds (two bud spurs) was removed from the treatments and replaced with a cane pruning treatment to maximise the number of buds per vine. In 1996, the overall yields achieved were less than the yields in 1995. This reduction in yield for Red Globe was also observed in the southern grape producing areas of Australia for the 1996/97 season. In addition, the general trend of

'an increase in yield with an increase in bud number' was not as obvious in 1996 as it was in 1995. However the cane pruning treatment still produced the highest yield for 1996. In June 1997, all the pruning treatments were converted to cane pruning and yields will be monitored in the next season.

In 1995 and 1996 a large proportion of the crop was considered to be unmarketable with berry damage caused by sunburn, very tight bunches and 'hen and chicken'. Management systems will need to be greatly improved in order to increase the amount of marketable fruit produced per vine.

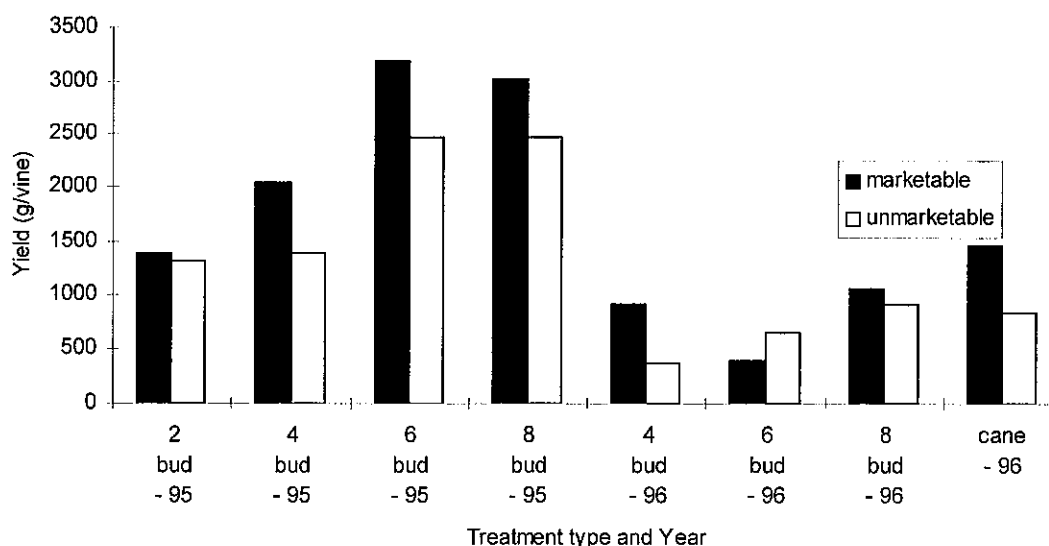


Figure 1. Marketable and unmarketable yields of various pruning treatments for Red Globe table grapes harvested in October 1995 and October 1996.

4.2.8 USING CHEMICAL TREATMENTS TO BREAK GRAPEVINE DORMANCY

G Kenna, J Mansfield, K Young, N Isgro, C Ellis, S Miller (DPIF), N Dokoozlian (University of California) and D Luvisi (University of California Co-operative Extension Farm Advisor)

Although grapevines do not require long cold winters for dormancy and budburst to occur, problems can result in years when the winter months are quite mild. In these years, the vines tend to drop all or most of their leaves, however as temperatures increase in late winter the budburst may be reduced, prolonged or irregular. This can result in uneven vine vigour and may delay maturity of bunches on shoots which have delayed budburst. This can present management problems such as timing the application of sprays such as giberellic acid which is essential for the production of quality fruit. Market returns may also be reduced when early maturity is a key marketing advantage.

A compound known as hydrogen cyanamide was found to break dormancy in grapevines and alleviate many of the problems associated with uneven budburst. This chemical has been manufactured and marketed as Dormex[®] (active ingredient = 50% hydrogen cyanamide). It has been used in grape production areas throughout the world where climatic conditions are unlikely to be conducive to a satisfactory budburst or where early maturity creates a marketing advantage.

There are however a number of disadvantages associated with the use of this chemical. The user hazard is high and requires stringent adherence to the safety precautions and directions for use. The cost of the chemical is high, especially when the higher recommended application rates are required, or very large areas of vines require treatment. In addition, where vineyards are located in intensive horticultural areas where other fruit crops are grown, a very small amount of drift associated with the application of Dormex[®] can cause considerable damage to non-target crops. Such is the case in California where vineyards are located close to citrus plantings and damage to this crop may result from drift after a Dormex[®] application to vines.

It was for these reasons that the Californian grape growers requested researchers to look for alternatives to the use of Dormex[®]. Trials conducted in California in 1994-1995 indicated that liquid calcium ammonium nitrate (CAN-17) was an effective dormancy breaking agent when applied in conjunction with another chemical known as Armobreak[®]. Field trials were established in Central Australia in 1995 to assess dormancy breaking treatments. The trials were a cooperative effort between Dr Nick Dokoozlian (Dept of Viticulture and Enology, University of California, Davis), Mr Donald Luvisi (University of California Extension, Kern County) and DPIF staff in the Alice Springs region.

In 1996 it was decided to conduct a follow up trial to further assess the potential of some of the combinations of chemicals which did show some promise as effective dormancy agents when trials were conducted at Territory Grape Farm in the previous season.

Field trials were established to examine if the efficacy of a lower than normal rate of Dormex[®] mixed with several surfactants or calcium ammonium nitrate (CAN -17) and the surfactant Chemwet[®] were similar to the standard dormancy agent Dormex[®] at its recommended rate of 4% (volume/volume).

Materials and Methods

The experiment was conducted in a commercial table grape planting of *Vitis vinifera* cultivar Red Globe located at Territory Grape Farm, approximately 200 km north of Alice Springs. The vines are planted at 3.6 m (between rows) and 2.8 m (between vines). The vines are cordon trained and spur pruned. The vines are pruned to two bud spurs leaving 25 to 30 spurs. All cultural practices are as for this cultivar in this region.

The experiment was organised in a randomised complete block design. Treatments were replicated ten times using three vine plots. The middle vine in each plot was used for data collection. Ten two bud spurs on each vine were selected and numbered by stapling tags to them. Treatments were applied to the cordons and spurs of the

vines using a hand held spray wand at the rate of 1,000 litres of solution per hectare on the 16/7/97. The buds on the numbered spurs were monitored twice weekly from the 28/8/97 to assess bud emergence and shoot growth.

Treatments were as follows;

1. Control,
2. Dormex[®] at the rate of 4% (referred to in the text as “Dormex[®]”),
3. Dormex[®] at the rate of 2% with the surfactant Agral[®] at the rate of 2% (referred to in the text as “Dormex[®]/Agral[®]”),
4. Dormex[®] at the rate of 2% with the surfactant Chemwet[®] at the rate of 2% (referred to in the text as “Dormex[®]/Chemwet[®]”) and
5. CAN -17 at the rate of 40% with the surfactant Chemwet[®] at the rate of 2% (referred to in the text as “CAN/Chemwet[®]”).

Results and Discussion

“Dormex[®]” was the most effective treatment for breaking dormancy with 70% of the vines reaching budbreak 51 days after the chemical was applied. “Dormex[®]/Chemwet[®]” also had a satisfactory budbreak rate with 70% of the buds breaking 56 days after treatment. Vines treated with “Dormex[®]/Agral[®]” took 72 days to reach 70% budbreak, which was considerably slower than “Dormex[®]/Chemwet[®]”. While those treated with “CAN/Chemwet[®]” were similar in performance to the control vines. They did not reach 10% budburst until 62 days after the spray application and only 59.5% of buds had burst when the experiment was completed on the 26/9. The control vines did not reach 10% budburst until 64 days after the treatments were applied and had only reached 60.5% when the experiment was completed (Figure 1).

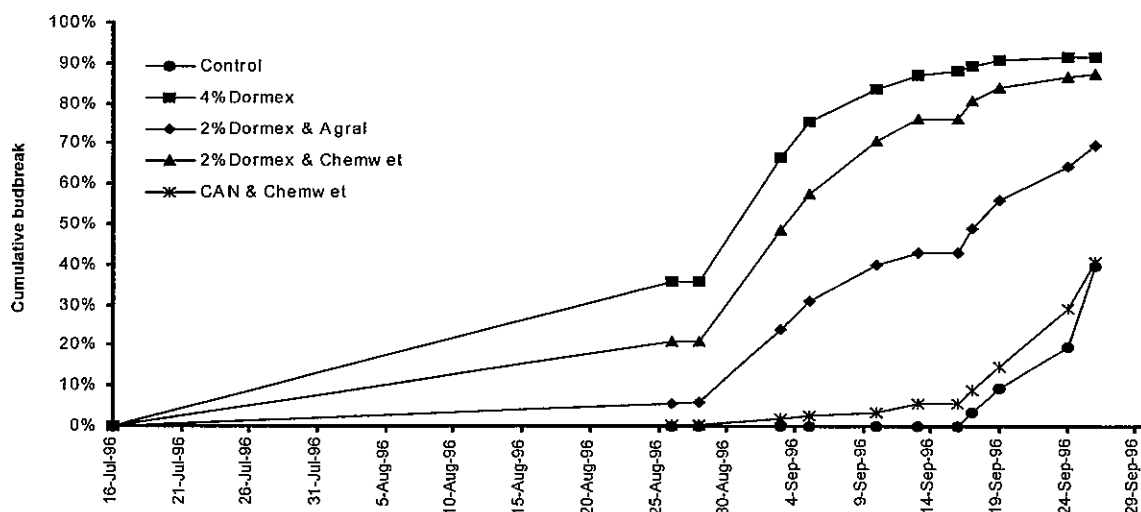


Figure 1. Effect of various chemicals on the amount and timing of budbreak.

4.3.1 BANANA VARIETY TRIAL

J Bright and G Foord

The aim of this experiment was to develop a database on the performance of different banana cultivars and identify cultivars suited to the climatic conditions of the Katherine region.

During 1996/97, we have made banana plant material available to local growers and the Katherine community. Making plant material available, we believe, will discourage illegal plant importation and prevent introduction of pests and diseases not yet experienced in Katherine bananas.

Materials and Methods

A trial was field planted in February 1995. Observations were made on flowering and fruiting times, as well as bunch weights and fruit quality.

Results and Discussion

Most cultivars are performing well under Katherine conditions (Table 1).

Table 1. Descriptions of various banana cultivars grown at KRS

Cultivar	Planting to Flowering (months)	Flowering to Harvest (months)	Height at Flowering	Bunch Weight (kg)
Goldfinger	9	4	3	40
Pacific Plantain	9	3-4	2.8	27
Ducasse	8	3-4	3.6	28-30
Sugar	9	3-4	3.1	15-20
Santa Catarina	7-8	3-4	2.5	20
Prata				
Lakatan	11	2-3	3.5	19
JDSpecial	9-10	3	2.5	45
JDDwarf	9-10	3-4	3	45
Pisang Gajih	7-8	3	3.7	20
Merah				
Simoi	11	5	5.5	25
Sucrier	7-8	3-4	3.5	24
Wain	18	-	3.0	-
Horn Plantain	8-9	2-3	3.8	17

The cooking bananas Pacific Plantain, Horn Plantain and Pisang Gajih Merah (Saba), all produced good sized bunches (compared to their performance elsewhere). Indications are that these cultivars are well adapted to the environment at the trial site.

Goldfinger suffered slightly from leaf burn, but produced bunches (20 kg) that appeared cleaner (less marked) than some other cultivars.

Santa Catarinas Prata (Dwarf Ladyfinger) produced bunches that barely resembled ladyfinger fruit. However, the taste of the fruit was similar to ladyfinger. The plant

was shorter, standing only 2.5 m at flowering, which is a big advantage with regard to wind damage.

Simoi produced huge pseudostems that reached heights of over 5.5 m making the fruit very difficult to harvest.

Some cultivars did reveal problems in this environment. Wain was very slow to establish and Sugar produced fruit that was particularly short and susceptible to splitting (which is typical of the variety in other regions).

Several people have requested planting material. Records of the material taken to each location, have been kept for future reference.

4.3.3 BANANA NUTRIENT MONITORING

J Bright

Leaf and soil nutrient sampling are popular ways of determining the adequacy of crop management practices. In the case of banana, a large body of information exists as to what nutrient levels should be, and under what conditions nutrients are likely to be limiting production.

Materials and Methods

All commercial plantings of bananas in the Katherine area were sampled at three monthly intervals from January 1994 to January 1996. Both leaf and soil samples were taken, at each sampling date. Great care was taken to ensure samples were sufficiently large to be truly representative of each block.

Results and Discussion

During the period of the nutrient survey, commercial interest in bananas declined rapidly, such that there was only one commercial property growing bananas at the last sampling date. This had a significant impact on the usefulness of the information gathered because between-farm comparisons were not possible.

It is also reasonable to suggest that the usefulness of the nutrient information was undermined by the low level of crop management, particularly in the area of irrigation inputs.

Despite these problems, there were some important lessons, that must be recognised if research resources are to be better utilised in the future. Firstly, it is essential to have access to good records of crop management, particularly fertiliser inputs. Leaf and soil samples should not be taken unless such information is available. Secondly, growers need to be in a financial position to adjust inputs in response to nutrient analysis results. There is little point in determining that a particular nutrient is critically low, if the grower is not in a position to correct it.

From the experience of this project, combined with banana production in research plots at KRS, it is felt that efforts should concentrate on regular applications of fertiliser in accordance with a fertiliser program. Nutrient analysis can then be used as

a means of modifying the fertiliser program rather than directly determining what nutrients need to be applied.

4.3.4 RATOON SELECTION INFLUENCE ON BANANA PRODUCTION

J Bright, G Foord, M Smith, S McAlister and M Hoult

‘Nurse technique’ is a widely employed method of manipulating banana production, so as to maintain year round production or to bring in bunches at periods of better prices. The technique involves the foregoing of the parent bunch to achieve a synchronised harvest and higher prices with the ratoon/follower crop. The main purpose of this trial is to obtain production during the dry season months when market prices are high and also to achieve consistent year-round production.

Materials and Methods

The trial was designed with three ratoon selection dates (31 May, 15 August and 15 September) and two nurse treatments (parent pseudostem cut down on 20 September and parent pseudostem left to carry a bunch). Plots consisted of four stools in a row, with each of the six treatments replicated four times within a randomised complete block design. Flowering and harvest dates, bunch weights, and number of hands per bunch were recorded. In addition, the length and circumference of the middle finger on the third hand, and the number of fingers and weight of fingers on the third hand were measured.

Results and Discussion

Results from 1996 show significant differences in days-to-flower as a result of nurse management ($p=0.0001$) and timing of ratoon-selection ($p=0.03$). Ratoons of parents that were nursed produced flowers 40 days earlier than those ratoons that were selected from parents that were not nursed. Although there was no significant difference in days-to-flower between August and September ratoon selection, the difference between May and August, and May and September, selection dates did prove to be significant. May selected ratoons produced flowers 24 days earlier than those selected in August and 20 days earlier than those selected in September.

Significant differences also existed in days-to-harvest ($p=0.02$). Where nurse management was implemented, the days-to-harvest was shortened by 30 days. Time of ratoon-selection did not appear to affect the days-to-harvest.

The period between flowering and harvesting was affected by time of ratoon selection ($p=0.02$). No differences were observed between July and September selections although there were differences between May and August (30 days), and May and September (22 days).

4.3.4 NURSE INFLUENCE ON BANANA PRODUCTION

J Bright and G Foord

As a continuation of the bunch production timing trial it was agreed to incorporate nurse management along with ratoon selection. Having already established results from the ratoon selection timing trial we now thought it necessary to find out details of the effects of nursing at different times.

This trial (which is a continuation of the KRS ratoon selection trial), utilises the second ratoon, being the nurse for the third ratoon from the previous trial. Nurse management treatments were applied in September, October, November and December 1996 and January 1997. The remaining treatment will be a no-nurse control. Results will be available in late 1997.

4.3.8 BANANA NUTRIENT MONITORING

K Blackburn and M Traynor

A banana nutrition monitoring program commenced in March 1994 consisting of bi-monthly leaf and soil analyses to be correlated with grower fertiliser practises, over a three year period, to optimise banana nutrition. Initially the project set out to establish what the present situation was in regard to nutritional status of the plants and the frequency, amounts and type of fertiliser applied.

Results in the first year (1994) over five sampling dates showed that regular monthly fertiliser application was not always occurring, especially during the wet season when access to the crop was restricted by water-logged conditions. The rates of application used by the five growers varied from 100 kg/ha/month with an average of about 200 kg/ha/month which corresponds to an annual rate of 330 kg N, 72 kg P and 720 kg K per ha. Generally, for 1994, leaf and soil potassium and zinc levels were low throughout the industry and the high soil magnesium levels were affecting the leaf potassium and calcium levels.

During 1995, farm fertiliser applications became more regular with an average increase in the total amount of fertiliser used. However, growers could not provide any yield estimates to determine whether the improved nutrition, has in fact, increased farm productivity, although all growers agreed that production had improved.

Again, high soil magnesium levels has affected both potassium and calcium leaf levels by altering the cation balance and restricting their uptake by the plant. Low soil potassium levels on most farms could be improved by small, regular applications of potassium with two or three major applications at seasonal intervals. The maintenance of adequate zinc levels in the leaf is an industry-wide problem. High soil zinc levels on one farm has not resulted in adequate leaf zinc levels, although foliar application of zinc is also used.

In 1996, all growers were more aware and concerned with their leaf and soil nutrient analysis and were basing their fertiliser programs on the results of the regular samplings. New plant crop blocks were selected at the beginning of the year as the older blocks being monitored were in their second or third ratoon. Three established growers replaced old banana blocks with new plantings based on undertree sprinklers with fertiliser injection systems for accurate nutrient control.

After three years of farm monitoring the results could be briefly summarised:

- Regular monthly applications of nutrients should be strictly carried out to maintain a constant supply to the growing crop. It is anticipated that, as the phenology of the crop is better understood, critical times for additional fertiliser applications will be determined. For example, additional potassium could be required in March/April before the onset of cool dry season conditions.
- The importance of precise irrigation scheduling in bananas under local conditions cannot be over-emphasised. Unless this is achieved, the response from an improved nutrition program will not be obtained. Current irrigation scheduling is generally variable and water is insufficient during Sept/Oct/Nov when climatic conditions are harsh and banana crops are under undue stress. New plantings on existing farms as well as two very large banana projects just commencing operations are using undertree sprinkler irrigation systems, rather than the traditional overhead method, and will be injecting fertiliser through the irrigation system at regular intervals. It is considered that this system will be more efficient in supplying the irrigation requirements and the nutrient demands of the banana crop under Darwin's climatic conditions.
- Strategies for improving both zinc and potassium nutrition to ensure constant and adequate levels in the soil and plant will have to be developed. The high magnesium content in the irrigation water from bores is a concern and the effect on potassium availability may only be partially overcome by small, frequent applications of potassium fertilisers. Maintaining adequate zinc levels in the soil and leaf is an industry-wide problem and both ground and foliar application will need to be employed to overcome deficiencies.
- The use of nutrient ratios such as the DRIS system, may offer more in analysing nutrient interaction over time in a banana crop, rather than attempting to define straight nutrient levels. There is a real need to develop the diagnostic technology necessary to improve crop productivity but grower feedback is essential for this to happen. Plant reserves and the cycling of some nutrients, such as potassium, need to be understood far more than the current knowledge available for this to happen.
- During the 1996 season a recommendation to increase potassium application to banana crops by frequent small amounts did improve leaf levels of K but a subsequent reduction in the high leaf Mg levels was only evident on two farms. On all farms Ca leaf levels remained low although two farms had reasonable analysis but only just above the critical range.

- By the end of 1996 it was realised that raising the leaf K levels to balance out the excess Mg did not significantly alter the low leaf Ca levels. Although soil levels of Ca in most cases was thought to be adequate, the addition of calcium compounds to the soil, without affecting the pH, was now considered essential. Gypsum applications would have to be used to dramatically raise soil Ca levels and this will have to be monitored to determine the effect on K and Mg levels in the leaf.
- Two local potential suppliers of raw gypsum were found in the Alice Springs district and negotiations have commenced to utilise this resource. Information on gypsum injectors from the USA, which is actually a water treatment process, has been obtained and the possibility of utilising this technology is being evaluated. The project will continue for at least another year or until the cation balance is partially restored in bananas. Other factors, such as high ammonium ions in the soil, may be affecting calcium uptake by the plant.

4.3.9 BANANA EXTENSION AND INDUSTRY SUPPORT

K Blackburn and M Traynor

During 1996, the Banana Industry expanded to a total area of approximately 220 ha with six growers and the value of production rose 45% to \$4.3m over the 1995 level. The total production was 3,768 tonnes with 65% being transported to interstate markets while the remaining 35% of production supplied the local market. The large increase in production was the result of a new banana farm coming into production as well as significant expansion in area by three of the original growers.

The Banana Working Group was formed in 1993 and is chaired by the Executive Officer of the NTHA. DPIF work closely with the grower members and the NTHA to discuss and implement R&D projects for the industry and any other relevant industry issues. The Working Group meets three to four times per year, usually on growers farms, and has been able to coordinate advisory services to growers and assist in the development of industry initiatives. It has been able to unite as a group, look at its problems and present a united front to DPIF and its industry organisation, the NTHA, rather than individual growers requesting DPIF to work on their own problems. Research results are presented regularly at workshop meetings, so growers are always aware of the progress of projects.

During 1996, there were four Working Group meetings on-farm and some of the issues covered can be summarised as follows:

- Plant Quarantine measures introduced included the prohibition of import of ornamental bananas and other seeded bananas which could form a wild population and be a sink for disease especially the Bunchy Top virus disease. Other measures to control the movement of banana planting material from farm to farm or growing areas would also be considered.
- Local banana promotion through contributions of \$7500 from the growers to have in-store banners, modules and pamphlets as well as TV advertisements.

- Invited guests presented results of their work for the industry, including IPM, control of weevil borer, irrigation trials and nutrition.
- The banana quality manual commissioned by the Australian Banana Growers Council (ABGC) was reviewed by members of the Working Group and was found to have good ideas on management. However, the system it proposes has not found support throughout Australia so will not be adopted universally by the banana industry.
- An in-store Quality Monitoring Project was conducted by DPIF at the request of the Working Group, in an attempt to identify the major defects that occur at the retail level and to pin-point where the damage was done. Assessments on a range of defects and blemishes were carried out in three major supermarkets at fortnightly intervals, both in store coolrooms as well as the sales counter to determine the level of damage. It was found that the level of bruising cuts and skin rub was relatively high, using the ABGC Manual standards, but the level of insect damage was low. Quite a lot of skin damage occurred through excessive and rough handling of ripe fruit at the retail sales counter.
- It was found that the ABGC Quality Manual had damage levels that were far too strict for NT use. As a follow on from the in-store Quality Monitoring Project it was decided by the Working Group that the NT should develop its own grade standards by being able, firstly, to recognise the defect and then to establish a level or allowance for it. Growers would bring ripe fruit to each meeting where the members would identify the defect, photos would be taken and the information used to develop a grading chart. There is no grade or defect chart available in Australia for grower use.
- Other matters of business attended to included a national ABGC sponsored benchmarking or best practice project, attendance at the Second National Banana Industry Congress in May 1997, a PLU numbering system for supermarket sales of fruit is being considered, farm bore water analysis work and involvement in the national Black Sigatoka Project
- During 1996 the value of the Banana industry rose by 45% to \$4.3m
- Total production was 3,768 tonnes - 65% interstate and 35% local markets

1996 Activities included:

- Seeded ornamental bananas prohibited input into NT
- Local banana promotion
- Invited guests spoke on areas of expertise
- ABGC Quality manual reviewed by growers
- In-store Quality Monitoring Project
- Defect identification and grade standards
- Benchmarking project
- Farm bore water analysis

4.4.1 RAMBUTAN PHENOLOGY AND NUTRITION

RAMBUTAN CROP NUTRIENT REQUIREMENT

TK Lim, L Luders, Y Diczbalis and M Poffley

The four year studies on rambutan crop nutrient requirement and fertiliser management have been completed and are reported in DPIF Technical Bulletin No. 261.

RAMBUTAN FRUIT PHENOLOGY AND HARVESTING INDEX

M Landrigan and TK Lim

This trial aimed to rationalise the harvesting index for rambutan and to establish fruit quality assurance standards for commercial packing.

Methods and Materials

Data were collected from tagged fruits and harvested at different colour stages. This was carried out on the commercial cultivars Jitlee, Binjai, Rongrien and R134 at Erindale Orchard and at CPHRF.

Results and Discussion

The best stage of harvesting was found to be from stages five and six. At stage seven, quality was reduced and the incidence of 'puffy' fruit increased. Further work is required to verify these results and consider any seasonal differences before a fruit quality packing poster can be finalised.

Table 1. Stages for harvesting Rambutan

Colour	Weight (g)	Length (mm)	Flesh Thickness (mm)	TSS (°Brix)	Titratable Acid (meq/100g juice)
1.pale green	25.73	42.1	6.4	17.1	8.09
2.colour break	33.11	46.1	6.8	18.1	5.62
3.orange/yellow	31.01	44.6	7.1	18.7	5.37
4.orange/pink	36.98	48.2	7.6	19.6	4.79
5.red/orange	39.3	49.4	8.3	20.4	4.68
6.uniform red	40.79	48.7	8.4	19.5	4.3
7.dark red	42.52	50.5	8.1	19.2	3.7

4.4.2 ENVIRONMENTAL FACTORS INFLUENCING THE GROWTH AND YIELD OF RAMBUTAN AND CUPUACU

ENVIRONMENTAL FACTORS INFLUENCING THE GROWTH AND YIELD OF RAMBUTAN AND CUPUACU - RIRDC FUNDED PROJECT DNT-10A

Y Diczbalis

In July 1992 funding was received from RIRDC for a three year study on the above project. Co-researchers included Dr Derek Eamus from the School of Biological Sciences, NTU and Dr Christopher Menzel from Maroochy Horticultural Research Station, QDPI. A number of DPIF-funded full time and project-funded part time technical staff assisted with the research. The findings of the study are reported in detail in the final RIRDC/DPIF report completed in late April this year. A summary of the background to the research, experiments undertaken and results appear below. Readers who are interested in the specific details of the research should contact the above.

Rambutan

Rambutan (*Nephelium lappaceum*), a relative of lychee, is native to the wet tropics of South East Asia. The crop was introduced into Australia in the 1970's and has been grown commercially in the NT since the early 1980's. In the NT, rambutans are distinctly seasonal with flowering occurring in June/July and harvesting occurring from November to January with the peak harvest in early December. Following harvest and a light tip pruning, there are four major vegetative flushes until the onset of cooler nights in mid May.

Detailed investigation of leaf net CO₂ assimilation in response to differing irrigation regimes in potted plants and nil irrigation in mature trees showed that there is a rapid decline in leaf water potential (Ψ_L) and CO₂ assimilation (A) following the cessation of irrigation.

Root distribution sampling on mature trees showed that 80 % of the root system is in the top 15 cm of the soil surface and within the dripline of the tree. This has major implications for irrigation and perhaps fertiliser management of trees which are grown in a wet/dry tropical environment. Controlled environment temperature studies revealed that rambutan vegetative growth ceases under cool day/night conditions with nights below 22°C likely to reduce growth even when day temperatures are high. The tropical adaptation of this species has been confirmed.

The response of leaf gas exchange to vapour pressure deficit (VPD) indicates that the tree can assimilate CO₂ over a wide range of humidity. This is surprising considering the tree's origin in the wet tropics. But, it does explain why the trees have grown well in the wet/dry tropics of the NT where low humidity is experienced during the dry season. Pre-flowering drought is reported to trigger flowering in the rambutans native environment. In the NT the onset of cool nights appears to be the dominant flowering trigger. Work on the effect of pre-flowering drought suggests that it can help

synchronise flowering, but does not induce flowering to occur earlier than is possible when trees are irrigated.

This study allowed the water requirements of rambutan to be assessed at different growth stages. Water use is highest during fruit filling and lowest in the pre-flowering vegetative phase. A practical irrigation guide has been designed for growers which calculates water requirements based on tree canopy cover and evaporation replacement factors for the various growth phases. The wet/dry tropics of northern Australia are more extreme than the plant's native environment. However, with the aid of careful irrigation management and limiting the range of production to areas with minimal periods of low temperature, rambutan production can occur successfully.

Cupuacu

Cupuacu is a relative of cocoa and is commonly used in Brazil for the production of juice, nectar and jams from the considerable mass of pulp found around the seeds. The fruits, commonly called pods, are generally larger than those of cocoa and rounder in shape. A number of publications, from Brazil, suggest that the seeds can be used to make a chocolate like product called "cupulate". The cupulate product is low in caffeine and theobromine, two stimulants which are found in chocolate, and hence may be useful for creating a "health food" product. Cupuacu also lends itself to mechanical harvesting as the pods drop to the ground when ripe, unlike cocoa which needs to be harvested by hand. The combination of novel product possibility and applicability of mechanical harvesting suggests that cupuacu may have potential as a new crop for the tropical north of Australia.

Seed of cupuacu were introduced into the NT in 1991. Tree growth, phenology and yield were monitored in conjunction with environmental parameters. The aim of the study was to determine whether cupuacu would grow and yield in the wet/dry tropics of the NT.

Cupuacu established and grew well under irrigation. Its performance was difficult to compare with other plantings as there is no publicly available data on growth and yield of cupuacu in its native or any other environment. The dry bean yield of four year old trees was 430 kg/ha. This yield is low when compared to similar aged cocoa trees where the dry bean yields are reported as high as 1,400 kg/ha. The low yields are thought to be partly due to the low bean recovery rate (10 %), compared to 31.5-46 % for cocoa. The direct comparison of cupuacu and cocoa yield data may not be appropriate as observations suggest that cocoa growth rates are appreciably higher than cupuacu.

The commercial potential of cupuacu needs to be thoroughly evaluated prior to further agronomic studies being undertaken. The current planting should be used for further yield monitoring and trial fermentation of seed so that the cupulate product can be evaluated by commercial chocolate manufacturers. Ideally this work should be carried out in conjunction with a commercial partner. Evaluation of the pulp as a flavouring in nectars and juices may increase the economic viability of the crop if the "cupulate" is found to be commercially acceptable.

4.4.4 RAMBUTAN ROOTSTOCK/SCION INTERACTIONS AND CROP WATER USE

ROOTSTOCK/SCION INTERACTIONS AND CROP WATER USE

Y Diczbalis, TK Lim

A trial was planned in 1995 in which the main aim was to ascertain whether rambutan rootstocks affected scion growth and productivity. The secondary aim of the project was to provide a planting in which further irrigation studies could be carried out.

Methods and Materials

Eight rootstocks were selected for their potential dwarfing properties. Following discussions with growers and other research staff, the rootstocks selected were; Bogor, Gula Batu, Jitlee, Rapih, Rongrien, R9, R37, R156 (red). The two scions selected, Jitlee and R134, are well regarded commercial varieties.

Results and Discussion

A considerable delay occurred during the budding process as some of the seedling material supplied to the commercial propagator was not ideal and then seasonal changes made successful budding difficult. In late 1996, approximately half of the planned budded material was returned to the Department. Planting occurred in February 1997 during a break in the monsoonal weather experienced at the time. Further heavy rain flooded the trial area and approximately half of the trees died due to water logging. There are insufficient surviving trees of the different rootstock/scion combinations for the trial to remain viable.

A number of options are being considered for the future of the trial.

4.4.18 RAMBUTAN PRUNING TRIAL

RAMBUTAN PRUNING TRIAL SUMMARY 1995-1996.

Y Diczbalis and C Wicks

In 1995 the Horticulture Division was invited to collaborate in a national project on Sapindaceae tree size control. Rambutan is a member of the Sapindaceae family along with lychee and longan. The three year trial funded by RIRDC is being conducted by QDPI, CSIRO and DPIF. The project aims to gather information on canopy management in the three species, but the bulk of the project funding is aimed at lychee due to the importance of the industry in Queensland. In the NT, DPIF is carrying out work on rambutan with the assistance of Erindale Tropical Produce.

Pruning of rambutans is important to maintain tree size, particularly as growers are utilising high density plantings (200 trees/ha) and netting to protect fruit from winged vertebrate pests. The aim of our work is to examine the relationship between time of pruning, vegetative growth, flowering and yield.

Material and Methods

In 1995 we examined the effects of three pruning treatments on two varieties (Jitlee and R167). Tree age at the time was six to seven years, depending on site and variety. The pruning treatments were:

P0 - Minimal tip pruning at harvest (December 1994)

P1 - Removal of two to three flushes (February 1995)

P2 - Removal of two to three flushes (April 1995)

Three trees of each variety were pruned at the above times and eight terminals per tree tagged and measured once per week. The measurements made were flush status and length, leaf number, flowering and harvest date.

In 1996 we changed the treatments slightly so that the treatments included some structural pruning which was necessary due to the constraints of the fixed netting and were as follows:

P0 - Minimal tip pruning at and harvest (December-January 1995/96)

P1 - Structural pruning in February followed by a tip prune (15-20 cm) in early June

P2 - Structural pruning in February

Results and Discussion

In 1995, measurement of flush number and length indicated that pruning treatments did effect growth and that the response was variety dependent (Table 1).

Table 1. Average flush number and length of rambutan (Data are means of 24 tagged panicles).

Variety	R167		Jitlee		Mean Response	
Pruning Treatment	Flush Number	Flush length (cm)	Flush Number	Flush length (cm)	Flush Number	Flush length (cm)
P0	2.9	143	2.5	139	2.7	141
P1	4.0	153	2.9	84	3.5	119
P2	4.5	124	3.1	85	3.8	105

Generally the results show that for R167, the later we pruned the more the tree flushed. In Jitlee pruning time had little effect on flush number, but later pruning resulted in shorter flushes.

Flowering was also affected by pruning treatment and variety. An average of six and a half of the eight shoots tagged per tree flowered in the P0 treatment. This dropped to an average of two and one flowering shoot per eight tagged panicles for the P1 and P2 treatments respectively. Therefore pruning appeared to greatly reduce the flowering potential of the tree. In the P1 treatment there was a clear variety difference with Jitlee and R167 producing an average of three and a half and one and a half flowering panicles respectively.

Late pruning in April (P3) delayed the onset of flowering and February pruning (P1) delayed flowering in the variety R167 relative to the P0 treatment. Total tree yield was not recorded as this initial trial was carried out to indicate where more concentrated research should be carried out.

For the 1996 season flush numbers and lengths, flowering times and whole tree yields were recorded.

The data suggested that flush number and length were unaffected by pruning treatments (Table 2).

Table 2. Flush number and length (cm)

Treatment	Jitlee		R134	
	Flush No.	Flush Lth (cm)	Flush No.	Flush Lth (cm)
P1	3.4	121	3.7	106
P2	3.4	122	3.1	111
P3	3.4	125	2.6	102

Pruning delayed the onset of harvest but tended to concentrate or synchronise the harvest period. Table 3 shows how pruning treatment and variety influenced the start of harvest, intensity of harvest (2/3 harvested) and the last harvest date.

Table 3. Start of harvest, intensity of harvest (2/3 harvested) and the last harvest date as influenced by pruning treatment and variety.

Pruning treatment	Commence harvest		2/3 harvested		Last harvest	
	Jitlee	R167	Jitlee	R167	Jitlee	R167
P0	15 Oct	15 Oct	26 Nov (6)	10 Dec (8)	31 Dec	14 Jan
P1	19 Nov	29 Oct	10 Dec (4)	17 Dec (7)	7 Jan	7 Jan
P2	15 Oct	29 Oct	10 Dec (8)	14 Jan (11)	21 Jan	21 Jan

() are weeks from commencement of harvest until 2/3 of the crop was harvested. All data are means of eight trees.

The pruning treatment which resulted in the most synchronous harvest was the structural prune in February followed by a tip prune in June (P1).

Tree yield was influenced by pruning treatment and variety. The P0 treatment resulted in the highest yields for both varieties with an average yield of 73 kg per tree. The P1 and P2 treatments resulted in a final yield of 44 and 37 kg/tree respectively. The variety R167 was the highest yielding variety for all pruning treatments except the P2 (February) structural prune.

When we expressed yield in terms of remaining canopy area the P1 and P2 treatments give similar results (Table 4). This indicates that the structural plus tip prune treatment was as productive per unit area as the minimal pruning treatment. Structural pruning alone (P3) decreased the yield potential.

Table 4. Yield per unit canopy area (kg/m²)

Treatments	Jitlee	R167
P1	1.3	1.2
P2	1.1	1.4
P3	0.9	0.7

Fruit size data showed that the average fruit size from the structural plus tip pruning treatment was approximately 9.0 g smaller than fruit from the other treatments (Table 5). This suggests that although the P2 treatment was able to maintain its productivity per unit area of canopy it did so with increased fruit numbers at the expense of fruit size.

Table 5. Average fruit size (g/fruit)

Treatments	Jitlee	R167
P1	33	35
P2	23	27
P3	34	35

Pruning does appear to reduce the subsequent season's yield potential, however, it appears that well managed pruning can be used to alter the onset of fruit set and the intensity of harvest, thereby spreading the work load. Since regular structural pruning will be a required practice in netted orchards, the frequency and timing of the pruning will be an important feature of management. The June tip pruning treatment appears to improve the yield potential following major structural pruning. This treatment needs to be further investigated as a means of altering the timing of harvest and the synchrony of harvest.

The variability of results between varieties is a concern as it suggests that pruning practices may have to be examined for the major commercial varieties. In the mean time the trial is continuing this year (1997) with the same treatments as last year to see if the effects are consistent across years. The results of the trial were shared with the NT rambutan industry at a rambutan growers workshop, held in conjunction with the NTHA in March. Grower interest is strong as pruning management is seen as a relatively unknown area.

4.4.5 DURIAN INTRODUCTION AND VARIETAL TRIAL

TK Lim and L Luders

One of the ways to boost durian productivity is to introduce more adaptable, high-yielding and compatible clones. There is an urgent need to bring in authentic high yielding, compatible clones and *Durio* species from southeast Asia, as the difficulties in obtaining germplasm are increasing. Many of the named durian clones introduced into northern Australia were erroneously identified and may not represent the authentic clones from their original sources in southeast Asia. The confusion of cultivars can have a serious impact on the durian industry, extending across the whole spectrum from research to production to marketing. Marketing the wrong clones will damage

the industry and cause its premature demise. This study is part of the RIRDC project DNT 13A - Boosting Durian Productivity - which ended in July 1996 after three years funding.

Methods and Materials

From the overseas trips to Sarawak and Peninsular Malaysia a total of 440 plants and seeds of 45 plant species were brought back, besides durian cultivars and *Durio* species. On the whole, the plant collection trip to Sarawak was extremely fruitful. Besides achieving our objectives, the trip served as the catalyst and springboard for the establishment of collaborative research and exchange of germplasm with the Department of Agriculture, Sarawak. Another spin-off from our efforts was that we helped establish contacts between growers and the Sarawak Department of Agriculture officials and private growers in Sarawak.

We found that a much higher success level was obtained by bringing in scionwood and budding them onto rootstocks in the quarantine screenhouse than by introducing bare-rooted grafted durian seedlings. Many of the cultivars already introduced into Australia have different characteristics to their namesakes in their sources of origin. The misidentification and erroneous labelling of cultivars and individual durian trees are not only rampant in Australia, but also in other countries in southeast Asia. The confusion created by the wrong identification of cultivars can have a serious impact on the durian industry. Imagine the frustration and tremendous waste of time, money and effort spent on research and development as well as the cultivation of wrong clones with low market acceptance. Marketing the wrong clones will damage the industry and cause its premature demise.

As a prelude to correct identification, detailed information was collated on recognised cultivars from southeast Asian countries gleaned from various sources and the principal investigator's personal notes and a novel method called polygonal graph analysis developed to correctly characterise and identify cultivars based on leaf parameters. Polygonal graph analysis of leaf characters can be used to differentiate among durian cultivars instead of using reproductive characters which entails a long waiting period of ten to twelve years for seedling trees and six to eight years for grafted trees. This technique rectified eleven cases of misidentification and confirmed similarities in identity between samples from different localities, regions and countries. Fifty samples from 32 designated durian cultivars were reduced to 21 cultivars. Similar polygonal graph profiles can be done for fruit characteristics or a combination of leaf and fruit characteristics as identification aids that can be conveniently and accurately developed and used by growers without the employment of sophisticated expensive instruments. This technique offers a good alternative to differentiate among cultivars in the absence of a determinative DNA finger printing test for durian and other tropical fruits.

Additionally a multiple linear regression model was developed to estimate leaf area (A) in durian based on non-destructive measurements of leaf length (L) and mid width (Wm). The model $A = -52.1 + 2.67 L + 13.3 Wm$ had a high coefficient of determination $R^2 = 0.967$ and lowest error mean square. The model was found to be highly predictable, precise and rapid. Leaf area, leaf length, width and dry weight are

common leaf parameters employed as indices of growth and development in crop physiological studies and in horticulture.

4.4.6 DURIAN PRECOCITY TRIAL

TK Lim and L Luders

Durian has a long gestation period. For seedling trees, a juvenile period of ten to twelve years is not uncommon, whilst for vegetatively propagated trees six to eight years period is the norm. The long gestation period is a major deterrent to potential growers because of the lengthy lag time for realisation of returns to investment and the accompanying risk factors involved in production. There are many ways to obviate the long juvenile period and enhance precocity, such as using chemical growth hormones or by cultural manipulation using various forms of grafting onto precocious or dwarfing rootstocks, interstocks and multiple rootstocks. The aim of this study is to attempt to reduce the juvenile period using various precocious rootstock-scion combinations and propagation techniques with introduced *Durio* species and clones. In our study we compared double rootstocks and single rootstock topworked with mature scion-wood against seedling trees for growth and precocity performance. This is part of the integral durian project which was partially funded by RIRDC entitled Boosting Durian Productivity DNT - 13A, from July 1993 to July 1996.

Results and Discussion

Results from such studies are only achievable after several years. Top-working the rootstocks during the wet in 1994 with scion-wood from bearing Gumpun and D 24 trees gave 95% success. Also we found no difference in success rate between Fokert budding and cleft grafting. Multiple rootstock can produce faster growth and advance maturity by its more extensive, and better root system which facilitates greater uptake of nutrients and water. The better and stronger root system can result in better anchorage and support, making the tree less prone to wind-throw by strong winds. Also multiple rootstocks can be used as an important component in an integrated disease management strategy if all or one of the rootstock is tolerant or resistant to the soil borne disease such as that caused by *Phytophthora palmivora*, the most devastating pathogen of durian.

4.4.7 DURIAN FLOWERING, POLLINATION AND NUTRITIONAL MANAGEMENT

TK Lim and L Luders

The aim of these studies is to improve our understanding of the crop phenology and reproductive biology of durian with regard to pollination, so as to rationalise cultural practices such as assisted pollination and fertilisation; and improve fruit yield, size, quality and uniformity by practical cultural measures. This is a part of an integral study RIRDC Project DNT -13A , entitled Boosting Durian Productivity. Funding ended in July 1996.

Materials and Methods

Vegetative and flowering phenology were monitored on durian trees at BARC and on two growers' orchards at Lambells Lagoon from 1992-1996. Simultaneously meteorological monitoring of temperature, rainfall, relative humidity, evaporation and sunshine hours were carried out at CPHRF, near Lambells Lagoon. Floral initials were monitored and their development measured at weekly intervals from the first appearance of pimple protuberance through to anthesis and through fruit development to harvest drop at BARC.

Vegetative flushing was assessed by measurement of shoot growth extension and visually. Ten shoot terminals on each of two trees were tagged in one property in Lambells Lagoon and fortnightly measurements were taken on shoot growth extension from April/May 1993 - May 1994.

After thinning of flower clusters, the remaining flowers were tagged and emasculated before pollination and bagged. Subsequent pollinations were emasculated without bagging which was found unnecessary. Flowers were pollinated at and after anthesis from 4.30pm-10.30pm, the late night pollinations being done with the help of growers. Pollination was affected manually using a fine-hair brush. Deposition of pollen on the stigma was checked with a hand lens. Pollen viability was also determined using Alexander's stain (Lim and Luders 1996). Successful fruit set was recorded at two, four and six weeks after pollination and at harvest. Fruits were evaluated for all fruit and seed characteristics including:- fruit weight, shape, colour, size; peduncle length and thickness; spine shape and length; rind thickness and weight; aril number; flesh colour, thickness, weight, texture, Brix, firmness, taste and flavour; seed shape, size, weight and number.

Two durian orchards on yellow-brown earths (Kandosols) in Lambells Lagoon were sampled for plant analysis and soil analysis every two months for more than three years. These were Lemcke's orchard with seven year old trees from March 1992 to May 1996 and Siah's orchard with five year old trees from March 1993 to May 1996. Four trees of mixed clones were selected and tagged for nutrient sampling in each orchard. The sampling procedure was standardised by randomly taking the fifth and sixth leaf from the fully expanded tip leaf of the latest mature flush from four quadrats of the tree. For soil analysis, four soil cores, 15-20 cm deep were taken from around the tree close to the canopy drip line and bulked. More than 180 leaf and soil samples were taken and analysed for nutrient levels.

Results and Discussion

Crop phenology in the Darwin area was found to be governed closely by changes in the local weather conditions. Generally, vegetative flushing is extensive and more pronounced in February to late April and less so in September/October which coincides with fruit development, and in December. Vegetative growth is slow during the dry, cool months from June to August. Floral initials appear as small, pimple, grape-like protuberances on the branches in May to July. It takes about six to eight weeks for the floral protuberances to develop into flower buds and thence to flower anthesis. Anthesis usually occurs from late afternoon 3.30pm to early evening 6.00pm. At this stage the stigma is mature and receptive. The durian flower is protogynous ie. the stigma matures before the anther dehisces but the flowering phenology provides

ample opportunity for autogamous and geitonamous pollination. Autogamy and geitonomy are common in monoecious and hermaphroditic fruit like the durian. The former refers to the transfer of pollen, from the stamen to the stigma of the same flower. The latter refers to the transfer of pollens from one flower to the stigma of another flower on the same tree. Anther dehiscence follows stigma maturation by a lag time of one to three hours, but the stigma still remains receptive for 12-18 hours after anthesis coinciding with the maturation and transfer of the pollen, ie. it is also homogamous thus still facilitating self-pollination. Flowering usually occurs in consecutive overlapping cycles, giving rise to an extended flowering period for two to three months and it takes 110 to 130 days from anthesis to fruit ripening. Fruit set generally occurs from August through to October. Fruit development stretches from September through to fruit harvest in December/January or in some years, as early as late October or as late as early February, depending on the extent of the cool "Dry" which affects flower opening and fruit set.

In the pollination and incompatibility studies, it was found that selfing resulted in lower yields and poorer fruit quality. The selfed fruits were mis-shapened and distorted with a fresh weight reduction of 33-50% and a lower flesh recovery of 20% compared to >30% flesh recovery with assisted cross-pollinated fruits. Selfed fruits had heavier rind that was of uneven thickness, lower number of arils 2 (1-4 range) per fruit, lower seed number, lower total seed weight, more shrunken, dysfunctional seeds and comparatively poorer flesh quality. Selfing also resulted in more fruit drop. Assisted cross-pollination resulted in higher fruit set, producing higher yields and better quality fruit. Manually assisted cross-pollination gave significantly higher fruit set of 31% in contrast to <10% for selfing.

The studies also revealed that there was variability in the magnitude of self-incompatibility among durian clones. Durian clones can be totally self-incompatible with no fruit at all, or partially self-incompatible, or self-compatible as was the case observed with some seedling trees. Ovule shrinkage or abortion after fertilisation but with well-developed aril was common in both well formed and deformed fruit but with a higher incidence in deformed fruit. This indicates that both pre- and post-zygotic self-incompatibility are operative in durian. The data also indicated that the self-incompatibility system operating in durian is gametophytically controlled. The assisted pollination studies also showed that there was variability in the fruit harvest maturity period ie. from anthesis to harvest drop among the female parent and pollen source. The maternal parent was found to influence the following fruit traits:- flesh colour, taste, flavour, basic fruit shape and spine length. The data indicated that the pollinizer source had a greater influence on the fruit traits and exerted differing influence over the maternal fruit tissues. The pollen had a metaxenia effect on fruit weight, size (length), rind weight, number of locules with fertilised ovules, number of well-formed arils per locule, number of arils per fruit, percent flesh recovery and sweetness (Brix). The pollen also exhibited xenia effects on seed shape, total seed weight and number of seed formed.

Crop and soil nutrient monitoring studies

Nutrient concentrations for all the micro- and macro-elements changed in accordance with seasonal fluctuations in durian crop phenology, which in turn appeared to be governed by the prevailing meteorological patterns as described above. This

emphasised the need to consider the most appropriate time for leaf sampling to estimate the nutrient status of the durian tree. We developed a standardised sampling technique by taking the fifth and sixth leaf from the shoot tip. We suggest that leaf sampling should be done in November as the variability for the nutrients were comparatively the least. Also another advantage is that results could be obtained on the leaf nutrient status just before a large fertiliser application is carried out at the tail end of harvest in January or February. The three to four year monitoring study also allowed the setting up of tentative durian leaf nutrient sufficiency range norms for Australia based on nutrient status in the leaf in November. A comparison of tentative Australian standards with published Malaysian standards revealed that our standards have narrower ranges and are higher for Ca and Mg but marginally lower for K and Zn and lower for Mn. All the leaf macroelements and the microelements Zn and B declined or were lower during fruit set and development. Generally, N, P and Ca were more limiting during fruit development after September until harvest in January. K became limiting during the latter part of fruit development through harvest and remained limiting until July. Leaf N was also lower during periods of active vegetative flushing. Soil N, P and the bases - K, Ca and Mg also exhibited similar trends - lower during fruit development in October-November and during active leaf flushing from March to May.

The traditional method of leaf nutrient interpretations using critical nutrient concentrations (critical values) or sufficiency range (as described above) do not account for the dynamic nature of foliar nutrient composition influenced by the physiological stage of crop growth, nutrient interactions and interactions between nutrients, dry matter accumulation and metabolic activities. To overcome such limitations a modified Diagnosis and Recommendation Integrated System (m-DRIS) method was used to establish norms for durian. Our results showed that the m-DRIS norms were able to detect more limiting nutrients than the sufficiency range approach. There was closer agreement with the Australian than with Malaysian sufficiency range norms. For durian m-DRIS norms defined seasonally or yearly is more preferable because of seasonal and yearly variations. Highest nutrient imbalance periods were observed during flowering especially in July 1993 in both orchards as indicated by the higher Nutrient Imbalance Index (NII) values. There is a need to develop more m-DRIS norms for the other elements as well.

The study of plant, plant-soil, and soil nutrient relationships can enhance our understanding of crop nutrient requirement and nutrient application. The significant low to moderate correlation and regression relationships among leaf nutrients, soil nutrients and between leaf and soil nutrients indicate that interactions between nutrients are more complex and dynamic and involve multiple interactions rather than two factor interactions. Also the significant but weak relationships ($R = 0.2-0.4$) between foliar and soil nutrients suggest that the utility of soil tests to predict leaf nutrient status in durian was rather limited.

Fertiliser scheduling should be made in accordance to the crop phenology and the crop nutrient requirement fluctuations. Diagnosis of crop nutrient demand should be assessed from leaf and soil sampling done in November using the tentative standards drawn up for northern Australia. For instance, from our studies it is evident that most fertilisers should be applied in February/March after the crop harvest and at the

incipient stages of major vegetative flushing, another smaller application just before the Dry during the time in late April/May and another round in late August/September to coincide with the early stages of fruit development. The quantity of fertilisers used should be adjusted yearly according to the results of leaf sampling as well as the crop load (yield) removed. Application of micronutrients as foliar spray should be done during flushing in March and another application in May.

4.4.8 CARAMBOLA FRUIT DEFORMITY -NUTRITIONAL AND POLLINATION PROBLEMS

SEASONAL FLUCTUATIONS IN CROP NUTRIENT LEAF LEVELS

TK Lim and L Luders

Fruit deformity in carambola could be attributable to nutritional and pollination problems. For satisfactory fruit production it is necessary to plant a mixture of two different morphs in close proximity or as is practised to graft a morph onto the branch of the desired clone to act as the compatible pollinizer source. Earlier preliminary studies carried out showed that spraying with boron had no effect in increasing the percentage of well-shaped fruits nor increasing fruit yield. The crop nutrient requirement is not known and leaf level standards for carambola in Australia are not available.

Materials and Methods

As a prelude to the study of effects of nutrition and pollination on fruit deformity in carambola, leaf and soil samples were collected from carambola trees at CPHRF every two months from March 1992 to March 1997. Leaf samples were standardised by taking the middle pair of leaflets from the median, mature leaf on terminal shoots. About 40 leaflets were collected/sampled because of the small size of the leaflets.

Results and Discussion

Generally, it appears that the N and K levels are lower from January through March and higher from May through November (Table 1). This could be due to the greater competition for both elements from the higher yield realised in the Wet, from November to April, and the more active leaf flushing during this period. Yields of carambola during the Dry are much lower, especially from June to August, and leaf flushing is also less active. Ca and Mg levels are also lower during the periods of higher yield. Among the micronutrients, Zn and Fe are lower from September to January, probably resulting from dilution effect of the active leaf flushes and growth. Levels of B are high through the year indicating that B may not be the limiting factor involved in fruit set and development. However, more detailed studies are needed to investigate the effects of B, Zn and Ca in fruit deformity.

Table 1. Seasonal fluctuations in carambola leaf levels from March 1993-March 1997

	N %	P %	K %	Ca %	Mg %	Na %	Cl %	S %	Cu mg/kg	Zn mg/kg	Mn mg/kg	Fe mg/kg	B mg/kg
Mar	1.88	0.15	1.36	1.14	0.76	0.03	0.19	0.23	5.91	30.86	187.9	80.83	67.01
May	2.18	0.17	1.73	1.66	1.13	0.04	0.12	0.27	6.63	39.15	320	36.25	90.02
Jul	2.14	0.17	1.68	1.42	0.99	0.09	0.13	0.26	6.50	37.15	367.2	78.15	76.46
Sep	2.22	0.18	1.93	1.33	0.92	0.06	0.11	0.29	5.46	27.04	217.5	43.48	66.40
Nov	2.3	0.16	2.08	1.39	1.06	0.06	0.20	0.27	5.78	19	204.1	35.15	68.67
Jan	1.88	0.15	1.49	1.34	0.91	0.03	0.22	0.22	6.08	19.01	200.8	47.40	65.06

4.4.9 TRELLISED VERSUS SINGLE TREE CARAMBOLA

TK Lim and L Luders

Studies on field cultural management requirements for different trellis types and single tree carambola planting and their impact on productivity were established at CPHRF. Trees were fertilised every two months with a basal dressing and sprayed with a complete foliar fertiliser every month. Trees were trained and pruned as necessary every three to four months and yield records taken throughout the year.

Owing to the prolonged water-logging in the block this year which lasted for more than two months, growth and tree development was affected and one free standing tree died and will be replaced. This has impacted negatively on the productivity this year and the trees are still being revitalised for productivity observations and measurements.

4.4.10 MANGOSTEEN PRECOCITY AND PHENOLOGY

HARVESTING STAGE FOR MANGOSTEEN

M Landrigan, TK Lim, L Luders and Y Dizcbalis

Although mangosteen is considered the ‘queen’ of tropical fruit, little is known about maturity indices and post harvest quality for the fruit grown in Australia. This is an important part of the phenological studies of the fruit. Due to our ongoing collaboration with north Queensland growers, we had the opportunity to examine fruit quality at a range of harvesting stages of mangosteen and come up with some suggestions for the time of picking to optimise fruit quality. The fruit were supplied to us by John McCormack, an exotic fruit grower near Cairns.

Materials and Methods

Two 2.5 kg boxes of freshly harvested mangosteens were divided into groups based on colour. The following parameters were measured: fruit weight, diameter, segment number, total soluble solids (TSS), pH and titratable acidity (TA). Incidence translucent flesh (an internal disorder) in fruits were also recorded. Mineral nutrient analyses were also undertaken for the rind (skin), normal and translucent flesh and seed.

Results and Discussion

Six distinct colour groups were observed and their parameters are outlined in the following table:

Table 1. Fruit quality parameters for different colour stages of mangosteen

Stage	1	2	3	4	5	6
Colour	pale green yellow	blotchy pink	pinkish red	maroon red	dark maroon	black
Fruit wt (g)	102.58	101.88	69.02	93.37	91.72	111.95
Diameter (mm)	58.29	58.67	50.77	55.80	56.26	60.92
Segment no.	5.8	6	5.5	5.6	5.8	6.2
Firmness	7.88	6	5.03	4.96	4.99	5.01
%Flesh	24.6	30.45	27.96	27.26	29.09	32.89
TSS	11.48	12.83	16.47	16.04	16.64	13.78
pH	3.9	3.3	3.21	3.25	3.22	3.64
TA (meq./100g)	5.91	8.7	9.2	10.67	9.86	7.08

The best stage to harvest fruit appeared to be at colour stage 3-5. At any of these stages fruit have both a high TSS and TA giving a full flavour fruit. These were the main parameters as well as a softening of the fruit which showed differences among the colour stages, as well as a reduction in sappiness with maturity. Fruit at the black colour stage were also more susceptible to bruising and insect damage.

We noticed the translucent flesh occurred only in the black colour group of fruit ie the over ripe. This flesh had lower TSS and TA and poorer texture (flesh became hard) and overall flavour. There were also differences in some elements for the mineral analysis. Ca, Mg and Na were all slightly lower in the translucent flesh. This is interesting as it suggests some electrolyte imbalance causing cell leakage and loss of white opaqueness. Other differences were lower Fe and higher B in the translucent flesh.

Further work is thus required to look at a larger sample size and the interaction of days from fruit set with storage life on post harvest quality.

4.4.14 ESTABLISHMENT OF CHENIT SEEDLINGS

M Smith, J Bright and S McAlister

Chenit [*Melicoccus bijugatus* also known as Spanish lime, mamoncillo, and various other names] is one of the few edible Sapindaceae that will flower and fruit in the lowland tropics, in addition to being tolerant of low humidity and soil moisture stress. It is also reported to be tolerant of alkaline soil conditions. These factors make it worthy of consideration for regions such as Katherine, that experience extreme climatic conditions. To date, there has been limited work with this fruit in Australia.

Efforts were made to introduce more genetic material, while at the same time assessing techniques to speed-up seed germination.

Materials and Methods

Fruit in the markets and street stalls of Trinidad, West Indies, were sampled in an attempt to find superior material. Once identified, de-fleshed seeds were dispatched to KRS where they were planted on 3 January 1997. Half of the seeds (21) were de-shelled prior to planting, with the remainder planted with the shell intact.

The emergence date of each seedling was recorded. On 30 June 1997, the height of each seedling was measured.

Results and Discussion

Shelling the seed clearly increased the rate of germination (Figure 1). Seedlings from shelled seeds were significantly ($p=0.08$) larger at 4 months after planting than those seedlings from unshelled seed (190 mm and 161 mm respectively).

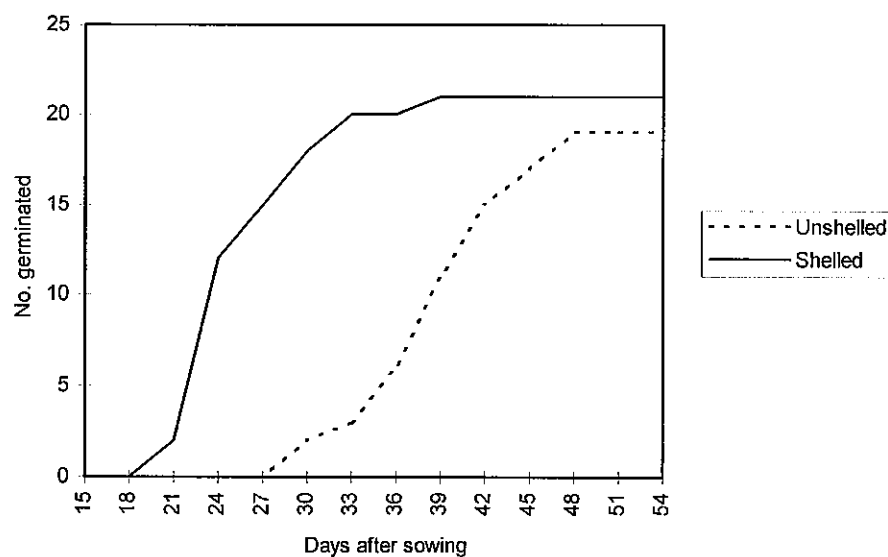


Figure 1. Effect of shelling on the emergence time of Chenit seedlings.

Given that the shell is relatively easy to remove from the seed, it is recommended that seed of this fruit be de-shelled prior to planting. A small number of the seedlings will be distributed for planting, whilst the remainder will hopefully be retained for graft compatibility testing with other Sapindaceae crops.

4.4.20 AVOCADO CULTIVAR EVALUATION

M Smith and M Hoult

A low-land tropical environment, such as Katherine, presents considerable problems in terms of avocado production. Most importantly, many cultivars recognised by the market and consumers simply fail to flower under the warm conditions. 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.

Materials and Methods

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

Results and Discussion

All trees have established well, and were around 1.5 m tall by mid 1997.

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.

4.4.21 MANAGEMENT TECHNIQUES FOR ANNONACEAE SPECIES

M Hoult, M Smith and S McAlister

Custard apple types are recognised as a crop with considerable market opportunities, and for which the Katherine region may prove a suitable production area. However it is also recognised that much research effort will be required if this opportunity is to be captured in the medium to long term. Cultivar introduction, screening, and possibly development, together with the development of management techniques, are seen as the four critical areas for research attention.

Materials and Methods

Pinks mammoth, Gefner, African pride and Bradly trees (on 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.

In July 1997, the trees were cut back to branches no more than 1.5m in length. The trees were defoliated by hand at the same time.

Results and Discussion

All trees have established well, and some fruit was picked from Gefner early in 1997.

The effects of pruning and defoliation on flowering and fruiting will be reported on as results become available.

Early in 1997, DPIF received a generous offer from a private plant breeder in Florida to evaluate some of the early selections from his breeding program. One introduction has already taken place, and more will occur in the next few years. Such access to superior genetic material is considered essential to the accurate assessment of commercial opportunities for the crop in northern Australia.

4.4.22 ESTABLISHMENT OF LYCHEE

M Smith and M Hoult

Lychee trees have been growing in the Katherine region for many years, but with few exceptions, they seldom fruit. It is felt that this is a consequence of the high night time temperatures generally experienced throughout the year. Opportunities for crop phenology manipulation, and the identification of cultivars better suited to the environment, are two areas where some research is justified.

Materials and Methods

Marcotts of Tai-so and Kwai may-pink were planted at KRS in June 1994 and February 1995 respectively.

A commercial planting of over 100 Kwai may-pink trees were also made by a commercial farmer around December 1993.

Results and Discussion

Trees at both sites have established well and should be suitable for some phenology manipulation work in the coming season.

An inspection of a lychee collection in Florida revealed a cultivar that may be suitable for the warm conditions at Katherine. This cultivar, Amboina, is available in Australia and is currently being sourced.

4.4.23 INTEGRATED PEST MANAGEMENT IN TROPICAL TREE CROPS

D Chin and E S Smith

This project serves to demonstrate and encourage the practice of Integrated Pest Management on commercial properties.

Through a series of extension exercises, commercial growers were supplied with information to enhance control of arthropod pests in tree crops, particularly mango, abiu, citrus, and rambutan orchards. Recommendations emphasised an integrated approach using a combination of cultural and biological methods or, when necessary, the application of non-disruptive pesticides. The main pests targeted were fluted scales, mealybugs, thrips, mites and sucking bugs.

Results

The Branch has continued to work toward reduced insecticidal use and further grower acceptance of IPM principles in NT mango plantations. Investigations included the control of Redbanded thrips using soaps and petroleum oils; collecting further data on flower caterpillars and the use of commercially available predators against mealybugs and fluted scales. For example, observation trials were conducted on the introduction of predatory ladybirds to commercial properties for the control of mealybugs and fluted scales on flush tissue. The technique appeared quite successful and further observations will be made in the coming season to assess the effect of these predators on mango scales.

Demonstrations of effective IPM practices for arthropod pests in fruit trees have continued. In conjunction with the use of cultural methods and non-disruptive pesticides including biological formulations, mineral oils and high concentration potassium soaps, inundative releases of commercially available biological control agents have been very effective in on-property trials on rambutan and mango trees. There has been a noticeable swing away from acceptance of the more toxic chemicals in favour of less disruptive and “softer” pesticides by many tree crop growers.

IPM trials in mangoes included the application of potassium soaps for control of red banded thrips, and the introduction of *Cryptolaemus montouzieri* Mulsant (Coleoptera: Chrysomelidae) to establish natural control of fluted scales in a fruit orchard with mangoes, rambutans and abius. Laboratory trials showed that *Cryptolaemus* was also effective in controlling mango scale, *Aulacaspis tubercularis* Newstead, (Hemiptera: Diaspididae) and soft green scale *Coccus hesperidum* L. (Hemiptera: Coccidae). The green lacewing larvae *Mallada signata* (Schneider) (Neuroptera: Chrysopidae) was effective in controlling redbanded thrips *Selenothrips rubrocinctus* (Giard) (Thysanoptera: Thripidae) on mango leaves in laboratory trials. This predator will be tested in the field and may prove to be an important natural control agent for redbanded thrips, mealybugs, fluted scales, twospotted mites and small caterpillars.

A large coloured poster on IPM in mangoes has been finished and submitted for printing. This has been designed to be used in conjunction with DPIF Agnotes.

4.5.1 COMPARISON OF TISSUE CULTURE AND OFF-SHOOT PALMS

J Mansfield, G Kenna, K Young, N Isgro, C Ellis and S Miller

There is some reservation within the industry as to whether off-types may occur in tissue cultured date palms and that not all palms produced are “true to type”. Off-shoots (suckers produced by the parent palm), are the standard method of propagation. However, tissue culture offers the possibility of introducing material which cannot be imported as Off-shoots, due to quarantine restrictions. In addition, tissue cultured plants are cheaper to import than Off-shoot material and as they are in a sterile medium, they do not require fumigation on arrival and are subject to significantly less airfreight costs. Another use of tissue culture, besides being a means of importing plants, is that it offers a method of rapidly multiplying up planting material within Australia.

Materials and Methods

This experiment compared tissue cultured palms and Off-shoot palms of the same cultivar. Depending on availability, tissue cultured palms produced by two different methods of propagation were used - those from Date Palm Developments laboratory, England, produced by a callus multiplication method and those from the Group of French Research on Date Palm (GRFP) laboratory, France, which were produced using a bud proliferation technique. For each of the cultivars Fard No 4 (male), Medjool, Thoory and Zahidi, two palms of Off-shoots and two palms produced by each tissue culture method were planted. For the cultivars Barhee and Deglet Noor, two Off-shoots were planted along with four palms from the tissue culture laboratory in England. For the cultivar Khadrawy, two Off-shoot palms were planted with two palms obtained from the French tissue culture laboratory only. The tissue cultured palms from England and all Off-shoots, except the two Fard No 4 Off-shoot palms, were planted in April 1990. The tissue cultured palms from France and the two Fard No 4 Off-shoot palms were planted in April 1991. Information was collected on the flowering of all palms and the fruiting and fruit characteristics of the female palms.

Results and Discussion

This project was terminated at the end of the 1996 season. The evaluation of the palms was partially funded by RIRDC for three years (1992-1995). The palms first started flowering in the 1992/93 season and data on flowering and fruiting was recorded until the end of the 1996 season. Generally, the Off-shoot palms tended to flower and fruit earlier than the tissue cultured palms, probably because they were larger and older when they were planted. They also tended to yield higher, possibly because they had more leaves, more food reserves and became established faster. It is difficult to compare the performance of the tissue cultured palms from the French laboratory against those from the English laboratory due to differences in planting dates. A detailed write up of this experiment can be found in the RIRDC final report for the project DNT-11A "Evaluation of Date Production in Central Australia".

4.5.2 DATE CULTIVAR EVALUATION

J Mansfield, G Kenna, K Young, N Isgro, C Ellis and S Miller

The aims of this project were to assess the performance of four international cultivars under Central Australian conditions and to determine their suitability as potential cultivars for commercial production in this region. Many years are required to thoroughly evaluate a new date cultivar because of varying climatic conditions, the effect that certain management and cultural techniques sometimes have on successful fruit production and the irregular cropping characteristics of young palms.

The four cultivars evaluated were Barhee, Deglet Noor, Medjool and Thoory. Barhee is a cultivar increasing in popularity overseas. The fruit is egg-shaped, quite soft and very sweet. It has excellent eating qualities at all stages of maturity. Deglet Noor is the leading commercial variety in the United States. It is a semi-dry date with sweet flesh and a nutty taste, however, it is susceptible to rain damage and has a long fruit maturation period. Medjool is one of the main cultivars grown internationally for the

high value fresh fruit market. It produces a large, soft fruit with excellent eating qualities. Thoory is a dry date with an attractive appearance and a delicate flavour.

Materials and Methods

Four cultivars (Barhee, Deglet Noor, Medjool and Thoory) were imported from England as tissue cultured plants. In September 1989 the palms were established in a statistical planting comprised of four blocks, with each block containing four randomly distributed single palm replicates of each cultivar. Information was collected on the flowering, fruiting and fruit characteristics of the palms.

Results and Discussion

This project was terminated at the end of the 1996 season. The evaluation of the palms was partially funded by RIRDC for three years (1992-1995). The palms first started flowering in the 1991/92 season and data on flowering and fruiting was recorded until the end of the 1996 season. Some palms of Deglet Noor and Thoory produced flowers in the 1991/92 season, while it was a year later (1992/93 season) before some palms of Barhee and Medjool flowered. By the 1994/95 season, most palms of all cultivars had flowered. However, even by the 1995/96 season, flowering patterns were still irregular as all the palms were not producing flowers every season. A palm may flower one season and not the next. This was particularly the case for palms of the cultivar Thoory.

The overall trend seemed to be that Medjool was the earliest to produce fruit, normally followed by Barhee, while Deglet Noor and Thoory tended to begin fruiting later than the other two cultivars, although they continued to produce mature fruit after the other cultivars had finished. However, the timing of when cultivars commenced and stopped producing fruit varied from season to season.

Even six and half years after planting, the average yield of the palms was still low. When the average yield per palm is added together for the four seasons in which fruiting has been recorded since planting (1991/92 season not included), Deglet Noor has totaled 30 kg per palm compared to Barhee (20 kg), Thoory (19 kg) and Medjool (8.5 kg).

Medjool produced the heaviest fruit in both seasons (around 16 g), while Barhee produced the next heaviest fruit in both seasons (around 10 g). Deglet Noor and Thoory seem to produce fruit of a similar weight (around 8 g).

The cultivars showed some genetic difference in dimensions. The cultivar with the longest and widest fruit of these four cultivars was Medjool. The cultivar with the shortest fruit of the four cultivars tended to be Barhee, however it was the second widest fruit after Medjool. Deglet Noor and Thoory were very similar in fruit length and diameter.

A detailed write up of this experiment can be found in the RIRDC final report for the project DNT-11A "Evaluation of Date Production in Central Australia".

4.5.3 DATE CULTIVAR OBSERVATION

J Mansfield, G Kenna, K Young, N Isgro, C Ellis and S Miller

Throughout the world, several thousand cultivars of dates have been recognised, but of these, those which have any commercial importance are limited to about 100. Some cultivars are unique to a particular country but others, such as the top cultivars now grown in the United States, are grown fairly extensively around the world.

In western countries, dates are considered a confectionary or a dessert rather than a staple food. Consequently, consumers have a preference for fresh, dessert type dates and this has determined that the main cultivars grown here in Australia, and in most western countries, should be large in size, soft with a reasonable moisture content.

Careful attention needs to be given to the selection of cultivars likely to succeed in a particular location. The suitability of the cultivar to the climatic condition of that particular area (heat sum units, rainfall pattern) are of primary importance, but other considerations include the adaptability of the cultivar to the soil conditions and management techniques, the amount of high quality dates produced, and the present and future markets.

The aim of this project is to establish a collection of the world's best cultivars. From this, general observations can be made on potential cultivars for the area. In addition, it acts as a source of Off-shoot material. In the future, it is envisaged that planting material from the collection in Alice Springs could be sent to other areas to establish trials of these cultivars under different conditions.

Materials and Methods

The germplasm collection is made up of three male and eighteen female cultivars imported as Off-shoot and tissue cultured material from various international sources. The planting of the trial started in April 1990 and additions have been made as material has become available.

Results and Discussion

This project was terminated at the end of the 1996 season. The evaluation of the palms was partially funded by RIRDC for three years (1992-1995). The palms first started flowering in the 1992/93 season and data on flowering and fruiting was recorded until the end of the 1996 season. A detailed description of the results for each cultivar is presented in the RIRDC final report for the project DNT-11A "Evaluation of Date Production in Central Australia". From the information presented, it is possible to see the variation in the characteristics from year to year, the effect of palm age on these characteristics and fruit size, the differences between the three harvest stages (khalal, rhutab and tamar).

4.5.4 EVALUATION OF A RANGE OF BUNCH COVERS TO REDUCE RAIN DAMAGE IN DATES

J Mansfield, G Kenna, K Young, N Isgro, C Ellis and S Miller

The occurrence of rain on date fruit as it nears maturity can cause considerable damage to the fruit. This can cause a downgrade in fruit quality or render the fruit unmarketable. The primary damage caused by rain and humidity are:

1. Checking and blacknose - Checking results in small, transverse linear scars, chiefly near the apex. Although these ruptures tend to heal, the scars remain, and may downgrade fruit quality. Checking usually results if rain occurs just prior to the khalal stage. If checking is severe, particularly in the cultivar Deglet Noor, it can be followed by darkening and shrivelling of the tip, known as blacknose. If the fruit is badly affected it may be almost worthless.
2. Splitting and tearing - In the late khalal stage, the fruit is subject to severe splitting and tearing if exposed to direct contact with water.
3. Excessive hydration of the fruit - in some soft cultivars, contact with rain may cause sugar to concentrate on the fruit surface, producing a sticky skin, and a poor appearance.

Secondary damage to the fruit can occur, usually in the late khalal stage, due to fruit rots caused by fungi which are active during prolonged periods of high humidity. In addition, souring and fermentation of fruit can occur, usually in the rhatib stage. It tends to occur in the centre of heavy bunches during periods of high humidity following rain.

However, cultivars vary in their susceptibility to rain damage, some being more sensitive than others. By planting cultivars resistant to rain damage, losses can be reduced. But these cultivars are still susceptible to damage by vertebrate and invertebrate pests. Therefore, commercial orchards need some way of protecting bunches. The problem has been to provide a moderately dry atmosphere and favourable temperatures around the bunch but at the same time adequately protect it from rain, birds and insects. This problem would be relatively simple if it were not for the water vapour constantly transpired from the fruit surfaces. Moisture from uncovered bunches is quickly dissipated into the surrounding air. In covered bunches, however, some of the moisture may become trapped and the resulting condition tends to promote water injury and fungal attack. The aim of this project was to evaluate the effectiveness of a range of material when used as bunch covers.

Materials and Methods

Bunches were covered in the kimri (green/unripe) stage of development just before the Khalal stage (early ripening). This period was usually around January. The covers being tested were made from a range of materials including banana bags (plastic bags used for covering banana bunches), muslin, nylon, shade cloth, Tyvek® (a spinbonded polyolefin material used to make disposable overalls) and weedmat. In each season, where possible the bunches on each palm were covered using different materials. Bunches were covered in the 1992/93, 1993/94, 1994/95 and 1995/96 seasons. In the first two seasons preliminary observations only were made, as not many bunches were

available. However in the 1994/95 and 1995/96 seasons individual bunch information was recorded.

Results and Discussion

The ideal bunch cover would be one possessing all the following attributes:

1. Waterproof during heavy rains,
2. Allow free circulation of air throughout the bunch in periods of high humidity,
3. Allow easy entry for picking ripe fruit,
4. Exclude vertebrate and invertebrate pests, and
5. Be economical to manufacture and fit to the bunch.

Unfortunately, the covers trialed here, did not have all these attributes. In the 1994/95 season, when rain fell regularly throughout the maturation period, covers made of shade cloth and nylon appeared to be most effective in preventing losses due to rain damage, as they allowed air circulation in and around the bunches. Although they will only keep light rain off the fruit, good air circulation appears to be imperative in the prevention of mould growth following rain. Covers made of dense material (plastic banana bags and weedmat) appeared to be the least effective in preventing rain damage. This was probably due to condensation build-up and lack of air circulation in and around the bunches, leading to excessive mould growth and fruit rots. It should, however, be noted that on these relatively young palms the fruit bunches hang quite close to the ground and the problem of condensation build-up in these covers may not be as prevalent in older palms where bunches are higher off the ground and better air circulation is possible. In contrast, in the drier season of 1995/96, the denser materials, particularly the plastic banana bags, tended to reduce losses due to vermin and bird damage.

This project was jointly funded by RIRDC and DPIF. It was terminated at the end of the 1996 season. A detailed write-up of this experiment can be found in the RIRDC final report for the project DNT-11A "Evaluation of Date Production in Central Australia".

4.5.5 PARLATORIA SCALE ERADICATION

K Young, N Isgro, C Ellis, G Kenna, D Kennedy and R Mills

Parlatoria Scale is a major pest of date palms in the Alice Springs area. The scale, which was introduced into Australia in the early 1900's and into Central Australia in the 1950's, threatens the long term viability of the commercial date industry in Australia. It causes palms to become unthrifty and may also infest fruit, which either causes it to be downgraded in quality or renders it unsuitable for sale.

The insect has infested Mecca Date Gardens and Arid Gold Farm and plantings at the AZRI. A large percentage of palms growing in and around the Alice Springs town area are infested with the scale and there are also palms in a number of areas throughout the region which are infested. In most instances the scale has been spread by the movement of infested plant material.

Materials and Methods

A serious attempt to eradicate the scale from plantings at the AZRI, Mecca Date Gardens and Arid Gold Farm was commenced in 1991. The program involved:

1. The provision of assistance to Arid Gold Farm to apply insecticide sprays to all palms on the property.
2. The provision of chemicals to the owners of Mecca Date Gardens and Arid Gold Farm for scale eradication.
3. Foliar application of insecticides at three weekly intervals to palms in the Dahlenburg Block research planting.
4. Foliar application of insecticides at three weekly intervals and six weekly trunk injections to palms on De Fontenay Drive at AZRI with monocrotophos.
5. Three weekly trunk injection with insecticides to mature palms at the McEllister Block at AZRI.
6. Three weekly foliar sprays of insecticide to Off-shoots held in nursery rows at the McEllister Block at AZRI.
7. Removal of dead and unthrifty leaves from all palms.
8. Removal and destruction of infested Off-shoots from palms in the research planting.
9. Inspection and treatment of all Off-shoots by immersion in dimethoate before leaving AZRI.
10. Insecticides used for foliar sprays are alternated between maldison and dimethoate.

Results and Discussion

The resources required to conduct such a program over a number of years have been considerable. Progress in the eradication of the scale is being made. The numbers of live scale on palms at AZRI are declining. Scale numbers have also declined at Mecca Date Gardens and Arid Gold Farm. A survey to monitor the rate of decline by sampling grower properties and the plantings at AZRI will be conducted in late spring/early summer 1997.

Further methods of eradication have been considered in consultation with the Entomology Branch. This includes the trial release of ladybird beetles as predators of the scale. Red Chilocorus (*Chilocorus circumdatus*) and Blue Chilocorus (*Chilocorus baileyi*) have been released onto heavily infested date palms which are being grown as ornamentals. Their ability to survive the Central Australian climate and their effectiveness at controlling Parlatoria scale are yet to be assessed.

4.5.6 INTRODUCTION OF NEW DATE PLANTING MATERIAL INTO CENTRAL AUSTRALIA

G Kenna, J Mansfield, N Isgro and C Ellis

The number of date cultivars under commercial cultivation throughout the world is considerable. The fruit characteristics of these varieties are many and varied. They range from very soft sweet fruit of average size to fruit which is slightly drier, firm, sweet and has a large fruit size, and other varieties which are quite low in moisture and have a sweet nutty flavour. These fruit characteristics, together with maturity time

and the ability of the fruit to withstand rain as it nears maturity, are considered important for commercial date production in the Central Australian region. It is for this reason that a planting of 21 varieties of date palm have been planted at AZRI. As these palms begin to bear fruit they are assessed for palm growth and yield. Fruit characteristics are also assessed. This planting is increasing as new varieties are imported from overseas as tissue cultured material. A new addition to the planting in the near future will be the cultivar Sukkary which was imported in 1994 and has been grown in a controlled environment until the plant reaches a suitable size for planting out.

4.5.7 THE PROVISION OF OFF-SHOOTS OF IMPORTED DATE CULTIVARS TO DATE INDUSTRY IN CENTRAL AUSTRALIA

G Kenna, J Mansfield, N Isgro and C Ellis

The need to encourage the development of a commercial date industry in Central Australia by the provision of Off-shoot material has been a DPIF priority. The pastoral industry in this region has been considering options for diversification. This includes the establishment of date palms for small scale commercial production. Where adequate resources are available, including supplies of water, small plantings of palms are being established with assistance from DPIF. Planting material taken as Off-shoots from palms imported as tissue cultured material for research purposes is also being supplied to these pastoral properties in an effort to encourage this diversification.

4.5.8 ASSIST THE DEVELOPMENT OF THE COMMERCIAL DATE INDUSTRY IN CENTRAL AUSTRALIA BY THE PROVISION OF MANAGEMENT, POST HARVEST & MARKETING INFORMATION

G Kenna, J Mansfield, N Isgro and C Ellis

Considerable research work has been conducted on many aspects of date production in this region. This information has been collated into a report which is to be published in the near future. The report details various aspects of date palm management, including irrigation scheduling, plant nutrition, weed control and yields and fruit quality characteristics of a range of varieties. Marketing information is also shared with growers as many fruit wholesalers in the larger domestic markets are eager to obtain supplies of quality dessert dates produced in this region.

4.5.9 EXTENSION SERVICES TO DATE INDUSTRY

G Kenna and J Mansfield

Extension services have been provided to the date industry on a regular basis. This includes information on research results on all aspects of date production, including machinery for more efficient management of plantings. Marketing information includes passing on inquiries for the supply of fruit to wholesalers on domestic markets and the promotion of the Central Australian dessert date industry in various media including newspapers, magazines, radio and television.

4.6.1 SUPER-RED GRAPEFRUIT EVALUATION IN KATHERINE

M Hoult, M Smith, D Jaensch and P Gallasch

Red-fleshed grapefruit are expected to be popular in Australia because they are visually more appealing and some are more palatable than the traditional white-fleshed cultivars. This trial is part of a national HRDC project that aims to assess red-fleshed grapefruit cultivars in a wide range of growing conditions around Australia.

Materials and Methods

Eight cultivars of grapefruit were replicated eight times, budded to two different rootstocks and planted in randomised, single tree plots in 1995. The eight cultivars include: 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.

Trees were fertilised with either ammonium sulphate or 14:14:12 every six to eight weeks at 80-100 g/tree/year of age. Copper (5 g/tree) and zinc (50 g/tree) were applied as foliar sprays every six months. Irrigations were scheduled according to soil moisture requirements as determined by tensiometer readings.

Suckers were removed and trees skirted in June 1997.

Results and Discussion

All scion/stock combinations have established well. Some cultivars have exhibited better growth than others with Oroblanco, Rio red, Ray Ruby and Marsh showing good vigour and Star Ruby being the least vigorous. Scions on Swingle exhibited less micro nutrient deficiencies than Carrizo at the alkaline soil site of KRS.

Some trees flowered well and set fruit, notably Ray Ruby, Rio Red, BCP3-Ruby type and Marsh.

Yield and quality data will be collected for the first time in 1998.

4.6.1 NATIONAL RED-FLESH GRAPEFRUIT CULTIVAR TRIAL EVALUATION IN CENTRAL AUSTRALIA

N Isgro and G Kenna

There are three sites in Central Australia as part of the national project which have been established to evaluate newly imported red-flesh grapefruit selections and a white-flesh cultivar, Oroblanco.

Materials and Methods

A replicated trial planting was established at AZRI in August 1995. All cultivars are replicated on two rootstocks, Swingle and Carrizo. Trial layout is a randomised complete block design with 14 treatments and four replicates.

A demonstration planting consisting of 14 trees was established at TTRF in August 1995. A similar demonstration planting has also been established on Murray Downs Station, which is located approximately 140 kilometres south of Tennant Creek, in September 1996.

Results and Discussion

During the 1995/96 growing season it was observed that the variety Star Ruby reacted adversely to the very hot conditions experienced during the summer months. These growth patterns tended to be more evident on Swingle rootstock. Tree growth for all other varieties at all locations was satisfactory. A number of trees growing in the replicated trial planting at AZRI have carried a very small number of fruit. Preliminary investigation of these as they mature has indicated that the variety Rio Red has considerable potential for the Alice Springs region.

4.6.2 GRAPEFRUIT CULTIVAR EVALUATION IN KATHERINE

M Hoult, D Jaensch, S McAlister, J Grigg and M Smith

Hot conditions during fruit maturation, make the Katherine region ideal for quality grapefruit production.

This trial aimed to rapidly screen several new red cultivars for their production performance in the Katherine region.

Materials and Methods

Five super red cultivars, Star Ruby, Rio Red, Flame, Ray Ruby, Flame and Henderson, were planted on a range of rootstocks at KRS during 1992-1994. Henderson and Ray Ruby produced their first significant crop in 1996. Yields were recorded and quality assessments made over a number of months using five to six fruit at each assessment. All fruit was de-greened with ethylene prior to evaluation. Quality assessments were made for Henderson, Ray Ruby and Rio Red in 1997.

Results and Discussion

The external colour of Ray Ruby was outstanding, with most of the rind showing red background colour. Henderson tended to exhibit external colour only where fruit touched other fruit or foliage. The internal colour for Henderson and Ray Ruby was very similar with Ray Ruby being marginally darker. For both cultivars the colour was far superior to locally grown Ruby Blush. Rio Red also had good internal colour which was more uniform through the juice sacks than Ray Ruby or Henderson.

Internal quality was excellent with Ray Ruby and Henderson cultivars achieving Brix/acid ratios of 7:1 in late February 1996 (Figure 1). Fruit matured early, had high percentage juice, intense colour and thin rind (Table 1). In general, fruit quality for 1997 was poorer than 1996, a possible reflection of the heavy wet season.

Rind levels in 1997 were similar for Ray Ruby but slightly higher for Henderson (Table 2). Rio Red fruit was fairly course with thick rinds and bumpy stem end or 'sheep nose-like' condition. This has also been observed in California USA for this cultivar. Internal colour was darker than Henderson and Ray Ruby with external colour similar to Ray Ruby.

Fruit Piercing Moth (FPM) caused an estimated 5-10% fruit damage in 1996. However FPM was very severe in 1997 with 80-90% fruit damaged when the fruit was allowed to hang on the tree.

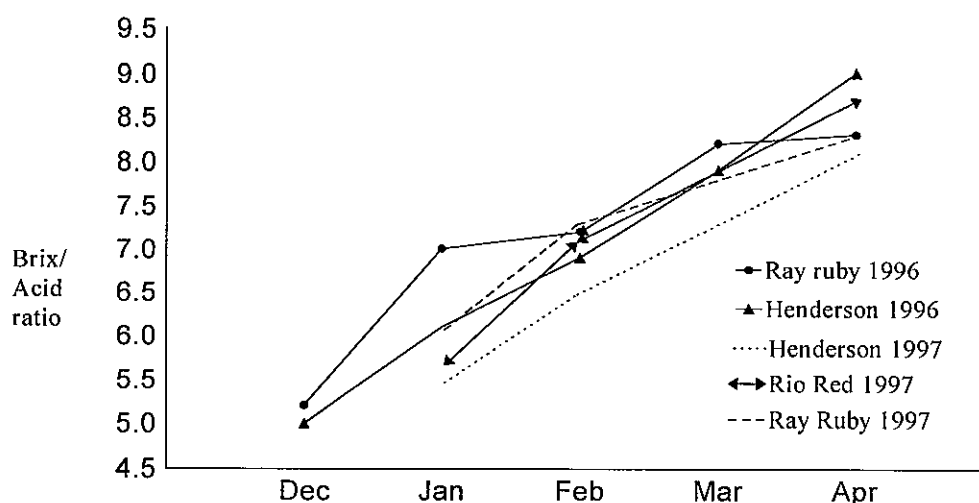


Figure 1. Brix / acid ratios for red grapefruit cultivars, Ray Ruby, Henderson and Rio Red, KRS, 1996 and 1997.

Table 1. Grapefruit cultivar yield and assessment, KRS, 1996.

Cultivar/stock	Harvest Date	Fruit No.	Est. Total Yield (kg)	Av. Fruit Wt (g)	% Juice	Av. Brix ⁰	% Acid	Brix ⁰ /acid ratio	Av. Rind (mm)	Av. Seed no./Fruit
Ray ruby/swingle	13/3/96	34	16	479	45.4	10.0	1.22	8.2	7.7	3.3
Henderson/swingle	13/3/96	74	32	415	51.7	9.2	1.17	7.9	6.0	1.3

Table 2. Grapefruit cultivar yield and assessment, KRS, 1997.

Cultivar/stock	Harvest Date	Fruit No.	Est. Total Yield (kg)	Av. Fruit Wt (g)	% Juice	Av. Brix ⁰	% Acid	Brix ⁰ /acid ratio	Av. Rind (mm)	Av. Seed no./Fruit
Ray ruby/swingle	19/2/97	-	-	411	43.2	9	1.32	6.82	7.7	2.2
Henderson/swingle	19/2/97	-	-	423	43.6	9	1.29	6.99	9.1	3.2
Rio Red/ swingle	19/2/97	-	-	472	36.9	9	1.31	6.87	11	2.3

In general, the quality of these cultivars was outstanding and indicates that there is potential for quality red grapefruit production in this region.

Similar assessments will continue for the 1998 season.

4.6.5 PINK-FLESHED GRAPEFRUIT EVALUATION EXPERIMENT

J Mansfield, G Kenna and S Marte

White-flesh grapefruit has received consumer resistance due to the perception that fruit is unpalatable (ie. it has high acid and low sugar levels). Pink-fleshed grapefruit tend to have higher sugar levels and lower acid levels and have gained consumer recognition for this.

Materials and Methods

The varieties available at the time of planting (Ruby, Foster and Thompson) were grown on four rootstocks (Symons sweet orange, Troyer citrange, Rough lemon and Swingle citrumelo) with and without mild strain tristeza. The trial was planted at TTRF in 1989 and yield data and fruit characteristic measurements have been taken.

Results and Discussion

This experiment is currently being written up into a report. The experiment was compromised by the introduction of Phytophthora with the trees in the potting mix. The results indicate that the mild strain tristeza had little effect on yield. Rough lemon and Symons sweet orange appeared to be the better rootstock, as scions on these had the highest yields and yield efficiencies. Of the scions, Foster had the highest yields.

4.6.8 GRAPEFRUIT ROOTSTOCK EVALUATIONS FOR DIFFERENT SOIL TYPES IN THE KATHERINE REGION

M Hoult, M Smith, D Jaensch and L Granger

This trial was initiated in order to identify the most appropriate rootstock for commercial grapefruit production in the three major soil types in the region.

Materials and Methods

Three cultivars of grapefruit were budded in the nursery at KRS, to seven different rootstocks, resulting in 19 scion/stock combinations. Scion/stock combinations were replicated four times. Field layouts have been designed with scion/stock combinations randomly assigned to single tree plots.

The three scion cultivars include: Rio Red, Flame and Star Ruby. The seven rootstocks include: Benton Citrange, Cox Mandarin, Cleopatra Mandarin, Carrizo Citrange, Trifoliate Orange (*Poncirus trifoliata*), Nelspruit hybrid 639, and Swingle Citrumelo.

Three trial sites on grower properties, with three different soil types namely Tippera, Blain and River levee, have been identified for planting.

Results and Discussion

One site was established on the Tippera soil type in mid-1996. After three months growth there already appeared to be dramatic differences in stock/scion combinations. Benton Citrange across all scions had very poor, weak growth or no scion growth at all. Trifoliate Orange was also weak and Carrizo Citrange showed moderate vigour. Swingle Citrumelo, Cleopatra Mandarin and Nelspruit hybrid were amongst the more vigorous stocks. Cox Mandarin also looked very healthy and was a surprise, given that it was selected for Eureka lemon in the lemon rootstock trial. Star Ruby scions exhibited distortion of new growth flushes due to suspected herbicide drift, a common complaint with this cultivar overseas.

Plantings at the other sites will be established in 1997.

4.6.2 LEMON CULTIVAR EVALUATION IN KATHERINE

M Hoult, D Jaensch, M Smith, S McAlister and J Grigg

With some manipulation of phenology, Top End lemons mature at a time when prices on the domestic market are at their highest, *vis* January - March.

This trial aimed to look at the production performance of various lemon cultivars in the Katherine region with particular emphasis on summer lemon production.

Materials and Methods

Four cultivars, Meyer, Eureka, Lisbon, Villa Franca, were planted on Benton rootstock at KRS in 1992. Fino and Verna were grafted to Benton rootstock in 1993. Yields for the 1996 crop and 1997 crop were recorded and quality assessments made over a number of months using five to six fruit at each assessment.

Results and Discussion

Yields increased dramatically in 1997 with trees reaching four years (Figure 1). Fino and Verna cultivars (three year old) produced their first crop in 1997, with Fino having one of the highest 'first-year' yields of all the cultivars observed.

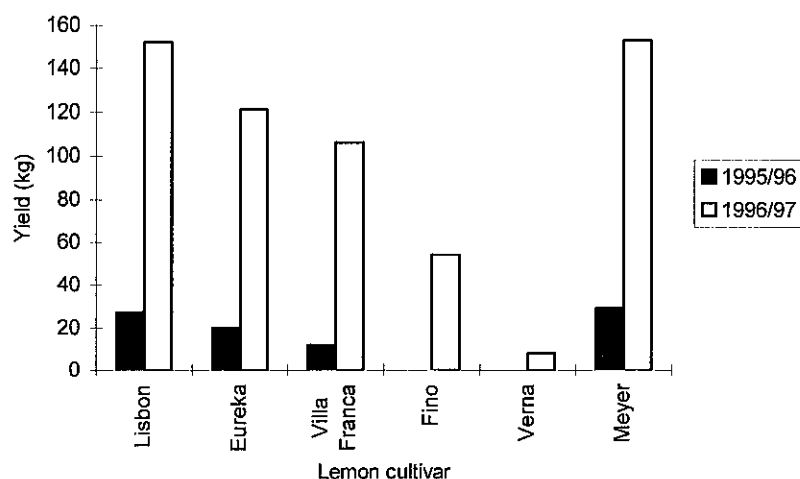


Figure 1. Average yields of various lemon cultivars in Katherine for 1996 and 1997 season.

The quality performance of the lemon cultivars was encouraging. Percentage juice was high, even at the first sampling date in December 1996 (Figure 2). Quality for 1997 was poorer and juice levels reached a maximum of 44% for Eureka, 44% for Fino and 34% for Verna (Table 1).

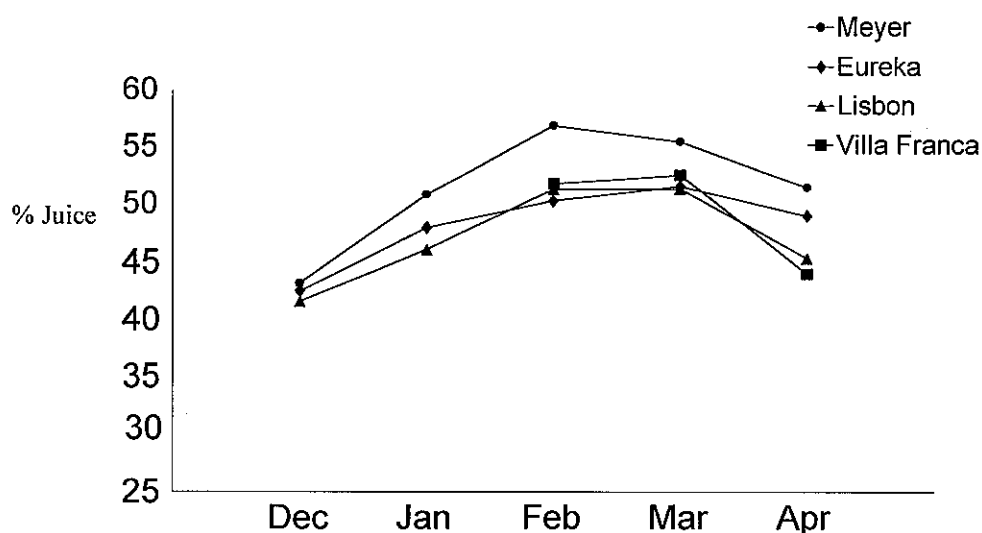


Figure 2. Percentage juice for lemon cultivars, KRS, 1996.

Table 1. Lemon yield and quality assessment, KRS, 1997.

Cultivar	Harvest Date	Fruit No.	Est. Total Yield (kg)	Av. Fruit Wt (g)	% Juice	Av. Brix ⁰	% Acid	Brix ⁰ /acid ratio	Av. Rind (mm)	Av. Seed no./Fruit
"Taylor" Eureka	19/2/97	751	121	161	44	8.0	6.3	1.0	5.3	18.7
Fino	19/2/97	205	54	263	44	8.0	6.3	1.27	5.8	9
Verna	19/2/97	39	8	204	34	7.0	5.6	1.25	7.1	7

Rind thickness was very good with no cultivar exceeding 4 mm in 1996 (Table 2). Rind thickness was slightly higher in 1997 with Eureka, Fino and Verna having rind thicknesses of 5.3, 5.8 and 7.1 respectively. Fruit size was large, which may be a negative aspect for certain markets.

Table 2. Lemon yield and quality assessment, KRS, 1996.

Cultivar/Stock	Harvest Date	Fruit No.	Estimated Total Yield (kg)	Av Fruit Wt (g)	% Juice	Av Brix ⁰	% Acid	Brix ⁰ /acid Ratio	Av Rind (mm)	Av Seed No./Fruit
Meyer/benton	15/2/96	128	29	228	56.9	7.4	4.31	1.72	2.6	7.6
"Taylor"	15/2/96	102	20	197	50.3	8.2	6.45	1.27	3.2	18
Eureka/benton										
Lisbon/benton	15/2/96	131	28	212	51.3	8.6	6.80	1.27	3.6	10
Villa	15/2/96	42	11	256	51.8	8.6	6.53	1.32	3.7	10.4
Franca/benton										

Overall, the lemons were very good quality and could be harvested during a period of reduced supply on the Australian domestic market, ie. January through to March/April, and for possible supply into Japan in late March-April. Apparently this is a period where the USA 'main crop' lemon season has finished and the southern Australian and South African 'main crop' season has yet to fully commence. All cultivars (except Verna) had fruit percentage juice greater than 44% for the 'main crop' by January. The most promising cultivars to date are Eureka, Lisbon, and Fino. The only cultivar to significantly be damaged by fruit piercing moth (FPM) was Meyer. For the other cultivars, no damage was observed in 1996 and there was only very slight damage (<5%) in 1997.

Yield and quality assessments will continue for the 1997/98 season.

4.6.7 ROOTSTOCK EVALUATION FOR LEMONS IN DIFFERENT SOIL TYPES IN THE KATHERINE REGION

M Hoult, M Smith, D Jaensch and L Granger

This trial was initiated in order to identify the most appropriate rootstock for commercial lemon production in the three major soil types in the region.

Materials and Methods

Four cultivars of lemons were budded in the nursery at KRS, to seven different rootstocks, resulting in 21 scion/stock combinations. Scion/stock combinations were replicated four times. Field layouts have been designed with scion/stock combinations randomly assigned to single tree plots.

The four scion cultivars include: Eureka, Lisbon, Fino and Verna. The seven rootstocks include: Benton Citrange, Cox Mandarin, Lockyer Rough Lemon, Rangpur, Nelspruit hybrid 639, Volkamer Lemon, Swingle Citrumelo.

Three trial sites, with three different soil types namely Tippera, Blain and River levee, have been identified for planting.

Results and Discussion

One site was established on the Tippera soil type in early 1996. At six months all trees had established well with Volkamer Lemon, Lockyer Rough Lemon and Rangpur having the highest vigour. Nelspruit hybrid showed moderate vigour while Cox Mandarin and Benton Citrange showed low vigour. Some trees showed slight iron chlorosis possibly due to the heavy rains saturating the soil in the 1996/97 wet

season. Rangpur exhibited some anchorage problems as trees had poor stability. The Swingle Citrumelo stock were field budded on planting so no comparison was possible.

Trees were budded for the Blain soil type site and have been hardened off ready for planting in July 1997. The third site is expected to be planted in late 1997.

4.6.3 BREEDING/SELECTION OF CITRUS VARIETIES

M Smith and M Hout

Research work to date has demonstrated that much of the citrus germplasm currently in Australia is of limited commercial value under the hot dry conditions of the Katherine region. Consequently, efforts have been made to identify alternative sources of suitable material, and to investigate the possibility of breeding new material.

Materials and Methods

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 24 trees field planted in May 1997 (again on their own roots). Nine seedlings from a pummello grapefruit cross (ex Zappalas Qld.) will be planted late in 1997.

Controlled crosses were made between Marisol clementine and Fremont mandarin at KRS in the 1995 season. Twenty-two seedlings were produced from this cross and have been budded onto Cleopatra rootstock.

Seedlings of Fairchild mandarin (origin USA), Quit Duong mandarin (origin Vietnam), an easy-peel selection from Indonesia, and Chironja tangerine (origin Haiti) have been established. All four of these are polyembryony and should come true to type from seed.

Ten seedlings of Temple (origin Jamaica) and eight of Cam Sanh (origin Vietnam) will be budded onto Cleopatra for field evaluation. These two cultivars are monoembryonic and hence seedlings will show genetic variability.

Eleven seed lots were collected during the citrus season in Jamaica and Trinidad in 1997, most of them being from highly coloured easy-peel types. Delays in quarantine treatment meant that practically all of the material failed to germinate. The exceptions were three seeds of Ugli (also spelt Hoogly) and one of Ortanique. These will be budded onto Swingle rootstocks and transferred to the field for evaluation.

Results and Discussion

Whilst currently of limited scope, it is hoped that some of the material may prove to be of commercial value to the region. Similarly, it is hoped that the material may also prove useful as breeding parents in the longer term.

4.6.4 CITRUS ROOTSTOCK EVALUATION FOR MINNEOLA TANGELO, IMPERIAL MANDARIN, MARSH GRAPEFRUIT AND MARISOL CLEMENTINE

ROOTSTOCK EVALUATION FOR MINNEOLA TANGELO, IMPERIAL MANDARIN AND MARSH GRAPEFRUIT

J Mansfield, G Kenna and S Marte

Citrus has shown some potential in the Central Australian region. The identification of compatible rootstocks, their effect on productivity, time of harvest and tolerance to soil and water characteristics in Central Australia is necessary for the successful establishment of a citrus industry.

Materials and Methods

The trial was planted at TTRF in 1987. Eight commonly used rootstocks: Rangpur (also known as Rangpur lime), Watkins rough lemon, Carrizo and Troyer citrange, Emperor and Cleopatra mandarin, Swingle citrumelo and Symons sweet orange were evaluated for their suitability as rootstocks for the Minneola tangelo, Marsh grapefruit and Imperial mandarin scions. Yield data and fruit characteristic measurements were taken until 1994.

Results and Discussion

This experiment is currently being written up into a report. The results indicated there was a variation in the performance of the rootstocks under the three scion types, but Rangpur, Watkins rough lemon and Carrizo citrange consistently outperformed the others.

4.6.4 CITRUS ROOTSTOCK EVALUATION FOR MINNEOLA TANGELO, IMPERIAL MANDARIN, MARSH GRAPEFRUIT AND MARISOL CLEMENTINE

ROOTSTOCK EVALUATION FOR MARISOL CLEMENTINE

J Mansfield, G Kenna and S Marte

Potential exists for commercial development of seedless mandarin cultivars for the early market niche. The identification of compatible rootstocks, their effect on productivity, time of harvest and tolerance to soil and water characteristics in Central Australia is necessary for their successful establishment.

Materials and Methods

This trial was planted in September 1991 to evaluate Marisol Clementine Mandarin on five different rootstocks (Watkins rough lemon, Carrizo citrange, Cleopatra mandarin, Rangpur cross Troyer citrange and C32).

Results and Discussion

The trial was harvested in 1994 and 1995 but the data is of little use as the fruit are cross-pollinated and consequently are very seedy and not what would be expected if each cultivar was grown in isolation. This experiment is currently being written up into a report.

4.6.6 CITRUS CULTIVAR EVALUATION PLANTING

J Mansfield, G Kenna and S Marte

Commercial citrus production has been identified as having potential for Central Australia. There is a constant release of new selections sourced from overseas as well as new selections bred or selected in Australia. These need to be evaluated for suitability for the region.

Materials and Methods

A number of trees of these selections, mainly easy peels and navel oranges, have been established at TTRF for evaluation. The potential of these cultivars are being assessed based on earliness, total yield, fruit quality and market acceptance.

Results and Discussion

Fruit piercing moth has limited the evaluation of these cultivars by causing extensive damage to fruit during high summer rainfall seasons. However it appears that grapefruit may have some potential for the Ti Tree region due it appearing to be less susceptible to damage. This experiment is currently being written up into a report.

4.6.9 MANDARIN CULTIVAR EVALUATION IN KATHERINE

M Hoult, M Smith and D Jaensch

Early cultivar assessments of mandarin production in Katherine were not encouraging given poor flowering, and low and erratic yields. With modification of management, using moisture stress to enhance flowering on certain cultivars, a re-evaluation of the potential for very early mandarin production was initiated.

This trial aimed to look at the production performance of various mandarin cultivars, including tangor and tangelo types, in the Katherine region with particular emphasis on the early, easy-peel cultivars.

Materials and Methods

Ten cultivars on a range of rootstocks were planted at KRS in 1993. Trees were first harvested in the 1996 season. Yields were recorded and quality assessments made over a number of months in the 1996 and 1997 seasons, using five to six fruit at each assessment.

Results and Discussion

The most promising cultivar was Fremont (Table 1) with high yield, high fruit numbers and excellent internal colour and rind colour (after degreening) and significantly lower levels of granulation than other cultivars. But fruit size was small with noticeable levels of pith. Fruit thinning may be required to increase fruit size.

Murcott yielded well but most fruit was sunburnt with an insipid taste and considered unmarketable. Fina had little granulation and reasonable flavour. Imperial, Emperor, Red Imperial, Page, Sunburst and Ellendale had little or no flowering and produced few or no fruit. The poor performance of Imperial and Ellendale confirmed past observations of these cultivars in the Katherine district.

Nova matured reasonably early with a Brix:acid ratio of 11.5:1 in mid-February. Internal colouring was good, although moderate to heavy levels of granulation developed during the season. Juice content was relatively high at 41.1% (Table 2).

Table 1. Mandarin, tangor and tangelo cultivar yield and quality assessment, KRS 1996.

Cultivar/Stock	Harvest Date	Fruit No.	Est. Total Yield (kg)	Av. Fruit Wt. (g)	% Juice	Av. Brix ⁰	% Acid	Brix ⁰ /acid Ratio	Av. Rind (mm)	Av. Seed No/Fruit
Fremont /cleopatra	21/2/96	123	10.0	81	56.2	13.2	1.27	10.4	1.5	12
Fremont/carrizo	21/2/96	54	5.9	109	54.8	12.2	1.19	10.3	1.8	15
Marisol/cleopatra	24/1/96	15	2.0	131	36.4	10.0	0.70	14.3	2.5	12
Marisol/carrizo	24/1/96	65	7.9	122	24.2	9.2	0.71	13.0	2.6	4
Nules/cleopatra	7/2/96	25	3.2	128	38.3	12.0	0.66	18.2	3.2	-
Nules/carrizo	24/1/96	38	5.2	137	28.2	11.4	0.75	15.2	4.7	33
Fina/cleopatra	6/3/96	69	7.8	113	45.9	10.2	0.65	15.7	1.8	-
Fina/carrizo	6/3/96	26	3.5	133	42.2	10.8	0.72	15.0	2.3	22
Oroval/carrizo	7/2/96	13	1.7	131	37.3	9.6	0.79	12.2	2.4	7
Murcott/cleopatra	9/4/96	135	16.1	119	40.0	10.0	0.62	16.1	2.2	-
Murcott/carrizo	9/4/96	96	13.0	135	36.7	9.2	0.49	18.8	3.5	16
Emperor/carrizo	9/4/96	20	2.8	138	36.5	9.4	0.82	11.5	4.0	13
Red Imperial/carrizo	21/2/96	7	0.7	103	30.9	9.0	0.58	15.5	2.6	-
Orlando/C35	6/3/96	-	-	156	56.5	10.4	2.02	5.2	2.2	21
Minneola/swingle	6/3/96	-	-	261	56.3	9.2	1.73	5.3	3.3	23

Table 2. Mandarin, tangor and tangelo cultivar yield and quality assessment, KRS, 1997.

Cultivar/stock	Harvest Date	Fruit No.	Est Total Yield (g)	Av. Fruit Wt. (g)	% Juice	Av. Brix ⁰	% Acid	Brix ⁰ /acid Ratio	Av. Rind (mm)	Av. Seed No./Fruit
Fremont/cleopatra	19/2/97	-	-	86.0	50.8	12.0	1.14	10.53	2.8	12.8
Fremont/carrizo	19/2/97	-	-	105.9	45.4	10.8	1.0	10.8	2.8	7.7
Nova/carrizo	19/2/97	-	-	181.5	41.1	9.0	0.78	11.54	4.6	8.2
Murcott/carrizo	19/3/97	-	-	162.2	35.3	8.0	0.61	13.12	3.1	-

In both assessment years, Fruit Piercing Moth caused severe damage with up to 90-100% of fruit damaged. Strip picking prior to severe infestations may not be an option given most cultivars are not mature at the onset of damage.

Cultivars such as Marisol, Nules, Oroval, Emperor and Imperial will be re-worked in 1997 to other promising cultivars such as Topaz, Fallglo, Daisy, Shekwasha and Wekiwa. Assessments of yield and quality will continue for Fremont, Murcott and Fina in 1998 with some adjustments made to crop levels during the season.

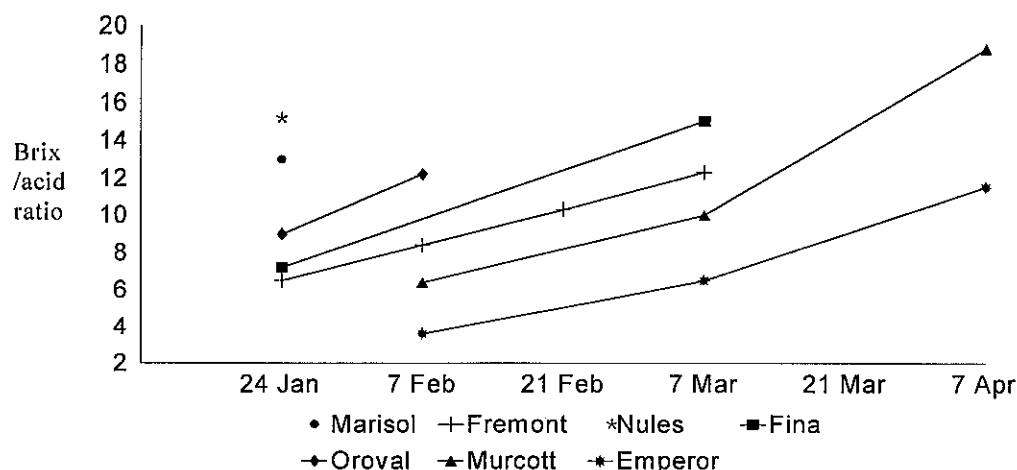


Figure 1. Brix / acid ratio for several easy-peel cultivars, KRS, 1996.

4.6.10 CITRUS MANAGEMENT IN KATHERINE

M Hoult, G Foord, J Bright, S McAlister, M Smith and D Jaensch

Past experience has shown that the challenges facing the management of citrus in Katherine include: poor and erratic flowering over a number of months due to warm temperatures experienced during the flower initiation phase; control of unnecessary vegetative flushes to minimise citrus leaf miner damage; determining irrigation and nutrient requirements for high quality and yield; and control of pests and diseases.

An effective management system for citrus in the tropical environment of the Katherine region has been evolving over a number of years. With some modification, this could also be adapted to the Darwin region.

Materials and Methods

Irrigation was withheld for six weeks in May/June 1996. At 'wetting-up' a 1% foliar low-biuret urea application was applied. Tensiometers, at 45 cm and 90 cm, were used to monitor soil moisture tension (SMT) and to schedule irrigation so that SMT was maintained below -40 kPa at 90 cm.

Nitrogen (ammonium sulphate) was applied at 80-100 g N/tree/year of age in July/August, potassium at 50 g K/tree/year of age and phosphorus at 10 g P/tree/year of age. Potassium and phosphorus were both applied in January/February. Two foliar applications of zinc sulphate heptahydrate at 2 g/L and one foliar application of copper oxychloride at 1.5 g/L.

Results and Discussion

Flowering was more prolific and concentrated for some cultivars after withholding water for six weeks. Observations of slow tree growth after this stress period suggests that the stressing period may need to be shorter in order to maintain tree health. The

stress period applied in 1997 was reduced to four weeks. Flowering levels will be monitored to determine if shorter stress periods are able to induce good flowering.

By maintaining a SMT of less than -40 kPa at 90 cm in three year old lemons, a crop factor of between 0.74 and 0.86 applied (assuming 18 square metre canopy). This is considerably higher than crop factors used for citrus in other areas. This crop factor was determined on one season's data only and soil moisture monitoring will continue.

Fertiliser application in July/August produced strong vegetative flushes in the following weeks and greatly reduced the amount of flushing during the wet season. This helps in managing citrus leaf miner which is most prevalent during the wet season on young vegetative flushes. Reducing wet season flush also ensures maximum reserves are available for fruit production at this time.

Leaf nutrient levels were within the standard range except for zinc and copper (Table 1). Nitrogen levels generally were on the high side and possibly reflect the high N inputs for maximising growth in young, non-bearing trees prior to first harvest year.

A diagrammatic summary of citrus management is shown in Figure 1.

Table 1. Leaf nutrient levels for various citrus scion/stock combinations, KRS, 1995.

Scion/stock	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	B (mg/kg)
Eureka/Benton	2.94	0.17	1.31	3.24	0.47	<i>5</i>	<i>15</i>	35	93	63
Lisbon/Benton	3.01	0.17	1.46	3.13	0.42	<i>5</i>	<i>17</i>	34	108	54
Fremont/Carrizo	2.98	0.18	1.21	3.47	0.53	<i>3</i>	<i>12</i>	27	70	57
Fremont/Cleopatra	2.65	<i>0.11</i>	0.94	4.54	0.54	<i>3</i>	<i>19</i>	38	69	85
Ray/Swingle	2.81	0.15	1.55	3.97	0.49	<i>4</i>	28	41	65	63
Henderson/Swingle	2.99	0.17	1.55	3.55	0.47	<i>5</i>	<i>20</i>	33	77	56
"Adequate" Range	2.4- 2.6	0.12- 0.16	0.7- 1.2	3.0- 6.0	0.26- 0.6	5.1-10.0	25-100	25-100	60-120	31-100

Italics indicate potential deficiencies; leaves sampled from middle of mature, non-fruitle spring growth flush - November.

The most troublesome pest in citrus has been the citrus leaf miner. However this is easily managed with horticultural spray oils, natural parasites and management of vegetative growth flushes. Fruit piercing moth may cause devastating damage to mandarin crops and to a lesser extent grapefruit and lemons. This pest will need monitoring over a number of years and would be a major limitation to commercial mandarin production, as there are no known effective control measures apart from netting the orchard. Citrus mealybug, red scale and citrus butterfly larvae are largely controlled using biological control methods in which it is essential to maintain effective ant control.

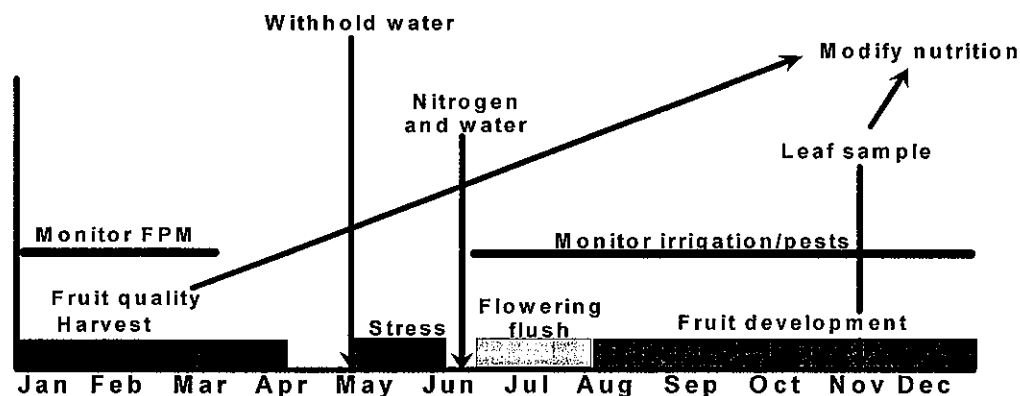


Figure 1. Citrus phenology and key management practices, Katherine.

4.6.10 CITRUS IRRIGATION OBSERVATION, MONITORING AND SCHEDULING

G Foord and M Hoult

The citrus planting at KRS provided an opportunity to closely monitor irrigation, record soil moisture tension and gain a better understanding of the irrigation requirements of citrus in Katherine on Tippera soil.

Materials and Methods

After the water 'stress' period in May/June, lemons at KRS were irrigated to field capacity to a depth of >90 cm. Tensiometers at 45 and 90 cm depths were installed to monitor soil moisture tension (SMT) and to schedule irrigation.

Results and Discussion

In July and August, a pattern developed. On the Tippera clay/loam of the trial site, we found that we needed to apply about 530 litres of water per tree when the SMT at 45 cm reached -20 kPa. This maintained SMT below -40 kPa at 90 cm. Applying 530 litres per tree, with a tree canopy area of 18 square metres (four year old trees) is about 29 mm per irrigation.

In August, five irrigations provided a total of 145 mm (Table 1). The total evaporation for August was 195.7 mm, this translates to a crop factor of 0.74. In September and October combined, 14 irrigations provided a total of 406 mm, the total evaporation was 488.1 mm, a crop factor of 0.83. November rainfall and irrigation totalled 175.6 mm, evaporation was 228.7 mm, a crop factor of 0.76. In December and January, rainfall exceeded evaporation and no supplementary irrigation was required.

These preliminary observations show that when using soil moisture tension to schedule irrigation in lemons, a crop factor of between 0.74 and 0.86 applied. This is

consistently higher than crop factors used for citrus in other areas. However, it must be stressed that we base this on only one season's soil moisture monitoring.

Table 1. Irrigation, evaporation and water use (four year old lemon trees).

Month	Irrigations	Irrigation Applied (mm)	Rain (mm)	Evaporation (mm)	Crop Factor*	Water Use L/tree/day
August	5	145	0	195.7	0.74	85
September	7	203	0	235.6	0.86	123
October	7	203	0	252.5	0.80	120
November	3	87	88.6	228.7	0.76	105**
December	0	0	407.5	140.4	***	***
January	0	0	532.7	90.5	***	***

*calculated on a canopy cover area of 18 square metres

**including rainfall

***rainfall far exceeded evaporation

4.6.11 EXTENSION SERVICES TO HORTICULTURE INDUSTRY (CITRUS)

SERVICES UNDERTAKEN IN CENTRAL AUSTRALIA

G Kenna and J Mansfield

Commercial citrus production in the Alice Springs region is limited at the present time to a number of small plantings in the Ti Tree area. There is however considerable potential to expand this industry to produce early maturing high quality fruit for both domestic and export markets. Considerable resources are allocated to providing results on various citrus research work which has been conducted in the area over recent years. This includes assessment of fruit quality, maturity times, rootstock performance and marketing information. Assessment of land and water resources suitable for citrus production is also made available to prospective developers.

Commercial citrus growers are supported with general information on management, postharvest handling, packing and marketing. Plant health certificates are issued for access of produce to interstate markets. Plants of the grapefruit variety Rio Red have been made available to a Ti Tree grower to encourage the planting of red-flesh selections.

J Grigg, M Hoult, E S Smith and D Jaensch

Damage by citrus leaf miner (CLM) is due to the activities by the larvae of a small moth, *Phyllocnistis citrella* Stainton (Lepidoptera:Gracillariidae) that feeds on young vegetative tissue by burrowing through the epidermal layers of citrus leaves, stems and, occasionally, fruit. The larvae leave silvery trails and cause the curling and distortion of leaves that retards normal, vigorous growth of young citrus and may affect the shape of the tree.

CLM is now found in most citrus growing areas of Australia. Since the level of control for this pest by indigenous natural enemies was very low, three species of parasitic wasps (*Citrostichus phyllocnistoides*, *Cirrospilus quadristriatus* and *Ageniaspis citricola*), were imported from China and Thailand and released into eastern and southern states of Australia during 1990 and 1991.

The aim of this trial was to establish a population of the three parasitic wasp species and to monitor the levels of citrus leaf miner, before and after release of the parasitic wasps, for signs of control.

Materials and Methods

Young grapefruit trees were monitored for CLM over a ten week period beginning 6 March 1997. Ten trees were randomly selected each week, with eight flushes per tree checked for damage, life stages and natural enemies of CLM.

Five batches of parasitic wasps were obtained from QDPI in southern Queensland and released (on 7, 14 and 27 March and 4 and 10 April) during the trial. Each batch contained approximately 50-80 wasps, comprised mainly of *A. citricola*, with some *C. quadristriatus* and *C. phyllocnistoides*. After the release, leaf miner chambers were examined for signs of parasitism, indicated by brown and dying larvae.

Later assessments included the collection and incubation of citrus leaf miner chambers to check for parasitism and identification of the parasite.

Fertiliser (super phosphate and ammonium nitrate) was applied on 27 March 1997 to encourage new flush growth, however it took three to four weeks before there was any response from the trees.

Results and Discussion

The levels of CLM changed significantly over time ($p=0.0001$).

There was a reduction in flushing activity from 26 March, due mainly to the onset of cooler weather and mineral deficiencies (magnesium and zinc) in the trees. This made it difficult to get an entire sample of 80 flushes (10 trees x 8) on 1, 8 and 15 April.

A distinct peak in the level of CLM activity occurred between 1 and 15 April (Figure 1). The decline following this peak could be attributed to an increase in population numbers and food availability (flushes) which resulted in the death of larvae through overcrowding.

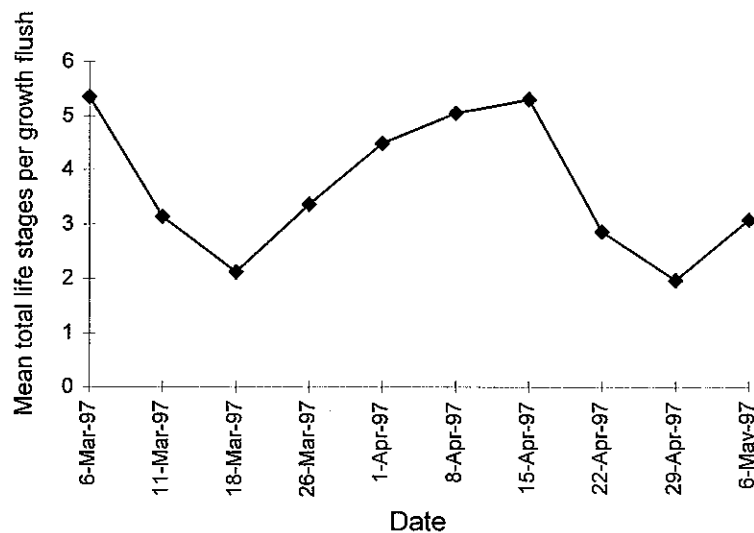


Figure 1. Mean number of total life stages for citrus leaf miner counted on grapefruit leaves.

The introduction of the parasitic wasps on 7, 14, and 27 March and 4 and 10 April did not appear to have any obvious effects on CLM populations to the end of the monitoring period.

Due to the limited time for monitoring, there was no evidence that any of the three parasitic wasps released in the grapefruit trees had established over the two month period. There was, however, one possible recovery of *C. quadristriatus* (awaiting identification). It is possible that the parasitic wasps failed to establish in the grapefruit due to the limited growth flush and low levels of CLM at the times of release. Better establishment of the CLM parasites may be achieved by releasing the wasps at the end of the wet season when the trees are flushing and the levels of CLM are high.

Several unidentified wasps were collected, one observed to be feeding externally on a CLM pupa and three or four other species were collected from the leaf blade. These wasps await positive identification but are suspected to be endemic species which have previously been noted attacking CLM in the Northern Territory (Wilson, 1991; Smith 1994).

4.6.13 CITRUS ENTOMOLOGY

E S Smith and D Chin

The objective of this project is to identify potential pest species, their control and to encourage the practice of Integrated Pest Management on commercial properties.

The area planted to citrus in the Top End and in Central Australia is increasing annually. The Branch has frequently been requested to advise on pest situations in citrus orchards but has rarely been involved in research programs. Recommendations have emphasised an integrated approach using a combination of cultural and biological methods or, when necessary, the application of non-disruptive pesticides. The main pests targeted were citrus leaf miner, scales, mealybugs, thrips, mites, fruit piercing moths and some leaf feeding caterpillars.

Results

Citrus leaf miner is found in most citrus growing areas of Australia but the level of control for this pest by indigenous natural enemies is generally very low. Three species of parasitic wasps, *Ageniaspis citricola* (Hymenoptera : Encyrtidae), *Citrostichus phyllocnistoides* (Hymenoptera:Eulopidae) and *Cirrospilus quadristriatus* (Hymenoptera : Eulopidae), were imported from China and Thailand and released into eastern and southern States of Australia during 1990 and 1991. Over a five week period in March - April 1997, batches of these three parasitoids were introduced from S-E Queensland to citrus blocks in both the Katherine and Kununurra (WA) areas in an attempt to establish populations which could control the leaf miner. The levels of citrus leaf miner before and after release were recorded. This trial is reported in more detail in the Horticulture Division Technical Annual Report.

Adults of a weevil, *Mylocerus* sp. (Coleoptera : Curculionidae) which commonly feed on flush tissue of other hosts were recorded for the first time on citrus.

Information on major and minor pest species in the NT was supplied to the authors of a book to be published by QDPI and HRDC. This book, entitled "Citrus pests and their natural enemies - Integrated pest management in Australia" will shortly be released.

4.6.14 ASSOCIATION BETWEEN CICADA DAMAGE AND CITRUS DIEBACK

E S Smith, M Hault, B Condé and J Grigg

The purpose of this project is to examine the role of cicada damage in the initiation of citrus dieback.

Over the past few years occasional reports of elongated lesion damage to recently expanded flush shoots on young trees of several citrus varieties have been received. Reports emanated from both the Darwin and Katherine region with Clementine mandarins and super-red grapefruit particularly affected. There were frequently three

to four or more lesions, each 5-6 mm long and 2-3 mm wide on a twig orientated in a line along the upper surface of the shoot and with 10-20 mm of undamaged tissue separating them. When noticed, much of the damage had calloused over, leaving a "lens-shaped" split in the bark. Under microscopic examination, the internal vascular bundles within the shoots were seen to be severed and old empty cicada egg shells were embedded amongst the "frayed" end of the bundles. Dieback and subsequent exudation of gum from the affected twigs was common on some trees. The physical damage was thought to be caused either by cicada adults laying eggs into the hardening shoots in December or by the emergence of the nymphs from the eggs and plant tissue some two to three months later. Since the latter period would be during mid-late wet season, disease organisms could enter the damaged shoot and perhaps cause twig dieback.

During late November 1996, heavy emergence of cicadas occurred on two citrus blocks at Katherine and adult feeding and ovipositing was particularly prevalent on lemons and mandarins. Between 10-100 % of hardened flush shoots were damaged on 50 - 80 % of all trees. The damaged shoots were largely pruned off in one commercial block while on the Katherine Research Station, most damaged shoots were tagged without pruning. Specimens of cicadas were collected for specialist identification.

Results

Two species of cicada, *Abrieta castanea* Distant and *Illyra hilli* (Ashton) (Hemiptera: Cicadidae) were identified as feeding and laying eggs into hardened flush tissue of citrus during early December 1996.

On the commercial property, very little dieback subsequently occurred within the citrus trees but on the Station where the affected shoots were not pruned off, many (> 50%) of the damaged shoots had developed typical "dieback" symptoms with rusty-red coloured gummy exudates when examined some three to four months later. At that time, diseased and non diseased shoots were excised and taken to Darwin for pathological testing.

The disease organism *Colletotrichum gloeosporioides* Penz. was consistently isolated from one sample of damaged shoots from various trees which exhibited dieback symptoms. *C. gloeosporioides* usually grows as an endophyte or latent infection within plant tissue and does not express itself until the tissue ages. The fungus is unlikely to be the primary cause of the dieback symptoms, but rather the fungus expresses itself on damaged or dying tissue.

4.7.1 EVALUATION OF A RANGE OF STONEFRUIT TYPES AND VARIETIES ON PEACH-ALMOND HYBRID ROOTSTOCK IN CENTRAL AUSTRALIA

G Kenna, N Isgro and C Ellis

At present there are no commercial plantings of stone fruit in the Alice Springs region. Although it is unlikely that stone fruit could be produced as early as the coastal areas of northern NSW, this would not matter, as there appears to be good market potential for Central Australian stonefruit in markets such as Adelaide, and the major Northern Territory cities - Alice Springs, Katherine and Darwin. In addition there may be some export potential into southeast Asia.

Research plantings to assess the potential for dessert stonefruit production in Central Australia have been established in this area in the past. Most of these initially grew well and produced heavy crops but then became unthrifty and only had a short life span. This was mainly due to the unsuitability of the rootstock available at the time for Central Australian conditions. Supplies of a new rootstock cultivar named Titan (a peach/almond hybrid also known as Bright's Hybrid) which was introduced from the USA, have become available. This rootstock is reputed to have a tolerance to high soil temperatures, high pH and nematodes, the problems identified as having caused the demise of the earlier plantings.

Materials and Methods

A planting of this rootstock has been established at AZRI and some have already been budded with selections of peach and nectarine including Flordagold, Flordaglo, Dessert Red, 6-3 and 84-16. These trees are growing well and the rootstock appears to be able to handle the growing conditions. In the near future more trees will be budded with selections of peach, nectarine and plum. A majority of the cultivars are low chill selections bred by Professor Wayne Sherman in the USA.

Results and Discussion

The trees which were initially budded with the low chill selections have grown satisfactorily. Vigour is not excessive and with summer pruning, good tree shape has been achieved. Nutrient status of the trees appears to be adequate at this time, with no visual symptoms of deficiencies evident. The tree nutrition program at this time comprises regular applications of nitrogen through the irrigation system and foliar applications of zinc. It is intended that a selection of patented medium chill varieties be included in the planting. Attempts to source planting material of these varieties from the relevant nurseries are being made at this time.

4.7.2 ASSIST THE DEVELOPMENT OF A COMMERCIAL FIG INDUSTRY

G Kenna and J Mansfield

A small commercial fig industry is established in Central Australia with a planting located in the Ti Tree area and another south of Alice Springs. Supplies of fresh fruit are sent to domestic markets including Adelaide, Melbourne and Sydney when supplies of this fruit are not available from the southern production areas. Second grade fruit is either dried or frozen and sent for processing as jams etc in the southern states. Assistance is provided to growers by the provision of Plant Health Certificates to enable fruit access to interstate markets, the provision of information on various aspects of fig production sourced from overseas literature or the provision of adhoc extension services to solve various problems including the monitoring and control of carpophilus beetle.

4.7.3 EXTENSION SERVICES TO HORTICULTURE INDUSTRY (SUB-TROPICALS)

SERVICES UNDERTAKEN IN CENTRAL AUSTRALIA

G Kenna and J Mansfield

Assistance and advice is provided to growers of these crops on a needs basis. A range of plantings of various crops are grown. Assistance and advice is provided on all aspects of production, postharvest handling and market requirements.

4.7.4 ESTABLISHMENT OF STONEFRUIT GERMPLASM

M Hoult

Over the last few decades, plant breeders have made significant advances in developing cultivars of traditionally cool season crops, that are adapted to warmer climates. These efforts, particularly with stone fruit in Florida, mean that it is now feasible to grow some tree crops in regions previously considered quite unsuitable. There are stone fruit cultivars now available that require limited chilling in order to induce flowering. Whilst some may find it fanciful to contemplate stonefruit growing at Katherine, the development of new cultivars and opportunities to manipulate crop phenology make it worthy of at least a preliminary study.

Materials and Methods

Six peach cultivars (Flordaprince, Newbelle, Flordaglo, Tropic sweet, Desert red, and Rayon) four nectarine cultivars (Sunwright, 81-6N, Sunblaze and Sundowner), one apricot cultivar (*Prunus mume*) and 24 plum cultivars (Gulfruby, Gulfgold, 85-1, 86-1, 86-2, 86-3, 86-4, 86-5, 86-6, 86-7, 86-8, 86-9, 87-1, 87-2, 87-3, 87-4, 87-5, 87-6, 87-7, 87-8, 87-9, 87-10 and 87-11) were budded onto nine month old Okinawa seedling rootstocks in the nursery at KRS in February 1997. Seedling Okinawa trees were also planted into the field in July 1996 ready for field working.

Results and Discussion

All cultivars established well in the nursery, except tropicsweet, Rayon, 87-4, 87-5 and 87-9. These cultivars will be sourced again together with additional low-chill peach cultivars, Flordaking, Tropicbeuty, Flordagrande and Earligrande.

Okinawa stocks in the field have also grown particularly well and initiated flower buds in the 1997 dry season.

Future work will see all cultivars transferred to the field where assessments of flower initiation and possible fruiting can be made.

It is anticipated that only a few years will be required in order to decide whether stonefruit are likely to be a commercial proposition in the Katherine region.

4.8.1 CASHEW SELECTION AND EVALUATION

V Kulkarni and D Hamilton

The climatic conditions of the Top End are ideal for cashew. Economic analysis however has indicated that the commercial success of cashew in the NT would largely depend on the availability of cultivars which can yield at least 4.5 tonnes of nuts/ha. Few of the existing cultivars can meet this target. Productivity can be improved either by evolving new genotypes or by developing new management techniques. New genotypes can be evolved by systematic crossing, as well as through selection. This project aims at evolving new genotypes through selecting promising types from a large population of seedling progenies and evaluating them for consistency.

Material and Methods

Seedlings were raised from genetically diverse material derived from Brazil and were planted at CPHRF in 1990. A total of 800 seedlings were tested. Evaluation of the seedling progenies for vegetative, floral and nut characteristics and yield of the trees resulted in 12 promising types, of which five were adjudged as most promising. These are, DPIF 5/9, DPIF 5/11, DPIF 5/13, DPIF 5/18, DPIF 5/19, DPIF 5/21, DPIF 5/22, DPIF 5/23, DPIF 5/24, DPIF 5/30, DPIF 5/40 and DPIF 3/28. These selections were grafted on seedling rootstock for planting and testing at Wildman River Plantation in the NT and Australian Cashews in Queensland. At least five grafts were prepared for each site. Four grafts in each selection were also planted at CPHRF.

Results and Discussion

Grafts planted at Australian Cashews have established well. QDPI researcher P.O.J. Farrel is monitoring the progress of this material. As a result of management problems faced by the Wildman River property, the selections at this site failed to establish and will be replanted under the new management. There were a few mortalities at CPHRF due to Cyclone Rachel and it is proposed to replant the selections at the new site.

4.8.2 CASHEW VISUAL YIELD ASSESSMENT

G Foord, M Smith, M Hoult, S McAlister and J Bright

Over 800 trees of about 450 different cashew hybrids were planted in 1992 as part of the DPIF, QDPI and CSIRO hybrid evaluation program. This presented us with the task of assessing a large number of individual trees, in a short time, with limited resources. The aim of this project was to test a visual ranking technique to record yields of cashew trees without hand-harvesting.

Materials and Methods

Yield was visually assessed in November, estimating yield by the number of nuts on the ground. Each tree was ranked from 0 to 5 (5=highest yield). Nuts were hand-harvested from the higher ranked trees, a selection of lower ranked trees and from trees that were hand-harvested in 1995. A linear regression was performed on the data from 1995 and 1996 harvests.

Results and Discussion

In 1996, leaf fall, caused by pesticide damage, made the visual assessment more difficult than in 1995. However, the correlation between visual ranking and hand-harvested yield in 1996 was strong ($R^2 = 0.5796$).

The high correlation between yield data and the ranking system used (Figure 1) supports the use of the visual ranking system for assessing the yield of individual cashew trees. We were able to calculate the yield of over 500 trees without hand-harvesting by simply multiplying the visual ranking by the 'y' value calculated. The visual assessment took three people about two hours and saved over 500 hours hand-harvesting and sorting time.

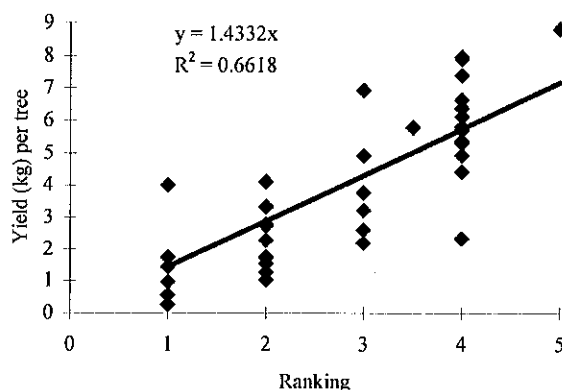


Figure 1. The comparison of hand-harvested yield and visual ranking of cashew trees in 1995.

4.8.2 CASHEW GERMPLASM ASSESSMENT

G Foord, M Smith, M Hout, S McAlister and J Bright

Since 1995, cashew research in Katherine concentrated on a collection of hybrids planted at King Producers' Venn block, 20 km south of Katherine. Over 800 trees of about 450 different cashew hybrids were planted in 1992. These are a part of an DPIF, QDPI and CSIRO hybrid evaluation program to identify superior hybrids.

Early in 1995 it became clear that management systems developed elsewhere did not necessarily suit Katherine conditions. Pest management emerged as a priority, the main cashew insect pests (the Mango Tip Borer *Penicillaria jocosatrix*, Helopeltis Bug *Helopeltis* sp. and the Fruit Spotting Bug *Amblypelta lutescens*) attack new flushes. This project looked at developing a system that would encourage new growth at critical stages and limit unnecessary flushing through 'high pest pressure' periods without adversely affecting yield or nut size. At the same time we could identify superior hybrids.

Materials and Methods

In 1996 we modified our irrigation and nutritional inputs outlined in the 1995/96 Technical Annual Report by withholding irrigation from the start of the wet season (December 1995) until the beginning of May, and applying all macro-nutrients in May, June and December.

Results and Discussion

The hybrid '1161' consistently yielded well, outyielding the next best in 1995 by about 10% and in 1996, and '1995 and 1996' combined, by >30% (Table 1).

Table 1. Yield and ranking of the ten highest yielding cashew hybrids in 1996.

Code	Nut in Shell (kg/tree) 1995	Nut in Shell (kg/tree) 1996	Nut in Shell (kg/tree) 95+96	Mean Nut Weight (g) 1995	Mean Nut Weight (g) 1996	Rank 1995	Rank 1996
1161	8.80	14.50	23.30	5.86	5.17	5	3.5
1526	*4.29	11.62	*15.91	**	4.21	3	3.5
1668	4.10	10.49	14.59	5.38	5.11	2	3.5
1246	*4.29	9.50	*13.79	**	6.98	3	3.5
1546	*1.43	9.50	*10.93	**	5.64	1	4
1873	7.38	9.32	16.70	5.6	5.62	4	2
1452	*4.29	9.31	*13.6	**	4.64	3	4
1267	*2.86	8.88	*11.74	**	4.39	2	4
1483	6.38	8.52	14.90	6.21	4.24	4	3
1213	5.73	8.27	14.00	5.2	4.94	4	3

*denotes yield calculated using the correlation between yield and ranking determined in 1995, $y = 1.4332x$

**denotes weight not recorded in 1995



Figure 1. Nut in shell yield of the ten highest yielding cashew hybrids in 1996 and their comparative yields in 1995.

The new management system developed at Katherine and outlined in the 1995/96 Technical Annual Report appeared to be effective. Compared to 1995, there was more uniform flushing and flowering, a general yield increase with similar nut size and a reduced reliance on chemicals for insect control. Withholding irrigation from the start of the wet season (November, December) until the beginning of May, represents a substantial saving of power and water resources, more than 0.4 megalitres of water per month per hectare could be saved. The more uniform flowering resulted in a more uniform nut fall. This will allow harvesting to take place over a shorter period with fewer passes with the machinery.

The next phase of this project is to further evaluate the hybrid '1161' and a promising Brazilian selection in multiple tree plots. This will enable more accurate estimates of yields (per ha) and the 'fine tuning' of cashew management in Katherine.

4.8.3 CASHEW ROOTSTOCK SCREENING

G Foord, M Smith and M Hoult

Superior cashew genotypes identified at Katherine and CPHRF will be grafted and further tested at KRS. The availability of seedlines for rootstocks and information on their performance as a rootstock is limited (or non existent). Smith and Bowman (1994) conducted an experiment to assess the possible existence of iron-deficiency induced chlorosis as a problem in young cashew and to determine the relative susceptibility of a range of cashew seedlines to symptoms of chlorosis. Distinct differences were detected within 45 days of sowing.

In this experiment, we investigated the selection of available seedlines most likely to perform well, as a rootstock, on the alkaline, irrigated soils of the Katherine region.

Materials and Methods

On 22 October 1996 the seedbed was prepared at KRS on Tippera clay loam. One kilogram per square metre (10 tonne per hectare) of calcium carbonate was incorporated into the soil.

Seed collected from 43 trees around Darwin and Katherine were sown in rows of seven at close spacings (15 cm x 20 cm) and irrigated daily using T-tape®.

Chlorosis severity was assessed on 27 February 1997.

Results and Discussion

October and November mean maximum temperatures and humidity were typically hot and dry. In contrast, December and January were particularly wet. Heavy rainfall caused local flooding and the trial area was inundated for up to ten days at a time. These extreme conditions were less than ideal. However, many of the 43 lines planted established well (>50% survival rate).

On 27 February 1997, most lines were severely chlorotic. Two lines from Darwin were very vigorous, with no chlorosis and two lines from Katherine, though less vigorous, also showed no chlorosis.

Seedlines from Darwin that performed well, were not available for the 1997 planting. Therefore, the seedline from Katherine that performed the best was selected because of its availability. Of the ten seedlines sourced in Katherine (collected from trees that yielded well in 1995), one did not germinate, two were severely chlorotic and only two were acceptable. In this instance, we had an 80% chance of selecting a stock with a low tolerance to elevated pH if we selected on availability alone.

5.1.1 HONEYDEW MELON VARIETAL ASSESSMENT

K Blackburn and M Traynor

The objectives of this project were to assess recent commercial releases, to assist a Burdekin grower and to evaluate varieties with a local commercial grower.

Materials and Methods

The ten varieties looked at were Honeymoon, Sweet Success, White Mist, Glacier, NW 456, Dewcrisp, Dewette, NKS 735, SPS 882 and Honeybabe.

Trial Design: RCBD (randomised complete block design) with two replicates.

Results and Discussion

Three cultivars, Dewette, Sweet Success and Honeybabe were outstanding. Advantages of these cultivars are:

- Bred for concentrated fruit set and once-over harvesting
- Easier to pick - uniform maturity
- Damage to plants at picking is irrelevant
- Easier to grade - uniform size and shape
- White Mist and Glacier did not rate as well
- Grower observation plots confirmed trial results

5.1.1 WATERMELON CULTIVAR EVALUATION FOR EARLY SEASON PRODUCTION

S McAlister, M Smith, J Bright and G Foord

There continues to be a steady flow of new watermelon cultivars available to growers. Previous trials had screened commercial cultivars and identified Red Tiger as being superior for mid-season production at Katherine, on either plastic mulch or overhead irrigation. This cultivar is now commonly grown in the district.

The aim of this experiment was to examine the comparative performance (yield and quality) of 15 watermelon cultivars.

Methods and Materials

The duration of this trial was from March 1996 to July 1996 at KRS. The trial was planted on 22 March 1996, with 82 days to first harvest. First harvest took place on 12 June 1996, second on 27 June 1996 and the rejects on 3 July 1996.

The 15 treatments were arranged in a randomised complete block design with two replicates. Plots consisted of three adjacent rows, 7 m in length.

Regular observations of any differences between cultivars in terms of establishment, biomass, pest or disease susceptibility were recorded.

Yields of marketable fruit (weight and number) were recorded from the 5 m of each plot, with a maximum of three harvests. At the completion of harvest, the number of all remaining fruit was recorded.

At each harvest, three randomly selected, marketable fruit from each plot were assessed for external and internal colour, shape, internal splitting and rind thickness. A sensory evaluation was also conducted by staff and local producers

Results and Discussion

Assessors consider most of the varieties to be suitable for commercial production, but showed a distinct preference for the quality of Red Tiger, and to a lesser extent Morocco and Red Devil. Watermelon appears to be a crop in which quality is far more important than simply yield per hectare.

Whilst there is a wide range of suitable varieties available to growers, there seems little justification for changing the current recommendation of Red Tiger as the preferred seeded watermelon for the region.

Table 1. Yield and fruit size of 15 different watermelons cultivars.

Cultivar	Yield (kg/plot)	Av. Fruit Size (kg)
Herculon	321	5.3
WM 753	310	6.7
Eclipse	308	8.8
Ebony	292	5.2
Sampson	291	5.4
Pharaoh	286	6.8
Tomahawk	271	7.5
NW 819	269	7.3
NK 466	252	5.1
Red Tiger	239	5.7
Phantom	221	5.5
616J	190	7.6
Morocco	184	6.0
NW 820	173	7.9
Red Devil	169	6.5

5.1.3 BASAL NITROGEN RATES FOR WATERMELONS

M Smith, S McAlister, C Brown, J Bright, G Foord, and M Hoult

There has been no research work to establish base fertiliser rates for watermelons in the Katherine region. Commercial practices, in terms of base nitrogen application, vary widely from as little as 30 kg N/ha up to 140 kg N/ha. Growers have been advised to apply between 30 and 50 kg N/ha. Given that watermelons are the most widely grown annual crop in the region, there was a need to refine fertiliser practices.

Materials and Methods

Nitrogen (as ammonium sulfate) was applied at five rates prior to plastic laying and sowing. The rates were 0, 30, 60, 120, and 240 kg N/ha. Plots consisted of three beds (1.2 m centres) of 10 m length. Data was collected from the central bed for 7 m of its length. Treatments were replicated four times, with the exception of the 0 kg N/ha treatment which was replicated eight times. Phosphorus and potassium were applied at the rates of 90 and 70 kg/ha respectively at planting, and an additional 70 kg N/ha was applied to all plots as side dressings.

Petiole sap nitrate concentration was determined for each plot at approximately weekly intervals. Canopy height was also assessed at regular intervals. Although three harvests were made, only data from the first two were included in calculating marketable yield. At each harvest, individual fruit were weighed and assessed for blossom-end rot and marketability. After the final harvest, a 1 m square quadrat was cut from each plot in order to determine harvest index and nutrient content. Soil samples, to a depth of 1.2 m in 200 mm sections, were taken in all plots.

At the first harvest, 15 fruit from each plot were collected for post harvest assessments. Five of these fruit were assessed immediately, five assessed after three weeks storage, and the remaining five fruit from each plot assessed after five weeks storage. Each fruit was assessed for diameter, rind thickness, firmness, flesh and juice Brix, juice percentage of the flesh, and flesh colour.

Results and Discussion

Base nitrogen rates had a marked influence on petiole sap nitrate levels from shortly after emergence right through until after final harvest. There was also an obvious influence on the rate and extent of canopy development. There was a clear optimum rate (120 kg N/ha) above and below which yields fell (Figure 1). Effects on fruit quality were less clear. It was expected that high rates of nitrogen would detrimentally effect fruit quality and post harvest storage. However there was little evidence for this, other than perhaps a slightly paler colour in fruit from the highest rate of base nitrogen. It appeared that the optimum base nitrogen rate in terms of yield, was also optimum for fruit quality.

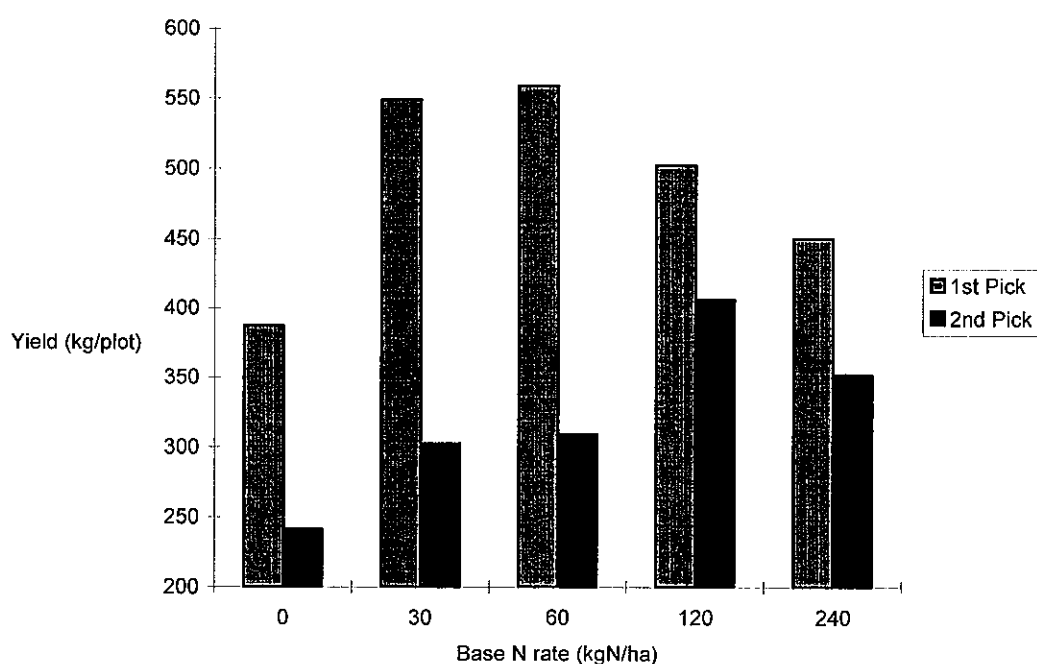


Figure 1. Base nitrogen rate effect on watermelon yield

Although these results need to be confirmed in further work, it would seem that there is a need to substantially increase recommended basal nitrogen rates to around 120 kg N/ha.

5.1.4 WATERMELON RESPONSE TO TEMPORARY MOISTURE STRESS

S McAlister, J Bright, M Smith, G Foord, M Houlst and C Brown

It is not uncommon to hear watermelon growers and researchers suggest that moisture stress for the right amount of time, and at the correct phenological stage can increase yield and quality. However this suggestion that moisture stress may be beneficial in watermelons, is not supported by any scientific literature that we are aware of.

Materials and Methods

An experiment was designed in which plants were stressed at different phenological stages (25, 38 or 60 days after sowing (DAS)) and for different periods of stress (three, six or twelve days without water). These treatments gave a 3 (DAS) * 3 (stress period) factorial design and were assigned to plots within a randomised complete block design with three replicates. An additional control treatment received no moisture stress. Plots consisted of three beds 10 m in length. Yield was assessed from three harvests, with fruit quality effects determined at harvest, after three weeks storage, and after five weeks storage.

Results and Discussion

The no-stress control treatment outyielded all other treatments. There was a clear trend with moisture stress later in the crops development (38 and 60 DAS) having the most detrimental effect on yield. Stress at 25 DAS had little effect except were it lasted for 12 days. It was during the fruit filling stage (60 DAS) that moisture stress was most detrimental to yield (Figure 1). Plants stressed at this stage also had an increased incidence of blossom end rot.

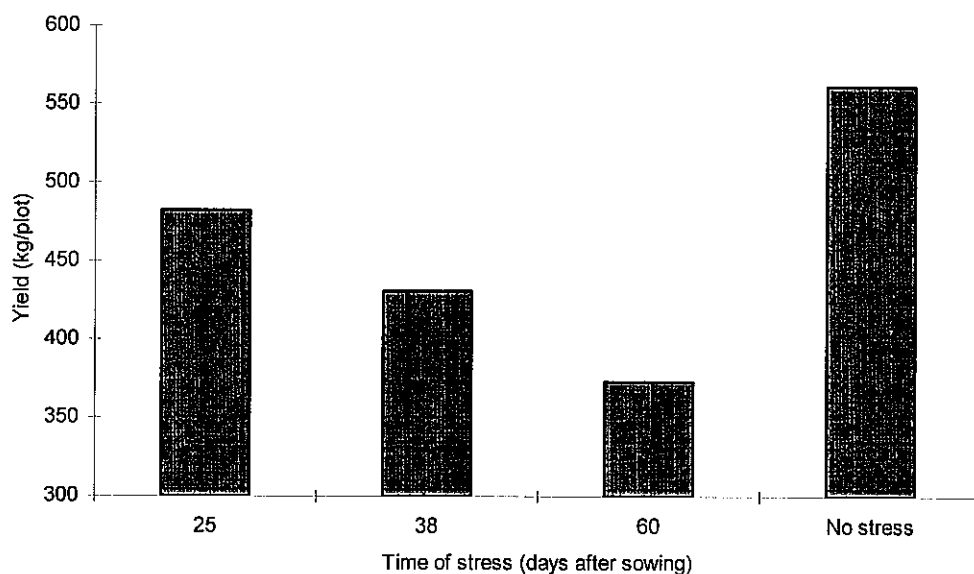


Figure 1. Effect of moisture stress, at different phenological stages, on watermelon yield.

Longer periods of moisture stress had a slight but detrimental effect on fruit Brix. Fruit from plants stressed at 60 DAS produced fruit which was firm at harvest, but deteriorated more rapidly in storage than fruit from other treatments. This is an example of the effect of pre-harvest treatment on post harvest performance.

It is clear from this experiment that growers looking for high yields of high quality fruit with good post harvest storage capacity should grow their watermelons without stressing them for moisture. Moisture stress is most damaging during the later stages of crop development.

5.1.4 HERBICIDES FOR WATERMELONS

M Smith, S McAlister, G Foord and J Bright

Currently there are no herbicides that give effective weed control in watermelons. However a review of literature revealed a number of chemicals that had been evaluated internationally with some promising results.

Materials and Methods

Samples of two of the more promising chemicals (ethalfluralin and clomazone) were obtained for trial purposes. Oryzalin (sold as Surflan) which is commonly used in Australian agriculture was also included. Each of these three chemicals were applied at two rates, and the effect of mechanically incorporating the chemical was also compared with incorporation by irrigation. This gave a 3 (chemical) * 2 (rate) * 2 (mechanical vs. irrigation) factorial treatment design. An additional two control treatments (no weed control, and regular hand weeding) resulted in an experiment with 14 treatments. Plots were 3 m by 9 m, with each treatment replicated three times. The field selected for the experiment had been under intensive cultivation for over 30 years and was heavily infested with caltrop, portulacas, cape gooseberry and couch. Treatment effects on crop growth and suppression of different weed species was assessed visually by two researchers at two different dates. Harvests were also made on the oryzalin plots and the control plots. All other plots had been too heavily infested with weeds, or the plants too badly damaged to warrant yield assessment.

Results and Discussion

All treatments resulted in some level of weed suppression, although phytotoxic effects on emerging watermelon plants were also noted in most cases. In general, this detrimental effect on the watermelons was worse at the higher rate of each chemical, and was also worse where the chemical had been mechanically incorporated. Increasing the rate of chemical tended to increase crop damage more than it increased weed control. None of the treatments (other than hand weeding) gave acceptable weed suppression without also damaging the crop (Figure 1).

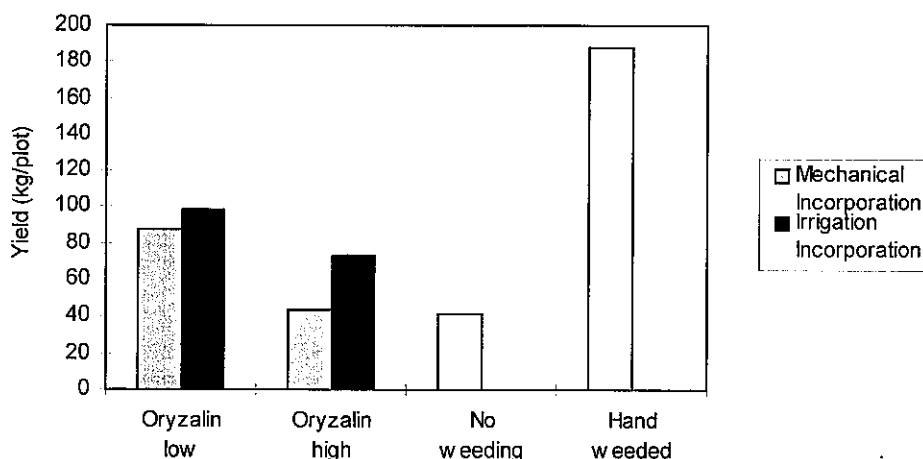


Figure 1. Watermelon yield for plots receiving oryzalin, compared with 'no weeding' and 'hand weeded' control treatments.

Future work should evaluate lower rates of application (without mechanical incorporation) as there may be a role for these chemicals in the early stages of crop development, after which mechanical weed control methods could be employed. Alternatively, these chemicals could be used to provide weed control from planting until the plants start to spread, after which another chemical could be applied. The important thing that developed from this work is that there are chemicals that will allow watermelons to emerge, while at the same time suppressing weed germination.

5.1.5 LEGUMES AS A GREEN MANURE CROP

M Smith, M Hoult, S McAlister, G Foord and J Bright

The current production system for annual crops in the Katherine area involves growing a tall grass (either millet or sorghum) during the wet season, ploughing this in around mid-February, and then sowing annual crops from March through to August. Whilst this system works well on sandier soils, the heavier 'Tippera' soils in the region lose their structure very quickly with cultivation, making continual utilisation of areas difficult. Furthermore, the need to plough-in grasses in mid-February increases the risk of soil erosion on steep slopes, from intense rainfall which sometimes occurs late in the wet season. There is therefore a need to develop an alternative production system in order to sustainably utilise heavier soils, and those areas with significant slope.

Past work has identified one cowpea genotype (40323) that sets seed very late (mid-May) and may be suitable as a mulch, into which annual crops could be direct drilled. New work was undertaken to examine the suitability of this cowpea for an alternative production system.

Materials and Methods

A 0.25 ha area of cowpea was sown (11 December 1996) adjacent to a similar sized area of Jumbo sorghum. The growth and development of both areas were observed

throughout the wet season. Prior to ploughing-in the sorghum (28 February 1997) three 1 m² quadrats were cut from each of the two areas to assess biomass production. Three quadrats were also cut from a nearby area of Putland mungbean, planted 1 January 1997 for comparison. A further three quadrats from the cowpea area were taken (8 May 1997) immediately prior to the area being sprayed-out with glyphosate. Both areas were sown to watermelon nitrogen experiment on 15 May 1997 (see 5.1.3).

Results and Discussion

The sorghum is clearly ahead, in terms of biomass, if all crops were to be ploughed-in around mid-February (Table 1). However, because the cowpea does not need to be ploughed into moist soil with sufficient rain to help it rot down (a problem with the sorghum), and because it does not set seed early (a problem with the mungbean) it can be left to grow until May. Because of this, the actual biomass added to the soil per year from the cowpea, starts to approach the levels normally added by grass green manure crops.

Table 1. Biomass production of cowpea, mungbean and sorghum at different dates

Sample Date	Days after Sowing	Above ground biomass (t/ha)		
		Sorghum	Cowpea	Mungbean
28-Feb.	79	8.65	2.55	2.47
8-May	148	N.A.	6.49	N.A.

The cowpea mulch presented considerable difficulties in terms of direct drilling, due mainly to the long spreading 'rope-like' stems that fouled the planting equipment. Whilst machinery modifications may help to overcome this problem, there may also be a need to identify legumes that can be more readily cut by coulter wheels.

Results for the response of watermelons to the two different production systems will be presented next season.

5.1.6 BAMBOO RESEARCH

K Blackburn and M Traynor

The bamboo research project is partially funded by RIRDC and is an Australian joint research investigation combining inputs from:

- The University of Central Queensland, Rockhampton (Principal Organisation).
- Bamboo Australia, Belli Park, Eumundi, Queensland (Commercial grower).
- QDPI, Bundaberg Research Station.
- DPIF and CPHRF

The objectives of the project, which was approved and funded in August 1994, are:

- To identify suitable species for the production of bamboo shoots under Top End conditions.
- To gain expertise in the cultivation of selected species and to develop cultural practices such as irrigation and fertiliser scheduling for optimum shoot production.
- To release trial quantities of fresh product to assess its market potential.
- To collate and extend information on species performance.

There is, effectively, no production of bamboo shoots within Australia. Canned bamboo shoots are currently imported from southeast Asia, with a retail price between \$3.00 and \$6.00 per kg and an estimated Australian consumption of 1, 357, 000 kg (value \$6 M) per annum. A potential export market exists for fresh shoots into Asian markets, particularly Japan, where they represent the largest category of imported fresh vegetables into the country (44 - 85, 000 tonnes pa.).

Methods and Materials

The two project officers visited Belli Bamboo Farm in November 1994 to attend the first RIRDC meeting on the project, as well as attending a Bamboo Workshop conducted by the grower participant, Mr Durnford Dart. A visit was made to Bundaberg Research Station to discuss the cooperative project with researchers and to inspect the bamboo collection. On the return trip to Eumundi, a visit was made to Rollo Campbell's Tiaro Bamboo Nursery and varietal collection. The RIRDC meeting was attended by John Leonardi of UCQ, Peter Bindon of the Australian Bamboo Network (Perth), Mr Dart and the NT officers. The RIRDC project was discussed at length and much valuable information was collected to support the NT part of the project. The most suitable bamboo species was selected and arrangements were made to have the plants prepared and grown on for shipment to Darwin early in 1995 for trial establishment.

RIRDC/DPIF Bamboo Trial: This trial was planted on 24 February 1995, with plants shipped by Mr Dart. The bare-rooted plants were planted directly into the field under heavy monsoon conditions and to date, no losses have occurred. The bamboo variety, *Bambusa oldhamii*, was chosen for the trial as it was less expensive than the two other preferred species *Dendrocalamus asper* and *D. latiflorus*.

The trial design is a 3x3x3 factorial arrangement with a split plot design

- 3 Irrigation Levels - 40, 60, 80% evaporation replacement
- 3 Fertiliser treatments - to be implemented at about 18-24 months from planting to allow the plants to establish
- 3 Replications.

Results and Discussion

During 1996, the trial plants made excellent growth with the culm diameters gradually increasing as the rhizomes matured. The thinning operation in April 1996 removed about ten to twelve culms per clump, leaving approximately three to four mature and six to eight new culms for growing on. There was a mass of lateral branches in each clump which seems to be typical of *B. Oldhamii* and makes thinning a labour

intensive operation. In contrast, *D. Latiflorus* has much less branch development which makes thinning an easier management activity. *D. Latiflores*, after two years growth is impressive and is one of the best performers in terms of growth and short size. Bamboo leaf and soil samples were collected and analysed in mid 1996 to check against nutrient leaf standards set for a similar species, sugar cane. It was found that the general nutrient levels were quite adequate and the current maintenance fertiliser program was maintained.

It is anticipated that the treatments will be imposed on the trial in mid-1997, after the plants have recovered from thinning, and when it is considered that the rhizomes are advanced enough in development to handle the trial treatments.

The current RIRDC project was programmed to terminate at the end of June 1997, but recent information received from the UCQ, Rockhampton, confirms that there is a very good chance that the project will be extended for a further 3 years.

Data collection will include:

- Number of shoots produced, size and height
- Diameter of culms at the seventh node above ground
- Leaf and soil analyses at regular intervals
- Soil moisture tensiometer and Environscan monitoring
- Phenology of shoot production in relation to treatments and to local conditions

Variety collection: An older collection of bamboo (12 species) gathered from around the Darwin area is now three years old but has only been managed well for the past two years.

A new collection of bamboos (19 species) which include edible, timber, windbreak and ornamental types was purchased mainly with DPIF funds. This collection includes seven plants each of *D. asper* and *D. latiflorus*, which are two of the preferred three species for edible shoot production.

5.1.7 *THRIPS PALMI* KARNY (THYSANOPTERA:THRIPIDAE) INTEGRATED PEST MANAGEMENT ON EGGPLANT

G Young and L Zhang

The objective of this project is to gain control of *Thrips palmi* on eggplant.

Thrips palmi has proved resistant to a wide range of pesticides. Bioassays using potassium soaps showed a high level of activity against the nymphs and adults of *Thrips palmi*.

Results and Discussion

Three applications of potassium soap at weekly intervals reduced the number of *Thrips palmi* nymphs from over 200 per leaf to 2 per leaf. The control rows remained at greater than 200 nymphs per leaf.

A study of the population dynamics of *Thrips palmi* on eggplant at Knuckey's Lagoon showed that populations started to increase in late June and early July. The populations remained high until January when numbers suddenly decreased and remained low for the rest of the wet season. The reason for the decline in numbers over the wet is thought to be high pupal mortality in damp soil. When populations of *Thrips palmi* on eggplant were suppressed with three applications of potassium soap, the pest's predators were able to keep it under control. Predators of *Thrips palmi* recorded from the Knuckey's Lagoon property were Chrysopidae sp.; the mirid, *Deraeocoris* sp.; *Haplothrips* sp.

5.1.8 MONITORING POINSETTIA WHITEFLY, *BEMISIA TABACI* TYPE-B IN PROTECTED CULTIVATION

G Young and L Zhang

The purpose of this project is to monitor the population dynamics of the whitefly and record any natural enemies.

Bemisia tabaci type B was first recorded from the Northern Territory during October 1994. From the insect's pest status overseas, it was predicted that it would become a serious pest in the top end.

Method

Ten potted rockmelon plants were exposed for five or six days each month from July 1996 to December 1996 in a nursery infested with whitefly. Overlapping melon crops at Berry Springs were monitored at monthly intervals from June to September 1996. One hundred plants being sampled on each occasion.

Results

Numbers of whitefly peaked during September. During the two years of the study the lowest numbers were recorded during the period January to April and numbers peaked during September/October and May. October and May were the only months when the whitefly was recovered from cucurbit crops in the field. Natural enemies recorded were: the fungus, *Verticillium lecani*, the nymphal parasitoids, *Eretmocerus* sp. (Hymenoptera: Aphelinidae), a another species of ? Aphelinidae and Signiphoridae sp. While *B. tabaci* type B is a minor pest of protected cultivation in the Darwin area, there is no evidence to suggest that the whitefly is likely to become a pest of broadacre crops in the top end. In nurseries the main host plants are mainly ornamentals of neotropical origin, such as *Duranta* sp., *Euphorbia* spp., and some *Hibiscus* hybrids.

5.1.9 ROOT KNOT NEMATODE, *MELOIDOGYNE* spp.

G Young, L Zhang and E Crowson

This project was undertaken to control *Meloidogyne* spp. by planting a completely resistant cover crop over the wet season.

Meloidogyne spp. is apparently endemic in virgin soils around Darwin. After several crops of snake bean or cucurbits, populations of *Meloidogyne* spp. build up to the point where it is no longer possible to grow either of these crops. The problem is more severe on the better soils containing some clay.

Methods

A property in Humpty Doo has been selected for a trial in cultural control. The soil in the area concerned has a history of nematode infestation. Soil samples will be taken in early October 1997 to estimate the populations of *Meloidogyne*. The soil will be ploughed with a chisel plough, as soon as there is sufficient soil moisture, probably during October 1997. During December, "Jumbo Hybrid" forage sorghum will be sown. Jumbo hybrid is completely resistant to *Meloidogyne* spp. The object is to deny the nematodes a host over the wet season. The crop will be slashed before flowering and eventually ploughed in during late March. A second estimate of *Meloidogyne* populations will be made in early April.

Results

Some useful results were obtained from last years experiments, but there was no indication as to whether to the forage sorghum method of nematode suppression would work in the top end environment. Pre-planting counts of nematodes were made on two of the three properties during October 1996. Sorghum was planted on one of the properties but the seed was washed out by heavy rain. The major problem with these experiments was the dis-interest shown by two of the three cooperators.

5.1.10 PARASITES OF THE COWPEA APHID AND THE MELON APHID

G Young and L Zhang

This project was undertaken to survey the parasites of the cowpea aphid, *Aphis craccivora* Koch (Hemiptera: Aphididae) and the melon aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae).

The cowpea aphid is a serious, if intermittent pest, of snake beans and some pasture legumes. The melon aphid attacks a wide range of cultivated plant including cucurbits. With the melon aphid, virus transmission may be far more important than direct damage to crops. In southern Australia, both cowpea and melon aphid are attacked by a parasitoid, *Aphidius colemani* (Hymenoptera: Braconidae) which appears to have been an accidental introduction from Asia Minor or India. Recently, *A. colemani* from Canberra was successfully introduced into Tonga, where the parasitoid established on *A. gossypii*.

The cowpea aphid is easily controlled with pirimicarb, a specific aphicide which does not harm other insects and is a component of integrated pest management. The melon aphid has shown widespread resistance to insecticides in other parts of Australia, but the level of resistance in the NT is unknown. If introductions of natural enemies are to be considered in the future as an alternative to chemical control, then it will be necessary to have some data on the natural enemies already present in the NT.

Results

Several species of parasitoid have been recovered from melon aphid, while no parasitoids were recovered from cowpea aphid. One parasitoid reared from melon aphid was identified as *Aphelinus gossypii*, known to be polyphagous parasitoid. Predators recorded feeding on melon aphid were; a lacewing, Chrysopidae sp. and the mirid *Deraeocoris* sp. A shipment of aphid mummies containing parasitoids was received from C.S.I.R.O. in December 1996, but none of the parasitoids reared were *A. colemani*. Most of the available evidence would suggest that *A. colemani* prefers a cooler climate than the top end.

5.1.11 PRODUCE INSPECTION AND CERTIFICATION SERVICE

E Crowson

This service provides an inspection and certification service to growers of annual vegetables, cutflowers and ornamental plants to enable produce to be marketed interstate.

In 1991, NT producers and exporters of annual vegetables, cutflowers and ornamental plants suffered very considerably due to the detection of Melon Thrips (*Thrips palmi* Karny (Thysanoptera : Thripidae) on Top End properties. All interstate markets severely restricted access of NT produce until negotiations with interstate quarantine authorities allowed access under declared area freedom or property freedom status. Over the next few years, the situation eased with other interstate growing areas infested by the pest and the development of disinfestation techniques acceptable for quarantine security. The current situation is that producers exporting to WA, SA and Tasmania require certification of *T. palmi* freedom for each shipment of produce. This entails visual inspection following physical disinfestation on produce grown in infested areas or maintenance of a trapping program for declaration of area freedom.

In addition, the Entomology Branch maintains a trapping grid for declaration of freedom from Poinsettia Whitefly (*Bemisia tabaci* (Gennadius) Homoptera : Aleyrodidae biotype B) and surveillance for Western Flower Thrips (*Frankliniella occidentalis* Pergande Thysanoptera : Thripidae).

Results

More than 630 shipments were provided with inspection certificates against melon thrips and some Northern Territory growing areas were regularly monitored to allow certification through area freedom declarations.

5.1.12 ARTHROPOD IDENTIFICATION AND CONTROL SERVICE

D Chin, E S Smith and H Brown

This service provides accurate advice on identification and control of agricultural and domestic arthropods to producers, government personnel, pest control operators and the general public.

The Branch has provided an advisory service on entomological matters pertaining to agricultural or domestic situations for many years. Over the past few years, the demand for this service has increased dramatically as the number of horticultural producers has increased and fruit trees in suburban gardens mature.

Results

The nature of the enquiry and the recommendation provided are recorded and enquiries entered into a data base. The information recorded may be used for future planning and allocation of research.

During the 1996-1997 period, the Branch received over 1400 enquiries. The proportion of the various client group categories (and the change during the past 12 months) are summarised as follows:

Government:	45.0 %	(+3.9 %)
Primary producers:	21.2 %	(-1.5 %)
Householders:	17.3 %	(-5.0 %)
Pest control operators:	1.5 %	(-1.1 %)
Others:	14.7 %	(+3.7 %)

Most of the extension enquiries were associated with services provided on insect identifications and pest control for primary producers and to other officers of the Department. A large majority of the enquiries were based on pests of mangoes (commercial and backyard), mixed vegetables and ornamentals (especially palms).

The main investigations on mangoes were associated with termites, redbanded thrips, flower caterpillars, fruit flies and mango seed weevils.

The practices incorporated into Integrated Pest Management systems were encouraged and promoted through trials on fruit and vegetable growing properties. A series of displays were set up in the Department and at the rural shows in addition, lengthy discussions were carried out with growers.

Diagnostic identifications were provided to all outstations of the Department and extension visits were carried out at CPHRF, KRS and DDRS to cover enquiries on fruit, vegetables and crops.

5.1.13 BIOLOGICAL CONTROL OF PALM LEAF BEETLE IN COCONUT PALMS AND RE-INTRODUCTION OF A BIOLOGICAL CONTROL AGENT IN THE DARWIN AREA

D Chin and H Brown

The purpose of this project is to determine the level of infestation of *Brontispa longissima* (Gestro) (Coleoptera: Chrysomelidae) in coconut palms before and after the release of the biological control agent; *Tetrastichus brontispae* (Ferriere) (Hymenoptera: Eulophidae).

Coconut palms in the Darwin area are subjected to heavy infestations of palm leaf beetles (PLB). The Darwin City Council has planted coconut palms extensively as amenity trees along the foreshores throughout the Darwin area. Coconut palms are commonly planted in private gardens as they are attractive palms and are fast growing. Commercially, coconuts are grown as a fruit crop as well as an ornamental in nurseries in the Top End.

Palm leaf beetle is currently controlled with repeated spray applications of carbaryl which is applied to the unopened frond. On very tall coconut palms, the new frond is too high to reach easily and is therefore difficult to spray. Chemical spraying will not eradicate the pest and continual insecticide application is necessary for good control. The use of chemical spraying is expensive, time consuming and harmful to both the environment and the operator.

To reduce the usage of chemical sprays and to control palm leaf beetles in tall coconuts, a biological control agent was introduced. This biological control agent, *Tetrastichus brontispae* (Ferriere), is a very small wasp that is harmless to humans but is effective as a parasitoid of palm leaf beetles. *T. brontispae* parasitises PLBs by laying eggs into the late instar larvae or early pupae. The eulophid eggs hatch and develop into larvae which feed and pupate inside the beetle pupae and then emerge as adult wasps.

T. brontispae was first introduced into Darwin and Palmerston in 1982 and survived for about five years. In 1994, the Entomology Branch of DPIF re-introduced the parasitoid as field releases into selected Darwin City Council sites along the Darwin foreshores.

Study Sites

A total of seven sites were selected from the coconut tree plantings in Darwin City Council amenities sites (Table 1). These areas included picnic sites, street plantings, experimental plantings and parks. Most of the sites were situated close to the foreshore.

Table 1. Study sites selected for monitoring the PLB infestation levels.

Site No.	Location
1	Cullen Bay
2	Mindil Beach
3	East Point Reserve
4	Coconut Grove
5	Nightcliff West
6	Nightcliff East
7	near Nightcliff Pool

Methods

The eulophid wasp *Tetrastichus brontispae* was reared in mass numbers in the laboratory and released at selected sites of coconut palms along the Darwin foreshores. *T. brontispae* was re-introduced to Australia and the NT and reared in mass numbers in the laboratory and released at selected sites in Darwin, commencing in October 1994. The release sites included: site 1, Cullen Bay; 2, Mindil Beach; 4, Coconut Grove; 6, Nightcliff East and 7, near Nightcliff Pool. An extra release site was established at Berrimah Research Farm. *T. brontispae* was not released at East Point Reserve (site 3) and Nightcliff West (site 5) and these two sites were used as control sites to show the effect of PLB on coconut palms in the absence of *T. brontispae*. Monitoring in most of the sites commenced 12 months prior to the introduction of the parasitoid (ie about March 1993). The sites were monitored and scored at intervals of six to eight weeks pre and post release of the parasitoid. At each site, 12 coconut palms were selected randomly for assessment. The infestation rate of the palm leaf beetles in coconut palms was assessed by scoring the % damage of the first opened leaf frond. (A new leaf spear is produced approximately every 6-8 weeks).

Releases of *T. brontispae* at the selected field sites were carried out at intervals of 1-3 weeks. (Releases were made every week, alternating between sites from week to week.) At the time of release, observations were made on the population numbers of PLB in the new leaf spear of the coconuts. The sites were assessed and monitored every 6 weeks, or at intervals when there was new shoot growth.

Results

Monitoring of PLB damage levels

Comparison of the palm leaf beetle population in the field pre and post release of the parasitoid

The PLB damage levels of the palms were assessed from March 1993 to March 1997 (4 years) at approximately 6-8 weekly intervals (Figure 1 and Table 2). The information in Figure 1 and Table 2 was compiled by calculating the mean score damage of 12 coconut palms from each site for each period and show the change in the PLB infestation rate pre and post introduction of the parasitoid.

Release sites

There was a 20% decrease in the level of damage at three of the release sites, Cullen Bay, Mindil Beach and Nightcliff East. Unfortunately, site 4 did not have a damage assessment before release, however, it was estimated from observations to be about 60%. At the site near Nightcliff Pool, the PLB damage level pre-release remained the same as post-release.

Non-release sites

In the sites that have not had a release of *T. brontispae*, (site 3, East Point and site 5, Nightcliff West, the damage levels fluctuated from 0-60% at site 3 and 1-80% at site 5.

A comparison of PLB damage levels pre-release and post release is shown in Figure 1.

Effectiveness of parasitoid establishment (success of recapture)

Over 13 000 adult *T. brontispae* were released in the selected sites between October 1994 and April 1996. At six to eight weekly intervals, coconut palms at the sites were inspected for parasitised PLB pupae. Samples of pupae (healthy and parasitised) were collected and reared in the laboratory. Between January 1996 and March 1997, eulophid infested PLB pupae were recaptured from all of the release sites.

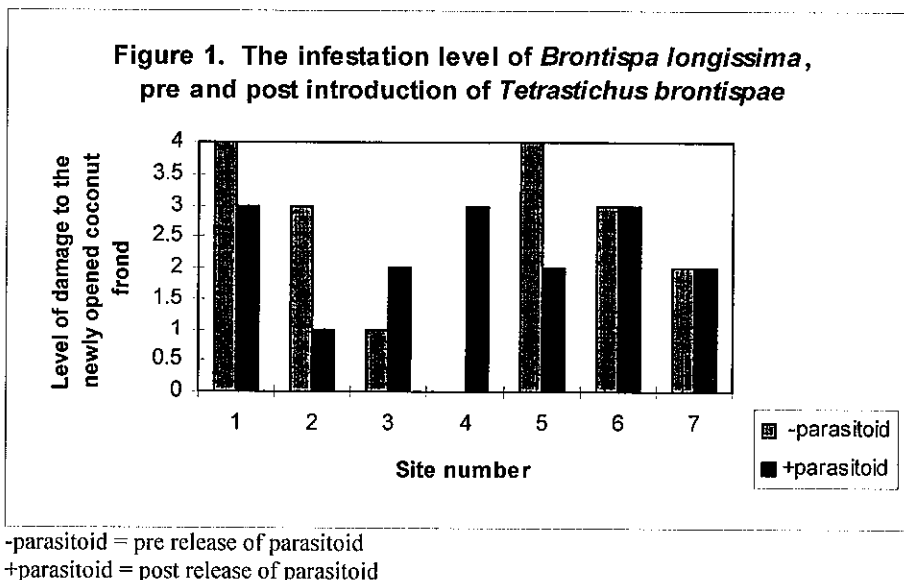


Table 2. Summary of the change in PLB damage to coconut palms at the study sites since the release of the eulophid parasitoid.

Site No.	Level of PLB Infestation			
	Pre-parasitoid release	Post parasitoid release	Parasitoids released (Yes/ No)	Change in PLB infestation level since the release of the parasitoid
1	4	3	Yes	decreased 20%
2	3	2	Yes	decreased 20%
3	1	2	No	increased 20%
4	-	3	Yes	-
5	4	2	No	decreased 40%
6	3	2	Yes	decreased 20%
7	2	2	Yes	no change

If *T. brontispae* survives over the 1997 dry season it may have adapted to the Top End climatic conditions. It is not known how long the parasitoid will be able to sustain its

populations in the released sites. When *T. brontispae* was released in Darwin and Palmerston in the 1980s, it died out after five years, presumably because the strain was not adapted to the dry season.

Conclusion

The biological control of *B. longissima* with *T. brontispae* has been more effective than using chemicals. *T. brontispae* has established in all five monitoring sites in the Darwin area and has reduced the PLB damage by up to 40%. The parasitoid will have a greater chance of survival, in areas that have overhead irrigation throughout the dry season. A second parasitoid such as the larval parasitoid, *Asecodes* sp, released in areas with *T. brontispae* may be more effective in controlling *B. longissima* over a longer term.

5.1.14 ARTHROPOD REFERENCE COLLECTION

H Brown, D Chin and E S Smith

The purpose of this project is to develop, curate and maintain a reference collection of economically important arthropods of the various NT agricultural industries and to develop and maintain a suitable, retrievable data base of all specimens held in the collection.

The insect reference collection was initiated in 1970 and rapidly became the main Insect Reference Collection in the NT. Over the years, the collection expanded to include economically important arthropods from agricultural and domestic situations as well as general collections. In 1992, the majority of the non-economic insect specimens were donated to the NT Museum.

Results

During 1996/97 the Branch forwarded 219 specimens for species confirmation or identification. Most specimens were of economic significance.

The majority of the specimens in the collection have been sorted and some updated with name changes. Computerisation of the museum specimens onto the network (ACCESS Database) is continuing. At this stage over 12000 specimens have been recorded on the database, which is about 55% of the entire collection.

New Records and Specimens of Interest

Thysanoptera: Thripidae

- *Chaetanaphothrips signipennis* (Bagnall) ex *Anthurium* sp. and flower bell of *Musa* sp.
- *Thrips hawaiiensis* Morgan ex *Mangifera indica* inflorescence (Kensington Pride and Irwin)
- *Frankliniella schultzei* Trybom collected from *Citrus grandis* flowers
- *Selenothrips rubrocinctus* (Giard) was recorded feeding on the fruit of *Nephelium lappaceum*
- *Dichromothrips corbetti* (Priesner) causing damage to “vanda” orchid flowers.

Acarina

- *Tyrophagus palmarum* Oudemans (Acarina: Acaridae) on calyx of mangosteen fruit. This species is often found feeding on mould and detritus and is common around all types of stored products
- Damage on badly scarred mangosteen fruit forwarded for examination appeared to have been caused by mites during the dry season. The mites causing the damage were no longer present but oribatid mites (fungus feeders) were collected and identified as Brachypylina: Poronota: Oripodoidea.

Hemiptera

- *Aphis gossypii* Glover (Aphididae) has been confirmed from *Mangifera indica* (new flush leaves) and *Gossypium hirsutum* leaves. Both samples were collected from the Katherine region
- *Aonidiella orientalis* (Newstead) (Diaspididae) ex leaves of *Dendrobium rigidum*
- *Coccus hesperidum* Linnaeus (Coccidae) ex *Mangifera indica* seedling leaf (Glenn var.)
- *Maconellicoccus hirsutus* (Green) (Pseudococcidae) ex asparagus plant stems
- *Pinnaspis strachani* (Cooley) (Diaspididae) ex asparagus plant stems
- *Aonidiella orientalis* (Newstead) (Diaspididae) ex *Solanum melongena* stem
- *Parasaissetia nigra* (Nietner) (Coccidae) ex asparagus stems.

Coleoptera

- Coccinellidae beetles swarming and aggregating in mango trees were identified as *Aphthona* spp. (Chrysomelidae).

Diptera

- Larvae of the predatory fly *Leucopis formosana* Hennig (Chamaemyiidae) which were feeding on *Aphis gossypii* Glover (Hemiptera: Aphididae), were collected from mango leaves in Katherine.

5.1.15 BEANFLY, OPHIOMYIA PHASEOLI (TRYON) (DIPTERA : AGROMYZIDAE)

G Young and L Zhang

The objectives of this project are to:

- (a) To identify the wild and cultivated host plants of beanfly.
- (b) To identify the parasites of beanfly.
- (c) To investigate methods of control of beanfly in snake bean crops.

Bean seedlings must be sprayed twice with dimethoate in the week after emergence. Failure to spray can result in high mortality of the seedlings. Data from East Africa and India suggest that a reasonable level of control is exerted by the parasitoid *Opius phaseoli* Fischer (Hymenoptera: Braconidae). Before any consideration can be given to importing an exotic parasitoid such as *O. phaseoli*, a thorough survey of the indigenous parasitoids needs to be carried out.

Nothing is known of the wild host range of beanfly in the Northern Territory.

Results

Spray trials to find an alternative to dimethoate were inconclusive. The formulation trialled was imidacloprid flowable, applied as a seed dressing. The formulation proved difficult to handle and it is unlikely to find commercial use in its present form.

A range of parasitoids have been reared from beanfly puparia, none of the parasitoids belonged to the genus *Opius*. The parasitoids reared from beanfly puparia collected on snake beans were; Pteromalidae sp? and Tetracampidae sp?, while those from puparia collected on phasey bean were; *Eurytoma* sp? and Pteromalidae sp?.

Cultivated host plants of beanfly identified were snake bean, *Vigna unguiculata* and phasey bean, *Macroptilium lathyroides*.

Wild hosts of beanfly are *Vigna radiata*, beanfly oviposited and completed its life history, *Vigna vexillata*, beanfly freely oviposited and fed on the oviposition punctures, but was unable to complete its life history. Both species of *Vigna* are indigenous to the Top End.

5.1.16 INTEGRATED PEST MANAGEMENT OF VEGETABLES WITH PARTICULAR REFERENCE TO SNAKE BEAN (*VIGNA UNGUICULATA*)

G Young and L Zhang

This project was undertaken to control two spotted mite and other bean pests by means of natural enemies and safe pesticides.

Two spotted mite (TSM), *Tetranychus urticae* Koch (Acarina: Tetranychidae) is the most serious pest of snake beans in the Darwin area usually limiting the productive life of the crop to less than 6 weeks. Two spotted mite is resistant to a greater or lesser extent to all of the available miticides.

A non chemical method of controlling two spotted mite is by the use of the Chilean predatory mite, *Phytoseiulus persimilis*, Athias-Henriot (Acarina: Phytoseiidae). The predatory is reared commercially in NSW and Queensland. When TSM appears on the crop predatory mites are released and the population of predators brings the TSM population under control.

Leaf feeders can be adequately controlled with either carbaryl, to which *P. persimilis* is resistant, or *Bacillus thuringiensis*.

The cowpea aphid can be controlled with pirimicarb which is only active against aphids.

Results

P. persimilis brought two spotted mite under control within three weeks of introduction to the crop, extending the productive life of the crop for up to five weeks

longer than normal. Two percent petroleum spray oil or the miticides fenbutatin oxide and propargite were used to retard the rate of increase of TSM and allow the predator populations to catch up with the prey. All of these substances are relatively non toxic to the predatory mite. Predators of two spotted mite recorded were; mites belonging to the families, Phytoseiidae, Cunaxidae and Chaetodactylidae?; *Scolothrips ?sexamaculatus* (Pergande) (Thysanoptera: Thripidae); *Feltiella acarivora* (Zehntner) (Diptera: Cecidomyiidae).

5.1.17 MANAGEMENT AND CONTROL OF *MASTOTERMES* IN NORTHERN AUSTRALIA

L Miller(CSIRO), M Neale and M Hoschke (CSIRO)

The purpose of this project was to develop effective control methods against *Mastotermes darwiniensis* in horticultural crops that are environmentally sustainable and can be applied by growers or other persons non-expert in termite biology and control. Studies of the biology of the species are being carried out in conjunction with development and testing of control methods so that their effectiveness can be fully assessed.

Mastotermes darwiniensis Froggatt (Isoptera: Mastotermitidae) is the most destructive species of termite in tropical Australia. In Northern Australia this species accounts for about one million dollars in annual production losses within horticultural tree crops and also is responsible for losses in vegetable and agricultural crops. *Mastotermes* can cause major damage to buildings, wooden structures, electrical cables and a variety of other materials. The main chemical registered for use in horticulture against this pest is an organochlorine. With organochlorines being phased out it is necessary that other alternatives be developed.

Methods

A series of plots designed to monitor *Mastotermes* activity on a seasonal basis were established and monitored at regular intervals.

The data gathered show that there is a complex pattern of relationships between *Mastotermes* and other termite species, and between termite activity and temperature/rainfall, but that different termites respond to different environmental factors.

Selected plots are being treated with a variety of bait formulations and monitoring of activity will continue until October.

Suitable aggregation techniques have been developed to deliver the current bait substrate (see below) in large quantities to *Mastotermes* colonies. Preliminary trials with various baits have shown that, although termite activity can be reduced using alternative toxins, quantity of bait delivered is critical.

A bait substrate has been developed which appears to overcome repellency associated with otherwise promising bait toxins. Testing of toxins has been largely confined to

those proposed by various chemical companies as suitable for social insect control, but a major restraint has been the availability of such experimental chemicals. In summary, a suitable bait substrate and delivery system has been developed, but as yet there is no commercially-available toxin to replace the currently-used organochlorine Mirex.

Results

Plots have been established in uncleared areas and have been assessed every six weeks over the last two years.

Mastotermes darwiniensis

Gunn Point 1-2 5m x 5m 192 stakes and 225 stakes

Gunn Point 3-7 1m x 1m 121 stakes

Wildman River 1-4 5m x 5m 121 stakes

There are also 4 *Coptotermes acinaciformis* Froggatt (Isoptera: Rhinotermitidae) plots 1m x 1m 121 stakes at Gunn Point

Data collected from these plots is essential in assessing new control methods.

Laboratory and field experiments are in progress to gather information on the biology of the insect eg. colony size, distribution, foraging territory and behaviour. Such information forms the basis for assessment of the effectiveness of new control methods. For example, there have been claims that termites do not generally forage deeper than about 30cm, so that a vertical physical barrier will prevent attack. In an experiment to test this theory field studies showed that a barrier to more than twice that depth (70cm) may be passed.

Different bait substrates have been tested extensively in the laboratory and in field trials with promising results.

New chemicals have been tested over the past two years with some good results. Several of these are currently being tested more intensively in laboratory and field trials.

5.1.18 ASIAN VEGETABLE GROWER GROUP

S Greenwell

March 1997 saw the formation of the Asian Vegetable growers group. Two members were elected to represent the group at NTHA council meetings.

The group was formed essentially to coordinate the industry's development. Primary concerns of the group include:

- Pest and disease management
- Establishing export markets
- Establishing quarantine requirements for interstate transfer of produce
- Fire service complaints
- Local promotion of Asian vegetables

5.2.2 PRODUCTIVITY RESPONSES OF ASPARAGUS TO DROUGHTING IN A TROPICAL ENVIRONMENT

J Bright, S Martin, M Smith, S McAlister, G Foord, M Hoult and Y Diczbalis.

Asparagus (*Asparagus officinalis* L.) has traditionally been grown in temperate climates where cool winter temperatures cause plant dormancy. Asparagus spears are picked as these plants emerge from their dormancy period in spring. Dormancy by the cessation of irrigation prior to harvest is used, where possible, in tropical areas. The effects of such droughting are, in some cases, believed to be detrimental to the plant, both in production and health. This project will quantify production results in response to droughting in terms of spear quantity and quality.

Methods and Methods

In 1994, asparagus plants (120) were transplanted into 200 L lysimeters with various droughting treatments being imposed on different plants to examine the effects on crop production. A total of 20 treatments were developed, using a combination of four droughting intensities and five droughting durations.

Treatments were as follows:-

Moisture Stress (kPa):	10	50	100	dry	
Droughting Duration (days):	0	10	20	40	80

The treatments were arranged in a 4 * 5 randomised factorial treatment design (total 20 treatments) with six replications. Once the fern had been removed (17 July 1995) the crop was watered to maintain a matric potential at 40 mm depth of 10-20 kPa. Emerging spears were then harvested for approximately one week before allowing the fern to regenerate. Harvested spears were categorised into first, second, and reject classes, and then weighed and counted for each plot.

Each lysimeter was weighed at field capacity (ie. complete saturation followed by 12 hours drainage overnight). Once the water was cut off and the desired tension reached, the drums were reweighed and the difference in weight added as water (for example, a 50 kPa lysimeter weighed 369 kg at field capacity and then 350 kg when tension was 50 kPa, therefore, 19 L of water needed to be added to the drum).

The field experiment involved the examination of five different droughting durations, namely 80, 40, 20, 10 and 0 days without irrigation, prior to harvest. Plot sizes were 4 m with 1.5 m guards at either end. Plots were guarded on all sides. At the time of each irrigation cut off, a 13 mm tube (blank) replaced the drip-tape for the 7 m of the plot.

Monitoring of water availability was by neutron probes, in the field trial, and EnviroScan®, in the lysimeter trial. Gravimetric determinations were made to a depth of 2 m in all plots at the cessation of droughting treatments. At slashing (using hand shears), fern was collected for biomass determination for each plot.

Harvesting commenced on 12 June 1995 and lasted for 14 days. Harvesting for 1996 commenced on 28 June and lasted for one month.

Results and Discussion

Results from the 1995 harvest show that, at the extreme droughting lengths there is a greater proportion of reject spears. High reject spear production was evident in both the field trial and the lysimeter trial (Figures 1 and 2).

In the lysimeter trial, drought duration significantly affected the quantity and quality of spears. Plants in the 50 kPa treatment took between four to five days to reach this tension, while those in the 100 kPa treatment required watering every six to eight days.

Different soil tensions had an effect on the production of different grade spears ($p=0.05$). Figure 2 shows a high yield of first and second grade spears produced in the field trial. The increased weight of reject spears in the 40 and 80 day treatments should also be noted. The main reason for rejecting spears in the lysimeter trial was due to flowering, while in the field trial, the predominant reason was the spears being too thin.

During harvest of the lysimeter trial in 1996, it became obvious that the crop required harvesting twice a day. Spears that were too short in the morning, flowered and became rejects by the next day.

1996 results were similar to 1995 trends (Figure 3). Droughting duration appears to have an effect on the number and quality of spears produced. In both years, increasing drought duration resulted in a decrease in the amount of first grade spears produced. The amount of first grade spears is also low where there is no water cut off.

Root samples taken in the field trial show that the plant is capable of extending roots below 3 m in depth. However the bulk of the roots are found between 20 and 40 cm depth.

The 1995 results suggest that a drought duration, prior to slashing and harvesting, of ten to 20 days will result in higher marketable yields than longer, more extreme drought durations. This is also the case for the no drought situation i.e. better yields are achieved from the ten and 20 day drought duration than from the 0 drought duration.

The field trial was not harvested in 1996 due to an outbreak of *Colletotricum sp.* It was decided that it would be better to leave this planting to regenerate for a year. The block was slashed in August and the fern burnt. Various techniques are being applied to control the fungus.

The field trial will be harvested in 1998 and 1999 (funds permitting). 1997 will see the final harvest for the lysimeter trial. Findings over the first two years of this project have conflicted with the recommendations of other tropical areas and in light of these findings an extra site may benefit us in understanding the management techniques of irrigation prior to harvest. It is important that we confirm findings from the lysimeter experiment in field plantings. In order to achieve this we must first deal with the fungal problem that currently exists with this crop.

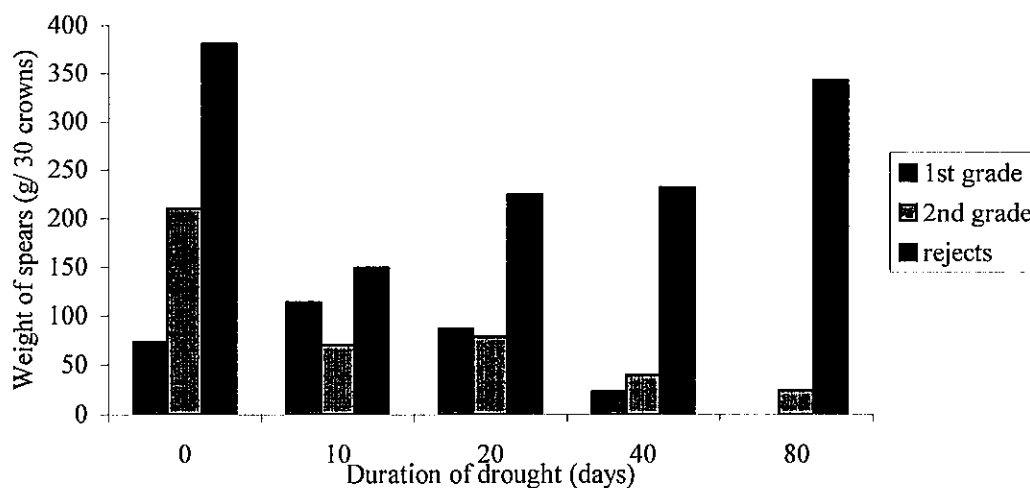


Figure 1. The effect of droughting duration prior to harvest on the yield of different asparagus quality grades 1995 (Lysimeter Experiment).

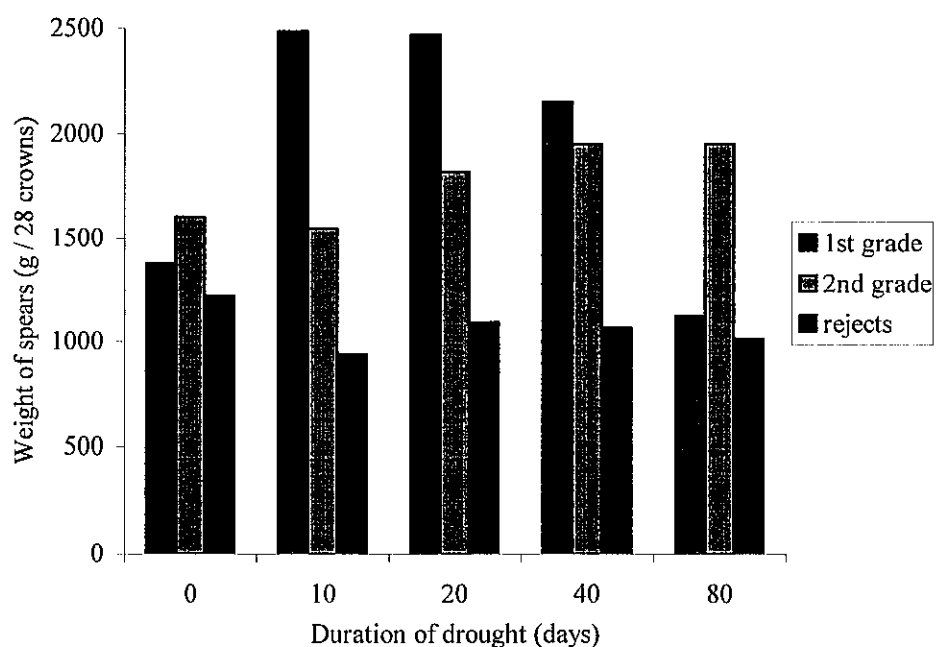


Figure 2. The effect of droughting duration prior to harvest on the yield of different asparagus quality grades 1995 (Field trial).

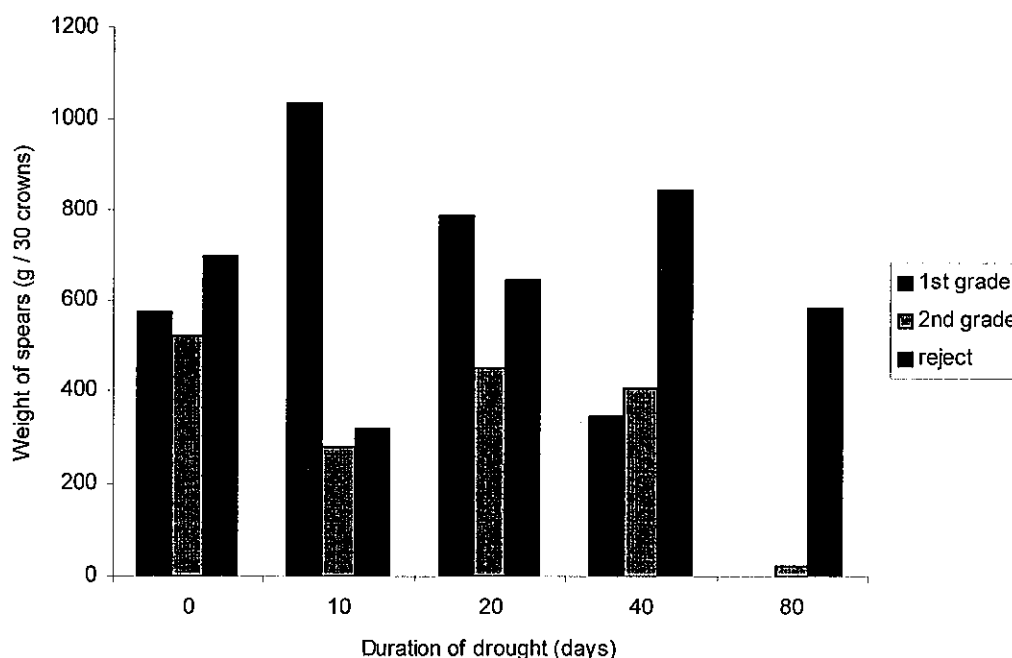


Figure 3. The effect of droughting duration prior to harvest on the yield of different asparagus quality grades 1996 (Lysimeter Experiment).

5.2.3 ASPARAGUS CULTIVAR ASSESSMENT

J Bright

Currently UC157 F₁ is the standard asparagus cultivar grown in northern Australia. The commencement of the Second International Asparagus Cultivar Trial provided an opportunity to obtain a wide selection of genetic material for comparison with UC 157 F₁ at Katherine.

Materials and Methods

Seed of 18 cultivars were sown in June 1997 for evaluation at KRS, including:

UC157F ₁	Andreas	Apollo
Grande	Val Prima	Boonlim
Tainana1	Larac	Cipres
Tainana 2	Venlim	PLA-2232
Tainana 3	PLA-2132	Atlas
JACQ MA 2004	Dariana	JACQ MA 2014

Results and Discussion

Preliminary results will be available in late 1998.

Of particular interest will be the relative susceptibility of the cultivars to the disease *Colletotricum sp.* Should there be any plants showing resistance, it may justify larger plantings of that cultivar.

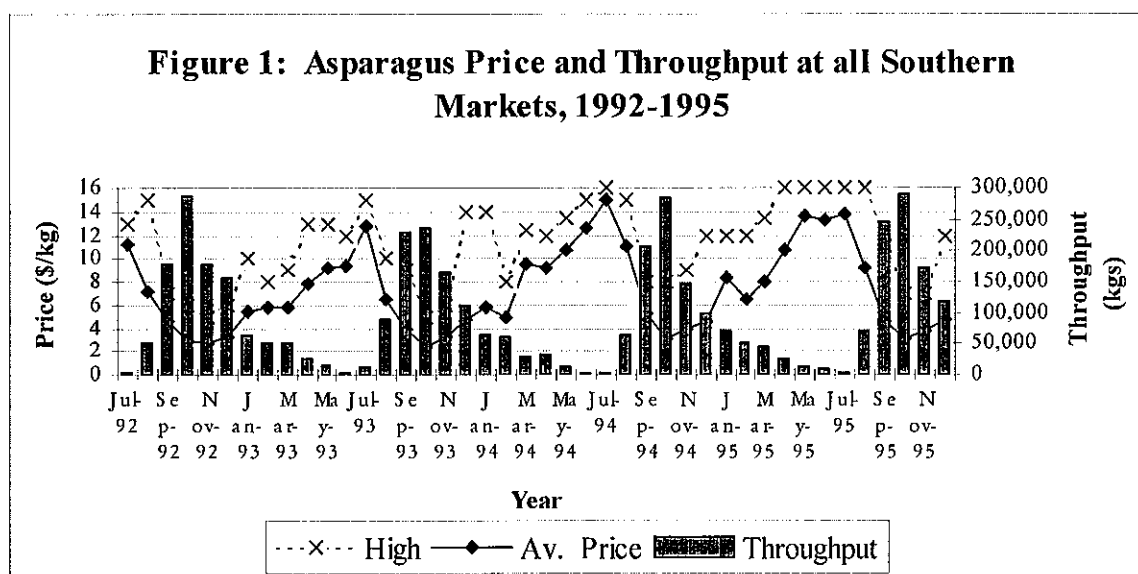
5.2.21 ASPARAGUS COSTS AND RETURNS

ECONOMIC ASSESSMENT OF ASPARAGUS PRODUCTION IN THE KATHERINE REGION

H Ngo

Asparagus (*Asparagus officinalis*) is an erect, perennial plant which can grow up to 4 m in height. Edible asparagus is nutritious, low in fat and carbohydrates and high in protein and some essential vitamins. In the Katherine region, asparagus can be produced out-of-season from May to August and consequently, the price is at its peak (Figure 1). Asparagus produced during that period can also be exported to overseas markets, especially Japan during the high priced period from August and September, when the Japanese harvest season finishes in late June.

This report provides estimates of the profitability of growing asparagus in the Katherine area. It is designed to assist potential growers in making decisions on production planning. Intending growers are urged to carry out their own assessment based on these guidelines.



Results and Discussion

- i) The total investment cost (or highest cumulative cash deficits without borrowing) is around \$460,800 to set up a 6 ha asparagus farm.
- ii) At a medium yield of 7 tonne per ha after year three and at a wholesale price of \$8/kg, the gross margin from year three is around \$31,400 per hectare per year. The average net farm income (income minus total operating expenses including depreciation) for the total 6 ha farm is around \$110,000 per annum from year three onwards. The break-even price is around \$5/kg.
- iii) Assuming no external borrowing, the project has a pay back period of around six and a half years.

- iv) The internal rate of return at the above median yield and price mentioned above is 16.8% in real terms which is equivalent to approximately 21.8% in nominal terms (assuming a long term inflation rate of 5% per annum). This compares very favourably with the current long term Commonwealth Government bond rate of approximately 9% per annum.

As a quick guide, Table 1 below also gives a summary of the internal rates of return of the asparagus project at various prices and yields.

Table 1: Sensitivity Analysis - Internal Rates of Returns (IRR) of 6ha of Asparagus Planting at Various Yields and Prices.

Price (\$/kg)	Yield (tonnes per ha)		
	5	7	9
4	negative	negative	-3.3%
5	-7.2%	-0.6%	5.2%
6	-1.6%	6.0%	12.7%
7	3.5%	11.8%	19.3%
8	8.1%	16.8%	25.0%
9	12.1%	21.3%	30.2%
10	15.8%	25.3%	34.8%

At the medium yield of around 7 tonne/ha and a long-term wholesale southern market price of \$8/kg, the internal rate of return of a 6 ha asparagus farm (without the cost of the owner's residence) is approximately 16%. This rate is roughly equivalent to 21% in nominal terms (assuming a long term inflation rate of 5% p.a.) and appears quite attractive compared with investment returns elsewhere in the current Australian economic climate (eg. ten year Government bond rate of around 8% currently). However, the internal rate of return declines to around 6% (i.e. the project is not considered profitable) if price falls under \$6 per kilo; assuming 7 tonne/ha average yield after year four. The situation could change if a yield of more than 7 tonne/ha can be achieved or if the cost of harvesting can be reduced.

The break-even price is around \$5/kg and the pay back period is around six and a half years (at \$8/kg and 7 tonnes/ha).

In general, the project's profitability could be further improved if:

- a wholesale price of \$8/kg or higher can be achieved,
- yields obtained can be higher than 7 tonnes per ha;
- production costs can be reduced, especially costs related to picking and packing;

Furthermore, if the planted area is larger, the rate of return is expected to be higher due to lower unit costs with better economies of scale.

5.3.1 HELICONIA AND GINGER CULTIVAR ASSESSMENTS

D Nielson, W Clape, J Powell and M Hoult

Cutflower production for the Top End of the NT is estimated at \$2 million annually, of which heliconias and gingers dominate. As the industry develops, there is increasing demand for more profitable and unique cultivars. The unfortunate introduction of *Fusarium oxysporum* f *cubenses* Race 3 has also reduced the number of cultivars available for commercial production due to susceptibility to this pathogen. Consequently, continued species/cultivar introduction and assessment is a priority, as it was in the formative stages of the industry. Suitability for the nursery trade, as well as cutflower production, is also assessed with any new introduction.

Materials and Methods

In most instances a minimum of one or two rhizomes per cultivar and/or species are established at BARC. Assessments are carried out for a minimum of two cropping years, where possible, on total yield, vase-life and overall appearance. The following cultivars were assessed for the reported period: *Heliconia bihai* - Manoa Sunrise; *Etilingera elatior* "Torch ginger" - Arafura, Ironstone, Thai white, Song, Penang and Tropicus light pink; *Etilingera hemispherica* - seedlings; *Costus barbatus* - seedlings; *Costus* sp. ex Thailand 1; *Costus* sp. ex Thailand 2; *Costus woodsiana* - French Kiss; *Zingiber spectabilis* - Lemon, Orange, Common green, Cameroon Highlands and Syzgium; *Zingiber otensii* and *Calathea lutea*.

Results and Discussion

Manoa Sunrise is a very tall, clumping heliconia of 3.5 to 4 m, seasonal from October to March, with large, maroon, green or yellow lipped bracts growing well in full sun. It is showing no outward symptoms of *Fusarium* to date. Of the torch gingers, Arafura, Thai white and Song look promising, due to vase-life and/or yield. Thai white with its good vase-life (10-14 days) will hopefully provide a valuable gene pool for developing hybrids with long vase-life, a lack of which has been a hindrance to the commercial development of torch gingers in the past. *Costus* French Kiss; *Zingiber* Orange, Lemon, Common green and *Zingiber otensii* all showed promise and have been released to industry.

5.3.2 THE EFFECT OF CYTOKININS ON YIELD OF *ALPINIA PURPURATA*

J Powell, P Albano and D Nielson

Alpinia purpurata is a popular cutflower in the tropics with significant production in Florida and Hawaii. Production is increasing in the tropics of Australia, notably far northern Queensland and the Top End of the NT. A small number of promising hybrids with varying shades of light to dark pink colours have been developed by DPIF. While these cultivars have outstanding bract colours, generally the yield has been lower than some of the original parents. Cytokinins have been used to increase the number of sprouting shoots from rhizomes. This study was initiated to see if

production could be increased by increasing the number of shoots and consequently, the number of terminal flowers.

Materials and methods

Rhizomes of the cultivar Darwin Lady were established in the field under 50% shade. The following treatments were applied : Cytolin @ 250 ppm, 500 ppm, 1000 ppm and gibberellic acid (GA₃) @ 500 ppm and 1000 ppm at intervals of one month, two months and four months, respectively, for a 12 month period. Data was collected on yield, stem length, stem calliper and flower size.

Results and Discussion

No treatment increased yield and quality over the control. All growth regulant treatments resulted in distortion of flower bracts and increased shoot height. In the future, selection of high yielding cultivars from breeding programs would be a more sustainable approach to improving the yield and quality of *Alpinia purpurata*.

5.3.3 ORCHID RESEARCH

D Neilson, J Powell, W Clape and M Hoult

Orchid research for the reported period was minimal, with some preliminary cultivar screening of locally available Vanda cultivars for suitability to commercial production.

Materials and Methods

The following cultivars were assessed (number of plants): *Mokara* Sayan yellow (ten), *Aranda* Chark Kuan Pride pink (ten), *Vanda* Merv.L. Velthuis x V. Lilliana (four) and *Mokara* Mak Chin On pink (five). Yield, flower quality and bud-drop data was collected.

Results and Discussion

The best yielding of the Vanda cultivars was *Aranda* Chark Kuan Pride (average of 4.1 flower spikes/plant/year) and *Mokara* Mak Chin On (average of 3 flower spikes/plant/year). Yields were half to a third of commercial levels from overseas. There is a need to source virus-free, high yielding clones of the best commercial cultivars and undertake a more thorough evaluation under Top End conditions.

5.3.5 ORNAMENTAL PLANT INTRODUCTIONS

D Neilson, J Powell and M Hoult

Plant accession and evaluation is an ongoing component of the ornamental program. Several valuable species and/or cultivars have been released to the local industry over the last decade, as cutflower and/or ornamental plants.

Materials and Methods

All overseas accessions go through a rigorous quarantine phase. On release, most material is evaluated at BARC. Any outstanding lines are then released to industry for further evaluation. In most instances, stock plants are held at BARC for a minimum of three years after release to industry.

Results and Discussion

The following species/cultivars are being evaluated: *Zingiber* sp.-Buddah Bud; *Alpinia* sp. -Pendant Pearls; *Zingiber longipendula*; *Zingiber gracile*; *Zingiber graminera*; *Zingiber marodcnia*; *Alpinia* sp. -white cone; *Etlingera* sp.-Sth. Thailand; *Zingiber spectabilis*-bright yellow; *Lagerstroemia* sp./hybrids - Sioux; Lipan; Zuni; Biloxi; Byers Wonderful white; Miami; Hopi; Acoma; Yuma and Osage. Approximately 20 species and cultivars of *Curcuma* are currently being sourced along with a number of new *Grevillea* and *Hibiscus* hybrids. Some of the more ornamental Arnhemland escarpment flora is also being evaluated.

5.3.7 SPECTABILIS AND TORCH GINGER BREEDING PROGRAM

D Nielsen and M Hoult

Collectively, the ginger group of plants offer great scope for the development of a large range of ornamental and cutflower types. A previous DPIF hybrid program with *Alpinia purpurata*, generated some promising hybrids out of a very small, F1 population of only around 40 seedlings. Within open-pollinated seedling populations of *Zingiber spectabilis* and *Etlingera elatiora*, sufficient variation in a number of desirable traits exists to warrant intensive selection and the instigation of a hybridising program. *Alpinia purpurata*, *Zingiber spectabilis* and *Etlingera elatiora* have been identified as species worthy of development. In the future, *Curcumas* and other *Etlingera* and *Zingiber* species will also be incorporated, as suitable genetic material is accessed.

Materials and Methods

Selected material and a number of open-pollinated seedlings were established at BARC. Over a number of years, several suitable parents have been identified and incorporated into the program. This process is ongoing. Studies on pollen viabilities, receptivity and pollination mechanisms have also been undertaken to ensure maximum seed generation from hybridising. All new material being generated is established at CPHRF.

Results and Discussion

A number of crosses of *Zingiber spectabilis* were undertake using three parents vis. yellow x yellow, yellow x green, orange x yellow and orange x green. Limited number of seed were generated from these crosses and germinated, then established in the field for evaluation. Percentage germination for the respective crosses were as follows: yellow x yellow = 35%; yellow x green = 12%; orange x yellow = 30% and orange x green = 26%. Some investigation into the low percent germination and possible seed treatments is warranted, so as to increase the number of hybrid seedlings

being established. Around 150 hybrids from the various *Zingiber spectabilis* crosses have been field established.

13.3.17 MARKET IDENTIFICATION AND DEVELOPMENT

MARKETING NORTHERN TERRITORY CUTFLOWERS

M Sullivan

The cutflower industry has grown rapidly since its beginnings less than ten years ago. Estimates now put its value at around \$3 million. As is to be expected in a new industry such as this, post farm gate issues needed more attention. This project was developed in order to address some of these issues, in particular those related to marketing.

The production of an Agnote containing market advice for cutflower growers, as well as lists of wholesalers in interstate markets who deal in tropical flowers, was the first initiative in this project.

In the beginning of 1997, a Cutflowers Growers group was formed. This group came together to develop an action plan for the future development of their industry.

From this planning process, DPIF was able to get a clear understanding of what activities could be undertaken to best assist the industry. The sub-projects which are currently being implemented are as follows:

- production of a brochure targeted at florists, profiling what flowers are grown in the NT and how they can be used;
- production of an identification chart of the most common flowers grown in the NT in order to develop the use of one common name for each flower;
- development of a set of quality standards to ensure uniformity of product in the market; and
- representation of the NT cutflower industry at the Melbourne International Flower and Garden Show.

13.3.18 NURSERY INDUSTRY DEVELOPMENT

M Sullivan

Since none of the recommendations of the 1991 Nursery Industry Study had been implemented in the past, the NIAANT decided to put together an action plan for this purpose.

From this planning process the industry identified the need for some fact sheets about common local species which could be used as a promotional tool. DPIF is in the process of producing these brochures in time for the 1997 Garden Fair on 9-10 August.

A DPIF staff member attended a workshop in Sydney, to develop an Export Development Plan for the Nursery Industry nationally. This plan is in its final draft and is due for completion following the NIAA National Conference in April 1998.

5.4.1 EVALUATION OF NATIVE SPECIES ENDEMIC TO CENTRAL AUSTRALIA FOR SUITABILITY OF CUTFLOWERS

J Mansfield and G Kenna

This project is jointly funded by DPIF and RIRDC. The first stage of the project was the completion of a literature review of previous research, which identified the potential of various Central Australian native species as cutflowers and their ease or otherwise of propagation. The second stage of the project involves field work to collect native species for the assessment of vase-life, further propagation work and a preliminary assessment of the potential of selected species for commercial production. Rainfall in Central Australia has been sparse in the past few years, with the incidence of significant falls only occurring in some areas during summer. Rainfall at this time is not conducive to the growth of wildflowers. Rain during late winter and spring is essential to enable growth to occur and the second stage of the project to be implemented.

5.4.2 EVALUATION OF NEW HYBRID SELECTIONS OF KANGAROO PAW AND GERALDTON WAX TO ASSESS THEIR SUITABILITY FOR CUTFLOWER PRODUCTION IN CENTRAL AUSTRALIA

G Kenna, J Mansfield and S Marte

Plantings of a range of new hybrid selections of Geraldton Wax have been made at TTRF. Growth of most selections has been satisfactory, although some plants have been badly damaged by kangaroos during the drought, which has prevailed in the area in recent times. Assessment of the flowers has not been continued as growers have scaled down production due to a lack of profitability. The production of kangaroo paw for cutflowers has also been reduced, due to the high costs of export to Japanese markets which has resulted in marginal returns.

5.4.3 ASSIST THE DEVELOPMENT OF THE CENTRAL AUSTRALIAN CUTFLOWER GROWERS GROUP

G Kenna, J Mansfield and K Young

This group was formed to share information on the production of cutflowers and to enable the cooperative marketing of cutflowers on domestic and export markets. The main market for cutflowers produced in Central Australia has been Japan. The quality of cutflowers produced by group members has been very high, however due to the high cost of export of the product to the main market, which is Japan, returns to

growers have been marginal. Many of the activities of the group have been curtailed, however assistance continues to be provided by the provision of inspection services for the export of the product.

5.4.4 EXTENSION SERVICES TO HORTICULTURE INDUSTRY (AUSTRALIAN NATIVES)

G Kenna, J Mansfield and K Young

The provision of extension services to growers producing Australian native cutflowers has been by servicing adhoc enquires on various aspects of management and marketing and the provision of an inspection service.

Interstate/International Visitors To Horticultural Research Establishments

- **July 1996**
 - Terry Guidera & Shaun Jackson, SPS Seeds
 - Ivan Koch, Batchelor Farm manager
 - Lester Burgess & Agriculture students from Sydney University

- **August 1996**
 - Dr Wendy Morgan and Wendy Chew, Institute for Horticulture Development, Knoxfield, Vic.
 - Helen Moody, Australian Horticulture
 - Phil Cheeseman & Andrew Manghan, S&G Seeds
 - Rollo Campbell, bamboo grower from Tiaro, Qld
 - Graeme & Dianne Reinbott, Batchelor Farm
 - Mr and Mrs Abdul , UAE
 - Mathew Plumkett, Robert Hoogers, NSW Agriculture
 - David Power and associates

- **September 1996**
 - Vido and Cecilly Musemeci, Qld Exotic fruit growers
 - Australian Trust for Conservation Volunteers, tour of AZRI
 - Nuffield scholars, tour of AZRI

- **October 1996**
 - John Blackwell, CSIRO Division of Water Resources and Keith Garzoli, Aust National University
 - Ian Bally and Mark Harris, QDPI
 - Tony Cooke, QDPI
 - Valerie Kelly, Austrade Kuala Lumpur
 - Brian Stockham, Woolworths SA

- **November 1996**
 - Several visitors from Malaysia, Kalimantan
 - Joe and Allan Zappala, Qld durian grower
 - Phil Ross and Chris Horsbough, QDPI
 - Tim O'Hare, QDPI, Brisbane
 - David Powell
 - Jim Swallow, Qld grower
 - Ken Wetherby and Geoff Kew, soil surveyors
 - Mr & Mrs YC Ng, YP Ching and CH Gau, Eden Farm, Malaysia
 - Staff from QDPI, Hamilton

- **December 1996/January 1997**
 - John Cormack, manager of exotic fruit orchard, Qld
 - DARTI Minister, visit to Ti Tree-Pine Hill
 - David Gregor, Regulatory Affairs Manager, AgrEvo

- **February 1997**
 - Patrick Lau, Santavan and Prof Yung, China
 - Barry Cavenagh, Cairns
 - Kym McMeek and Australian Banana Growers Council and Rob Spear, Rural Industry Training Advisory Board

- **March 1997**
 - Mr & Mrs Haidiko, Indonesian investors
 - Ernie Chin, Real Estate developer
 - Dr Trevor Olsen, CSIRO Brisbane
 - Andrew Maughan, S&G Seeds
 - Hilton Smith, Incitec, Ayr Qld
 - Andrew Meurant, Bayer
 - Terry Guidera
 - David Lange, grower

- **April 1997**
 - National executive of Rare Fruits Council and Qld growers
 - Matthew Buck, Export Facilitator, AQIS
 - Mr & Mrs Widodo Surono, Consul of Republic of Indonesia and Mr and Mrs Agus Sardjana, Vice Consul
 - Ok Ginys - PNG Dept of Agriculture

- **May 1997**
 - Durnford Dart, bamboo specialist
 - Fredorik Ylaya, Philippine visitor
 - Di Brennan, Horticultural Coordinator, Spencer Inst TAFE, SA

- **June 1997**
 - Rob & Erica Porter, Golden Gate Nursery, NSW
 - Dr Soemitro Arintadisastra & Mr Soesanto Prawirosoemarto, Indonesia
 - Keith Bodman, HRDC
 - Ali Rezwan, CSIRO Adelaide
 - Cattleman from Longreach, Qld

Organisation of Seminars, Workshops and Field Days

- **July 1996**
 - Displays at Alice Springs, Tennant Creek, Katherine and Darwin Shows Hort staff
 - Mango Anthracnose Seminar - Mike Poffley
- **September 1996**
 - Mango pre-season Seminar - Mike Poffley
 - Assisted with Nursery Industry Irrigation Workshop - Yan Diczbalis
 - On farm demonstrations re insect disinfestation - Elliot Crowson
- **November 1996**
 - Assisted with Durian Industry Strategic Plan - Hort staff
 - Mango Fertiliser Seminar - Katherine staff
 - Lecture on IPM in Tree Crops - Deanna Chin
- **December 1996/January 1997**
 - Mango Post Harvest Seminar - Mike Poffley
- **February 1997**
 - Seminar on recent quarantine detections of insect pests in Torres Strait - Stuart Smith
 - BARC Seminar, IPM on Vegetable crops in the Darwin area - Graham Young
- **March 1997**
 - Red Banded Thrips Workshop - Hort staff
 - Rambutan R&D Workshop - Hort staff
 - Asian Vegetables Workshop - Mike Poffley
 - Presentation to vegetables growers re pest management strategies and practices for Asian vegetables - Stuart Smith and Graham Young
- **April 1997**
 - Horticulture Industry Strategic Planning Meeting - Hort staff
 - Mango R&D Workshop - Hort staff
 - Research update on hot water treatment on mangoes - Stuart Smith

- **May 1997**
 - Exotic Fruits Seminar - Hort staff
 - Mango Pruning Field Day - Mike Poffley and Hort staff
 - Presentation of R&D Results - Katherine staff
 - Research update on entomological work on mangoes, other crops and Quarantine certification, Katherine - Stuart Smith
 - Live displays of beneficial arthropids - Deanna Chin & Haidee Brown
 - Presentation re entomology of exotic fruit tree crops - Stuart Smith & Deanna Chin
 - Presentation on biocontrol of Palm Leaf Beetle - Deanna Chin
- **June 1997**
 - Addressed Rare Fruit Council: carambolas - Mike Poffley
 - Integrated Pest Management Training Seminar - Graham Young

Staff Visits

- **September 1996**
 - Visit to Kununurra to visit the Ord area and inspect farming activities - CPHRF staff (1st group)
- **October 1996**
 - Visit to Kununurra - CPHRF staff (2nd group)
- **November 1996**
 - Visit to wholesale markets in Brisbane and Sydney - Margaret Landrigan
- **February 1997**
 - Visit to South Australia to study soil texturing techniques and irrigation management - Chris Wicks
- **April 1997**
 - Visit to Cairns to discuss collaborative research in exotic tropical fruits - Yan Diczbalis and TK Lim

Interstate and Overseas Seminars/Workshops/Presentations

- **July 1996**
 - International Tropical Fruit Conference, Kuala Lumpur - Niranjan Dasari, Yan Diczbalis, TK Lim (paper & poster presented by last two)
 - National Asparagus Grower's Conference, Mildura, poster presented - Jeremy Bright
- **August 1996**
 - International Postharvest 96 Conference, New Zealand, poster presented - Margaret Landrigan
 - Cashew Research and Development Workshop, Cairns, poster presented - Gavin Foord
- **September 1996**
 - 5th International Mango Symposium, Tel Aviv, Israel -papers and posters presented - Malcolm Smith and Vinod Kulkarni
 - Presentation to SA Research & Development Institute, Adelaide, on development of an on-farm hot water technique for disinfestation of mangoes - Stuart Smith
- **October 1996**
 - AQIS Workshop to develop protocol for direct release of bio-control agents of weeds. Canberra - Graham Young
- **November 1996**
 - Training on techniques for joint HRDC fruit fly tolerance project, Indooroopilly, Qld - Heather Wallace
- **March 1997**
 - Commercialisation of Transgenic Crops workshop, Canberra - TK Lim
 - Annual Disinfestation Researchers' meeting, Melbourne - Stuart Smith
 - Presentation to HRDC on disinfestation, Melbourne - Stuart Smith
- **April 1997**
 - Asian Vegetables workshop, Brisbane - Margaret Landrigan
- **May 1997**
 - Second National Banana Conference, Gold Coast - Kevin Blackburn
 - ACIAR workshops on disease resistance in fruits and storage extension life, Thailand - TK Lim (poster presented)

- **June 1997**
 - HRDC Skin Browning meeting, Ayr Qld - Margaret Landrigan

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Hoult, M.D., Donnelly, M.M. and Smith, M.W. Salt exclusion varies amongst polyembryonic mango cultivar seedlings. Poster presentation at 5th International Mango Symposium. Tel Aviv Israel. 1-6 June 1996

Kenna, G. and Mansfield, J. Centralian flower potential of Centralian species. Literature Review for RIRDC Project No. DNT-16A.

Kulkarni, V. and Hamilton, D. An integrated approach towards improving mango productivity. Oral presentation at 5th International Mango Symposium Tel Aviv Israel. 1-6/9/96.

Kulkarni, V. Mango varietal research - some new approaches. Oral presentation at 5th International Mango Symposium Tel Aviv Israel. 1-6/9/96.

Kulkarni, V. A new mango selection from Australia's Northern Territory. Poster presentation at 5th International Mango Symposium Tel Aviv Israel. 1-6/9/96.

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Landrigan, M., Morris, S.C. and Gibb, K.S. (1996). Relative Humidity Influences Postharvest Browning in Rambutan. (*Nephelium lappaceum* L.) *HortScience* Vol. 31(3):417-418.

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Lim, T.K. and Bowman, L. (1995). Control of sapburn on "Kensington" mangoes with postharvest chemical treatment. *ASEAN Food Journal* 10(3): 83-89.

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Smith, E.S.C.(1996). Insect pests of conservation farming systems in the Northern Territory. Proc. Workshop on Conservation Farming for the Semi-Arid Tropics. AIAS, Dec 1996. pp.208-220

Smith, M.W., Hoult, M.D., Bright, J.D., McAlister, S. and Foord, G. Rootstock research: Opportunities for the Australian mango industry. Oral presentation at 5th International Mango Symposium. Tel Aviv Israel. 1-6 June 1996.

Young, G.R. (1997). Mites and Sucking Insects attacking Orchids. *Aust. Orchid Review*, **62**(2):11-14.

Young, G.R. (1996). An association between the crazy ant *Anoplolepis longipes* (Jerdon) (Hymenoptera:Formicidae) and coconut spathe moth *Tirathaba rufivena* (Walker) (Lepidoptera:Pyralidae) on coconut palms in the Morobe province of Papua New Guinea. *Papua New Guinea Jnl of Agric. Forestry & Fisheries*, **39**(1):1-13.

Staff Training

- **July 1996**
 - Introduction to Windows and Intro to Pcs - Carolyn Ellis
 - Word 6 - Kylie Young and Nic Isgro
 - Access - John Mansfield, Mark Hoult, Gavin Foord, Chris Brown
- **August 1996**
 - Introduction to Windows and Word - BARC staff
 - Personnel Management Planning & Grievance Seminar - AZRI staff
- **October 1996**
 - Group leadership and Facilitation module - Gavin Foord and Stuart McAlister
- **November 1996**
 - Firearms Safety Course - Paul Albano and Andy Mullins
 - Public Speaking course - Carolyn Ellis

- **March 1997**
 - Rural Extension units - Gavin Foord and Stuart McAlister
- **April 1997**
 - Farm Chemical users course - Susan Marte and Anthony Heaslip
- **May 1997**
 - Scientific writing course - Jeremy Bright and Gavin Foord
 - “Practice of Extension” and “Project Planning” - Gavin Foord and Stuart McAlister
 - Extension Seminar for supervisors - Malcolm Smith
 - First Aid course - Carolyn Ellis