Northern Territory Department of Business, Industry and Resource Development

Primary Industry Group

Technical Annual Report 2002-03

Northern Territory Department of Business, Industry and Resource Development
Primary Industry Group
Berrimah Farm
Makagon Road
Berrimah NT 0828
GPO Box 3000
Darwin NT 0801

www.dbird.nt.gov.au
publications.dbird@nt.gov.au

Tel: +61 8 8999 2313
Fax: +61 8 8999 2307

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November 2003

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INTRODUCTION

The 2002-03 Technical Annual Report presents an overview of recently completed and currently conducted research and development activities by staff in the Pastoral, Horticulture and Resource Protection Divisions, which form the Primary Industry Group of the Department of Business, Industry and Resource Development. All such activities focus on improving productivity and profitability of primary industries in the Northern Territory in a sustainable and environmentally friendly manner.

The Fisheries Group is reporting its research and development activities for 2002 separately in *Fishery Status Reports 2002* (Fishery Report No. 69), which is available from the Publications Section at Berrimah Farm.

The pastoral industry is the most significant land user in the NT, managing close to half the landmass in 200 pastoral leases. Many members of the industry participate in Landcare activities, pest and weed control programs and the Bushfire Council. Some of the larger pastoral companies employ their own environmental officers to monitor conditions on their properties. The total cattle herd in the NT remains at 1.6m head, largely unchanged over the last 25 years, while the annual turn off rate has increased dramatically from 10% to over 30% in 2002. The Pastoral Division conducts research to improve the productivity of cattle on pasture, and protect and improve animal health so it meets the high standards required by interstate and overseas importers.

Sustained demand by the live cattle export trade to South East Asia continued to dominate the pastoral industry. In 2002, the NT supplied 510,000 head of cattle to the market, including 234,000 head for export, contributing $210m to the Territory economy.

The agricultural industry continued to expand, based on mixed farming including production of cattle on improved pasture, hay and dry season irrigated crops. The Peanut Company of Australia stimulated production in the Katherine Daly Basin. In March 2003, 400 hectares were planted with peanuts compared with only 200 hectares in 2002. Rotation crops of seed sorghum and forage crops are also increasing.

The total area for horticultural crops in the Territory continues to increase. However, it is still very intensive land use, estimated at 6,000 to 7,000 hectares. Within that area, the gross value of production was estimated to be $85.2m in 2002, a decrease of 7.6% over the previous year. The Horticulture Division conducts research to improve productivity and profitability of fruits, vegetables and ornamentals.

Mango production currently dominates the horticulture industry. Despite some major set backs, 1.8m trays of mangoes were produced in 2002, valued at over $36.3m. Currently, there are around 800,000 mango trees, potentially able to produce between 8m and 16m trays of fruit within the next five years.

The gross value of the banana industry was over $7.1m in 2002, which produced 3,943 tonnes of bananas. Banana production has decreased from last year due to the effects of Panama Tropical Race 4 disease. The project to find a Panama disease resistant variety is continuing at the Coastal Plains Banana Quarantine Station. Preliminary testing of the first introduced overseas varieties is almost complete.

Table grapes are the major commercial horticultural produce from Central Australia. Production from nearly 400 hectares was 1,977 tonnes in 2002, valued at $9.9m. There was a significant drop in production of nearly 50% due mainly to rain damage at harvest.

Both the Horticulture Division and industry are trialling potentially suitable tropical fruits such as jackfruit, carambola, pitaya, durian and a number of others in the Territory's tropical region. There is also a growing interest in citrus crops, which could play a major role in the future expansion of horticulture in the Territory.

In 2002, 4,360 tonnes of vegetables were produced with a gross value of over $12.1m. Asian vegetables are gaining prominence and were produced in over 50 farms, for both southern and local markets.

The Darwin region is renowned for producing unique, new and diverse tropical cut-flowers. The heliconia and ginger cut-flower industry has expanded rapidly during the last 10 years and represents the majority of commercially produced flowers in the Territory.

The nursery industry has more than doubled in the past 10 years. The Horticulture Division, in partnership with industry, is working to develop and trial new and exciting ornamental crops for the market and is encouraging the adoption of best practice as the key to profitable and sustainable production.

The Resource Protection Division helps producers to control pests, diseases and chemical residues so they do not restrict the production and market access of plants, plant products and (in cooperation with the Pastoral Division) livestock. It provides information, advice and other services to clients on agricultural resource protection.

The Division developed and implemented an eradication program for the grapevine leaf rust in the Darwin region and is negotiating the implementation of various quarantine programs with Indonesia. Plans are in place to increase surveillance and public awareness of the red imported fire ant, which is currently a major pest in the greater Brisbane area.

PASTORAL

PROGRAM: Agricultural Development

SUBPROGRAM: Pasture Development

Objective:

Expand the industry base through increased areas of pasture and expansion of industry skills and experience in managing pastures.

Outcomes:

Expansion of the industry through increased pasture production.

Continued support of forage research and demonstration programs aimed at increasing hay supply to the emerging forage cube industry.

Overview – 2002-03

The wet season was poor for the Darwin District.

The first significant rainfall for the season was on 14 September. While most of the rainfall recording sites in the Darwin and rural areas received one, or sometimes two significant falls of rain in September, only three sites in the Darwin – Daly area received significant falls. October was dry, except for one significant fall of 24 mm in Batchelor.

Rainfall in November was mostly isolated and erratic, with most areas receiving only one or two significant falls during the month. However, coastal areas such as Channel Point, and around the Adelaide River Township received significant amounts of rain. The only day with widespread rainfall was 28 November. This erratic rainfall pattern continued through December and into early January.

Significant falls occurred over the whole district on 2 January and over the Darwin and rural area on 4 and 5 January. There was widespread rain in the Darwin and rural area on 12, 13, 17 and 20 January, but falls in the remainder of the District continued to be isolated and erratic. The isolated falls continued into mid February. The exceptions to this were widespread falls in the Darwin and rural area on 3 and 6 February, and a series of days of good rain around Adelaide River.

While the Darwin and rural area received widespread monsoonal rain, including many heavy falls for the period 11 –27 February, the Darwin – Daly area received widespread rain only on nine of those days. More frequent, heavier rainfall continued until 4 March. The Darwin and rural area then received only one significant rainfall in five days, followed by widespread falls of 22 – 42 mm on 10 March.

Rainfall again became erratic and isolated, with most being coastal showers. After 20 March, there were few significant falls. The last significant falls were 28 mm at Cape Don and 50 mm at Leader's Creek on 20 April.

The low and erratic rainfall reduced pasture yields across the district. Pasture growth stopped quickly before the expected end of the wet season as pastures dried out rapidly because of the lack of soil moisture. As in 2001-02, this led to an earlier burning season than in most recent years.

The floodplains were not flooded for an extended period during that wet season, and dried out earlier than in most years. This allowed stock earlier access to floodplains.

Demand for pastures and seed extension/information continued at record levels during the year, with the number of enquiries up by 50% on last year, approaching 600.

There was an unusually widespread outbreak of army worms (*Spodoptera exempta*) in grass pastures in the Top End during February/March. This was mostly in pangola grass pastures, but Jarra and Gamba were also affected. The outbreak may have been partly due to the unusually dry weather in January.

PROJECT: Increase Early Generation Seed of Released Pasture Cultivars

Project Officers: G. Hore and A. Cameron

Location: Paddocks 8 and 9 Berrimah Farm

Objectives:

Evaluate new lines in a confined non-grazed environment.

Bulk-up seed from promising lines for further evaluation.

Bulk-up early generation seed of pasture cultivars released in the NT.

Project Period: Ongoing, 2001-06.

Method:

Small areas of cultivars released in the Northern Territory are maintained in Paddocks 8 and 9 at Berrimah Farm, Coastal Plains Horticulture Farm (CPHF) and at Katherine Research Station (KRS). Seed harvests are conducted as required to ensure that fresh early generation seed is available.

Seed crops of annual species are grown and harvested as required.

Results:

Weeds were controlled on the Arnhem pre-basic seed area. It was not possible to harvest seed because magpie geese ate it.

A pre-basic seed area of Cavalcade produced 8 kg of seed.

At KRS, 50 kg of pre-basic seed of Strickland finger grass was produced.

At CPHF, 11 kg of pre-basic seed of Katherine pearl millet was produced in the netted area. This will allow the sowing of a larger area next year to produce basic seed.

PROJECT: Predicting Environmental Weed Risk of Exotic Grasses in Northern Australia

Project Officers: **B. Ross, Dr. R. van Klinken (CSIRO), C. Wilson (DIPE), Dr. F. D. Panetta (QDNRM) and B. Cook (QDPI)**

Location: Berrimah Farm

Objectives:

Identify and rank current and impending grass-weed threats to northern Australia and identify benign beneficial species

Identify combinations of plant/environmental/cultural factors, which are favourable to local dominance of weedy grass species in natural ecosystems

Develop a landscape specific weed risk assessment for grasses.

Project Period: 2002-05

Background:

Exotic grasses are emerging as one of the greatest threats to northern Australian landscapes, both to the environment and the pastoral industry. In contrast, relatively few of the exotic grasses evaluated for agricultural purposes in northern Australia have survived six months or more and even fewer have been commercialised. Using the existing body of world literature, and leading-edge modelling techniques, this project seeks to explore the reasons for the ecological success of relatively few exotic grasses in an attempt to more accurately predict the weed risk of grasses in northern Australia.

In conjunction with other Weeds CRC projects, a broader significance of this work is to determine how well the existing AQIS weed risk assessment (WRA) applies to grasses. Can WRA models be further refined to take into account weediness within different landscapes and can WRA be used to help resolve serious issues of conflict?

Method:

A comprehensive database will be developed to list all exotic grasses known to have naturalised in northern Australia and detail traits for each species such as distribution, weediness, beneficial properties, life history and physiology. This will be done by reviewing the literature and by accessing personal knowledge of grass specialists from all over northern Australia.

For a subset of exotic grasses that are already widely distributed in Australia, but that differ in their weediness, sets of “best bet” predictive characters will be tested against known weediness and the predictions of existing AQIS WRA. Workshops will enable other collaborators, weed science and pasture researchers and practitioners to contribute to the selection of predictive characters.

A WRA type method for predicting weediness of exotic grasses across the different landscapes in northern Australia will be developed and validated. Available grass traits, spatial landscape data (climate, soils etc), and modelling/spatial analysis tools will be used

Results:

A database has been compiled that lists over exotic 200 grass accessions in northern Australia. Work is continuing to add information about each of these to the database.

A workshop was jointly hosted with the Northern Territory University in Darwin in April 2003, which was attended by researchers from Qld, NSW, SA, and the NT.

A Ph.D. student will work on modelling aspects of the project after enrolment in July 2003.

PROJECT: Assessing the Potential of Native Grass Species for Revegetation of Tropical Wetland Habitats

Project Officers: A. Cameron, B. Beumer, A. Simonato, B. Ross and G. Hore

Location: Berrimah Farm and Mary River District

Objective:

Identify the most efficient and effective methods of collecting, processing and storage of seed of native perennial floodplain grasses.

Project Period: 2001-03

Background:

There is considerable interest in the potential use of native floodplain grasses for re-vegetation following control of *Mimosa pigra*. For this to be practical, a ready supply of seed is required, and methods need to be developed for the harvest, clean, test and store seed of the main floodplain grasses.

This is an NHT Bushcare funded co-operative project between Agriculture, Weeds Branch and Greening Australia staff.

Method:

A brush harvester was constructed to fit onto the Weeds Branch airboat to harvest seed of *Hymenachne acutigluma*, *Leersia hexandra* and *Pseudoraphis spinescens* in standing water. These grasses produce their seed mostly during the wet season when the stands are generally accessible only by boat or airboat.

Progress:

The construction of the brush harvester took longer than anticipated as "new" ideas were needed to reduce the weight of the unit and to account for the lack of control over harvest speed, i.e. the speed of the airboat.

A frame was constructed to allow the brush harvester to be used in shallow water by towing with a small tractor or quad bike.

As the floodplains dried out earlier than anticipated in 2002 because of the low rainfall in the wet season in the Top End, the brush harvester could not be tested on the floodplains until the 2003 dry season.

The brush harvester towed by a Kubota tractor was successfully tested on Pseudoraphis on 20 May 2003 and on Hymenachne on 27 May 2003 at Middle Point on Marrakai Station.

On 28 May, the floodplain brush harvester was successfully tested on Hymenachne when mounted on an airboat. The harvesting period with the airboat was terminated early because the water was too low and the depth variable, which made controlling the speed of the airboat difficult. Added to this was the danger of having to jump out of the airboat into crocodile infested water to push the airboat through shallow areas and be exposed to potential injuries from hitting submerged objects, including tree trunks.

The low pure seed yields obtained (see Table1) show wild harvesting of these species is not an economical proposition.

Table 1. Seed yields from floodplain grasses using a brush harvester

Grass	Harvester mode	Pure seed yield (g/hour)
Hymenachne	Tractor	1.3
Hymenachne	Airboat	0.8
Pseudoraphis	Tractor	3.6

The Hymenachne seed yield was similar to that obtained in May 2000 with a cutter bar and catcher. Most of the caught seed is empty and blows off after drying, during cleaning.

The poorly synchronised seed set of these grasses and the high arthropod pressure on the developing seed cause harvesting problems. A Hymenachne inflorescence viewed under a microscope reveals a community of small mites, bugs, leafhoppers, thrips and caterpillars.

The quality of the harvested seed was poor for Pseudoraphis, but good for Hymenachne (see Table 2).

Table 2. Germination of harvested seed

Grass	Harvester mode	Germination %	Fresh un-germinated %
Hymenachne	Tractor	38	16
Hymenachne	Airboat	60	0
Pseudoraphis	Tractor	1	10

PROJECT: Seed Testing Laboratory

Project Officers: A. Simonato, L. Simington and A. Cameron

Location: Berrimah Farm

Objective:

Provide an accurate and reliable seed testing service to the pastoral industry, Government and the public in the NT.

During the year, 656 consignments were submitted for testing. The number of quarantine lots received by the Seeds Laboratory has again decreased dramatically this year, with lots for quarantine identification being directed to the NAQS Botanist. The Seeds Laboratory is now registered as a Commercial Premise by AQIS. AQIS, importers and exporters are now charged for services provided. Lisa Simington joined the Seeds Laboratory as a Seeds Technical Officer.

The following tests were carried out on submitted lots:

Test	No. of tests
Certification	17
Purity	32
Germination	578
Bulk search	47
Quarantine inspection	27
Quarantine identification	23
Comparative test	2
Tetrazolium test	5
Import examination international	11
Export examination interstate	26
Seed count	1
Identifications	4
Audit samples	3
Total	**776**

Other seeds issues

1. Seed certification applications were made for 85 hectares during the 2002-03 wet season. A total of 26 tonnes of seed was certified during late 2002. Half of the certified seed was for Cavalcade and Bundey and the other half was for Giles sesame.

2. Indonesian feed samples are being checked at the rate of approximately one per month for the presence and viability of weed seeds before importing feed pellets.

3. Albert Simonato and Arthur Cameron conducted a seed samplers' course for 12 industry participants.

4. Lisa Simington has developed an Access database to record information relating to seeds stored in the Laboratory's Seed Reference Collection. Details of over 500 seed samples have already been recorded.

PROJECT: Pasture Development Extension

Project Officers: **A. Cameron, B. Ross, A. Simonato, G. Hore and L. Simington**

Location: Berrimah Farm

Objective:

Maintain extension services to industry to assist it to increase and manage areas of improved pastures and to continue producing high quality seed.

During the year the Section received 599 individual requests for advice from a range of customers, including primary producers, Departmental staff, staff of other Departments, agribusiness, students and a range of others, including a number from interstate and overseas. Our biggest clients were primary producers (231) followed by departmental staff (161) and agribusiness (65). The highest numbers of requests were about pasture species (147), seed testing (145) and identifications (120). Requests were received by telephone (317), visit (205) and email (69).

Specific extension activities included the following:

- Show Judging: Arthur Cameron judged seven properties for the Royal Darwin Show Farm and Pastoral Competition.

- The Pasture Development Section is continuing a survey/removal demonstration on major roads in the Top End to show that Gamba grass can be controlled.

- Barbara Ross conducted a native grass identification day for the Litchfield *Land for Wildlife* group.

- Albert Simonato and Arthur Cameron conducted a seed samplers' course in Katherine for 12 industry participants.

- Greg Hore facilitated a Pasture Development Section workshop on Gamba grass management for 70 participants at Berry Springs in March.

- Arthur Cameron conducted two grass tours at the exotic grass workshop in Darwin.

SUBPROGRAM: Agriculture and Irrigation Development

PROJECT: Irrigated Maize Production on Blain Soils at Douglas Daly Research Farm

Project Officers: F. O'Gara, S. Lucas, C. Ham and M. Hearnden

Location: Douglas Daly Research Farm

Objective:

Determine the yield potential and agronomic requirements of irrigated maize in the Daly Basin.

Background:

Maize is a minor crop in the NT but one of the few field crops that lend themselves to centre pivot irrigation in the dry-season. It is a good rotation crop with peanuts and is capable of producing high yields and moderate to good returns under good management. In the past, commercial maize yields have been disappointing due to grower inexperience with the crop under tropical conditions.

For the past four years the Department has been evaluating commercial lines of maize under irrigation at Douglas Daly Research Farm (DDRF). The objective is to develop agronomic experience with the crop, to ascertain its potential under irrigation in rotation with peanuts and provide growers with specific recommendations on its production and management in this environment.

Method:

Eight of the most consistent commercial varieties from the past three years were evaluated this season. The varieties were sown into a conventionally prepared seedbed on 26 March using a Nodet Gougis precision vacuum planter. The average plant population over the trial was 69,642 plants/ha with a low of 65,000 and a high of 74,600 plants/ha.

The trial was a randomised complete block design with three replicates with plot sizes of 120 m long by eight rows. The total planted area was approximately 5 ha. Leaf samples were taken 35-40 days after sowing (DAS) and at silk time to determine plant nutrient content. The crop was harvested on 6 September and yields were measured using an *International* 1420 header.

An *Environscan*® soil moisture-monitoring system is used to monitor irrigation and soil moisture content. The crop received approximately 5.5 ML/ha. *Primextra*® was used as a post-plant, pre-emergent application to control weeds.

An *Insectigator* III® chemigation unit is used to apply insecticides and biocides to control various insect pests such as army worms, *Helicoverpa* spp. and the green vegetable bug. A low tolerance of insect pressure is maintained to ensure maximum economic yield. *Lorsban*® was applied pre-tasselling and *Dipel*® and *Gemstar*® were applied during pollination to control army worms and *Helicoverpa* larvae.

Seed was treated with *Gaucho*® (imidacloprid) to control leaf hoppers and the wallaby ear virus. *Gaucho*® is now recommenced for all dry season maize due to the presence and severity of the wallaby ear virus.

Fertiliser is applied pre-plant, at planting (as a band beside and below the seed) and through the fertigation system. A total of 330, 40, 250 and 30 kg/ha of nitrogen, phosphorus, potassium and sulphur, respectively were applied during the life of the crop. Magnesium, zinc and boron were also applied.

Results and Discussion:

Yields this season were better than in the previous three seasons. Insect pressure was considerably lower; the use of better yielding varieties and the increased rate of nitrogen (i.e. from 280 kg/ha to 330 kg/ha this season) probably assisted in achieving better results.

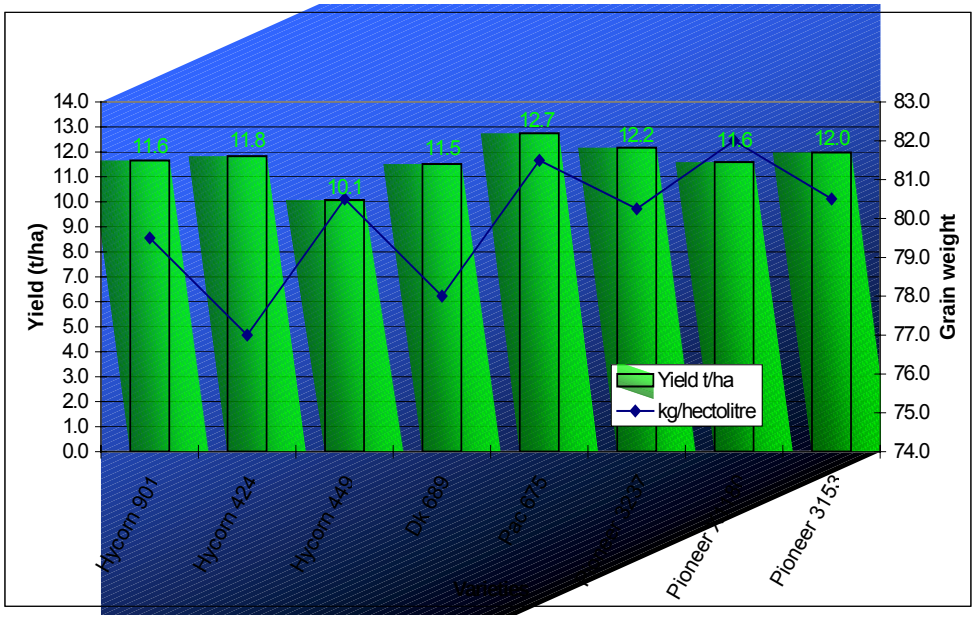
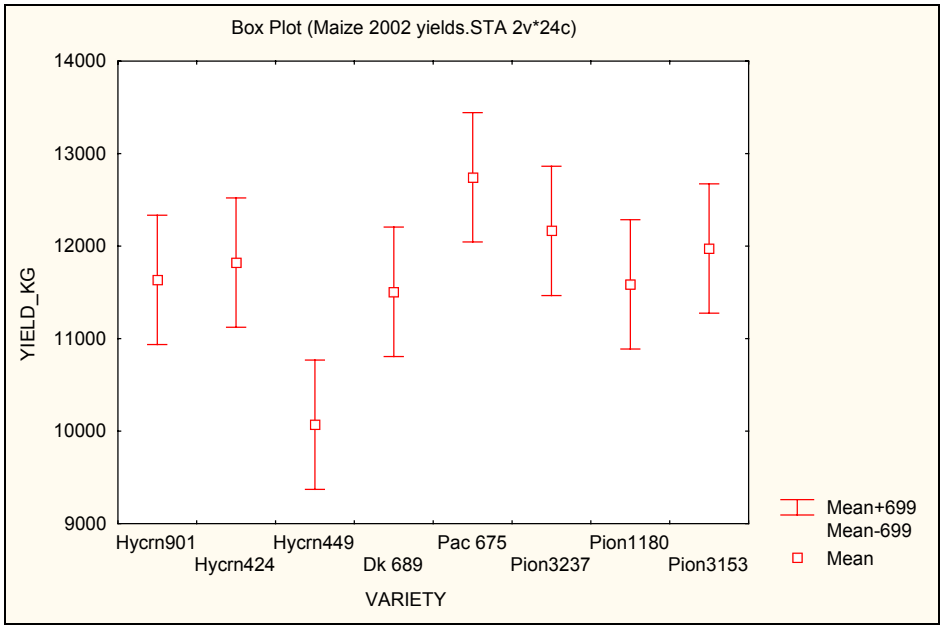


Figure 1. Irrigated maize yields at DDRF in 2002

The average yield for all the varieties in 2002 was 11.7 t/ha. The average yield over all varieties for the four years of the evaluation was 9.26 t/ha. In every year except 2000 several varieties exceeded 10.0 t/ha.



Varieties whose lines overlap the means of other varieties are not significantly different

Figure 2. Box plot of means and least significant (LSD 699, P>0.05) difference

Pacific 675, yielded 12.7 t/ha and was significantly better than all varieties except Pioneer 3237. Hycorn 449 had a significantly lower yield than the other varieties but still produced 10 t/ha. Hycorn 901, Hycorn 424, DK 689, Pioneer 3237, Pioneer X 1180 and Pioneer 3153 did not differ significantly in their performance.

Results from this and previous years indicate that Hycorn 424, DK 689, Pac 675, and the Pioneer varieties 3237, X1180 and 3153 are all capable of producing high yields in the Top End under good conditions using irrigation. Pioneer 3237, Pioneer 3153, Hycorn 75, Hycorn 424 and DK 689 have performed consistently well over a number of seasons.

Lodging resistance, stem strength and disease resistance are important criteria for maize in the tropics. Maize stalks tend to collapse relatively quickly after physiological maturity. Lodging is usually severe in thin stalked varieties. While lodging was not severe this season, varieties Pac. 424 and DK 689 tended to have a higher level of lodging than others. Pioneer X1180, Pioneer 3153 and Pac. 675 have strong robust stalks and less stalk collapse than other varieties. High daytime temperatures and moisture (from dews) seem to exacerbate the biological breakdown of stem material under tropical conditions.

Insect and disease management is a high priority in maize production in the NT. The wallaby ear virus causes an extremely damaging disease but is effectively controlled by *Gaucho*®. It is now a general recommendation that all dry season maize seed should be treated with *Gaucho*® prior to planting.

Army worms, *Helicoverpa* spp. and green vegetable bugs have the potential to cause economic damage in most seasons. Commercial crops may require one or two chemical applications if these pests reach threshold levels.

Conclusion:

The trials over the past four years indicate that good maize yields can be achieved under irrigation on Blain soils in the Top End. High fertiliser inputs, accurate water scheduling and management of insects and disease are necessary to achieve viable yields. While this series of maize evaluations demonstrated that trial yields of over 12 t/ha are possible with the best varieties, commercial yields of around 9 t/ha should be achievable under good management. The cost associated with growing maize is high in the NT due to the cost of fertiliser and water. Rotation with peanuts is a viable alternative and should assist in reducing the fertiliser inputs required for maize while reducing insect pest and disease problems.

The viability of irrigated maize in the NT is questionable unless 8 to 9 t/ha is achieved. The results and recommendations arising from these evaluations will be published in an extension publication.

Acknowledgments:

Thanks to Steve Lucas, Technical Officer Douglas Daly Research Farm and Chris Ham, Agronomist, for assistance with these trials over the past four years. Thanks also to Dr. Mark Hearnden for statistical analysis and to Pacific Seeds, Pioneer Seeds and Genex who have provided trial seed each year.

PROJECT: **Producer Initiated Research and Development Project (PIRD)**
Evaluation of Wynn Cassia as a Pasture and Fodder Crop for the Douglas Daly Area

Project Officers: **Douglas Daly Producers Group, F. O'Gara (Coordinator) and DBIRD Staff**

Location: Commercial Farms, DDRF and BARC

Objective:

Determine the productive capacity of Wynn Cassia as a pasture and fodder species in commercial enterprises in the Douglas Daly area.

Background:

Wynn Cassia, also known as Roundleaf Cassia (*Chamaechrista rotundifolia*) is an exotic legume, which was introduced to the NT as a pasture over 20 years ago. Wynn Cassia is a prolific seeder and invades pastures and bare ground rapidly. It can dominate pastures due to stock selecting more palatable species, leaving it to proliferate. Despite its dominance in many commercial pastures there is no hard data on how well cattle accept and perform on Wynn Cassia in the NT. There is little information on its ability to fix nitrogen or its role in sustainable grazing systems in the Top End. Its contribution to productivity needs to be quantified under NT conditions. There is a genuine fear that Wynn may become too dominant and reach weed status in the area.

The Project:

The Douglas Daly PIRD project was started in July 2001 and continued into the 2003 dry season. Producers saw a need to ascertain the value of Wynn Cassia as a pasture and fodder crop. Producers wanted to determine the performance of cattle on Wynn pastures in commercial conditions. Producers nominated a range of issues they would like answered and initiated a number of activities that would lead to better knowledge of the species.

A number of on-farm demonstration areas and monitoring sites have been established. Seasonal pasture growth, productivity and quality have been monitored on these sites.

Two sites have been used to determine the live weight gain of steers on a pure Wynn Cassia sward. One site is Paddock 42 at the Douglas Daly Research Farm (DDRF) and comprises five steers on 4 hectares of pure Wynn Cassia. The second site is on a commercial property and consists of a 250 ha paddock of which approximately 185 ha consist of a pure sward of Wynn Cassia. The balance is bush. On 3 January, 240 mixed weaner cattle were weighed and introduced to the paddock. They were weighed each month up to mid June. Results are shown in Table 1.

Table 1. Live-weight gain of weaner cattle on Wynn Cassia at Midway 2003

Weight gain/loss (kg) in weaners at Midway from January to June 2003			
Period of measurement	Average gain/head	Days	Av. gain per day
Jan 3 to Feb 5	18.3	33	0.55
Feb 5 to Mar 10	5.9	33	0.17
Mar 10 to April 3	17.7	24	0.73
April 3 to May 12	25.4	35	0.73
May 12 to June 16	- 4.7	35	-0.13
Total	**62.6**	**160**	**0.39**

Fifteen cattle were missing by the June weighing. A number of cattle died while others either were not mustered or jumped the fence. The effect of these missing animals on the average performance of the herd is hard to predict.

The overall results indicate that these particular cattle did not perform well on the Wynn Cassia. While the period from March to April was relatively productive the animals were rapidly losing condition by May. The cattle put on less than 0.4 kg/day over the entire wet season, which should normally be the most productive period on improved pasture.

Nutrient analysis of Wynn Cassia during this period suggests that cattle should do considerably better than they have. Figure 1 shows that Wynn has good levels of crude protein during the wet season.

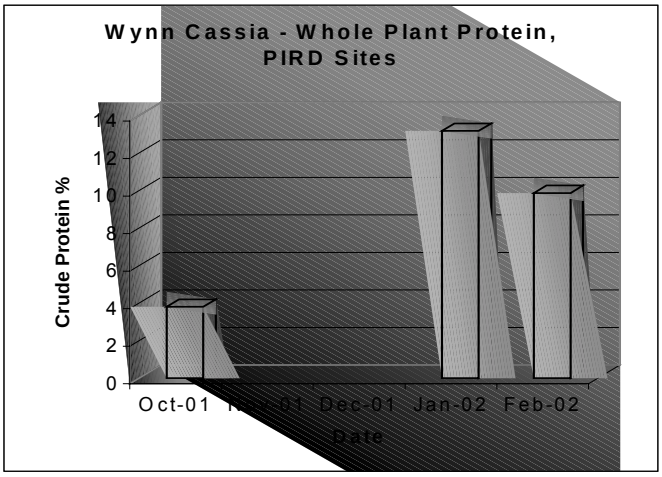


Figure 1. Whole plant crude protein of Wynn Cassia at evaluation sites

Empirical evidence indicates that Wynn Cassia has acceptance and/or palatability problems. Many cattle do not accept it readily and the lower than expected performance could be related to lower intakes of dry matter. Samples are being analysed for anti-nutritional compounds such as tannins. Protein, digestibility and energy have also been monitored throughout the season.

Information on the other grazing site at DDRF (Paddock 42) is detailed in *Evaluate the Benefit of Wynn Cassia as a Pasture Feed and Fodder Species in the Douglas Daly District* in this Report. The results of this project will be published in a report for Meat and Livestock Australia.

PROJECT: Irrigated Crop Extension and Industry Liaison

Project Officers: C. Ham, S. Lucas, F. O'Gara, and D. Parker

Location: Katherine/Douglas Daly

Objective:

Enhance the learning opportunities and information flow within and between industry and DBIRD to increase the performance of irrigated field crop enterprises in the Top End.

Introduction:

The peanut industry consists of a small dynamic producer base that is quickly forming a foundation for irrigated field crops in the Top End. Links are being formed with other cropping industries and may in time form an irrigated farming system. The knowledge base for peanut production in the NT is evolving year by year. This project is ongoing and integrates the “known” information, extends new information and identifies key issues for the future. Essentially, it facilitates information networks from “the paddock to the plate” by initiating one on one extension, field monitoring, farm walks, industry meetings, coordination of interstate expertise and industry performance reviews. From this process key industry issues are identified and incorporated into current research programs.

Outcomes:

Issue	Initial action	Follow up action	Assigned to	Time frame
Rotation options for irrigated cropping	Desktop study of crops information set up in matrix form	Compile input during 2003	DBIRD initially with help from all sectors if possible	Begun in 2002 by C Ham. Others sections in 2003
Rotation trials	Decided to initiate fodder trial during 2003 at DDRF, cotton trial at Florina Road, rotate with peanuts 2004	Follow progress and report back in 2003	DBIRD Irrigation team/Cotton CRC	2003 dry season
Peanuts on drip tape	Work with Fergus Roberts to investigate peanuts on drip tape for rotation with melons	2003 on farm demonstration at Fergus Roberts property	DBIRD Irrigation team	2003 dry season
Interim measures for rotation options for producers	Producers indicated they would make their own arrangements with this issue	Follow progress and report back in 2003	Producers	Review in Dec 2003
Cover crops and various methods of management for different soils	Cotton team to report back on cover crop trial 2002-03 wet season. Record observations on the commercial farms	Follow progress and report back in 2003	Cotton CRC/Producers/DBIRD irrigation team	Farm Walk at DDRF June 2003
Soil sampling	Agnote on soil sampling technique send out to producers. Options for lab testing forwarded on to producers	Producers to organise when they want to sample and when. Assistance with interpretation provided	Daryl Parker	ASAP
Identification of Rhizoctonia type	Put together procedure and costing	Farm walk 2003 at DDRF	KRS Pathologist	2003
Disease monitoring of upcoming peanut crops	Continue as planned, assist with budget in 2003 from GRDC	Weekly at Kath in peak times. Monthly at Douglas	KRS Pathologist	2003
Insect monitoring of upcoming peanut crops	Continue as planned, target peak times and not so much all year	Fortnightly in Katherine. Monthly in Douglas Daly	KRS/BARC Entomologists	2003
Weeds issues	Individual advice for various areas. Trial work at PCA farm to assist with new weed problems	Initiate weed trial at Florina Road Farm	DBIRD Weeds team/Irrigation team	2003 dry season
Sandwich digger trial (modifying moisture levels in windrow)	Digger needs repairs, PCA to advise when fixed		PCA Agronomist	Mid 2003
Seed issues Temp and humidity in transit	Cool room trial at DDRF 2003	Report back at Farm walk at DDRF 2003	PCA/Chris Ham	March 2003
Collection of sub lots at planting	Growers to collect regular sub lots at planting time	Keep cool and dry and forward to seed lab for testing	Growers/PCA/ seed lab	March 2003
Aflatoxin soil samples	Collected from DDRF	Forward to Qld aflatoxin team 2002	Chris Ham	2002
Variety trials	Amalgamate QDPI Breeding project/PCA	Report back at the end of 2003 year review	DBIRD Irrigation	2002-2004

Issue	Initial action	Follow up action	Assigned to	Time frame
	varieties and monitor disease resistance		team/KRS Pathologist/ QDPI and PCA	
Transport issues. Coordination of transport and pricing	NT AG to look into options and contact freight companies for options	Report back to growers by mid 2003	NTAG/PCA	2003
Field monitoring	Select three sites on each soil type for on farm monitoring	Report back in the end of year review 2003	Irrigation team DBIRD	2003

Farm walks

During the season several farm walks were coordinated both on Government and private farms

In field demonstrations

Local issues of concern are addressed through demonstration plots on private farms.

Season review

A review is held at the end of each season facilitated by DBIRD and includes the producers, processors, industry groups, researchers and extension officers. The results from the review set the objectives for the following year.

SUBPROGRAM: Cotton Industry Development

PROJECT: Research in Dry Season Cotton Production

Project Officers: **A. Dougall, M. Kahl, A. Duale, D. Owens, K. Lowndes, R. Sunnerdale, J. Wheeler, C. Martin, R. Eastick and N. Hartley**

Location: Katherine

Objectives:

Develop an agronomic package for efficient and sustainable field production systems for cotton.

Identify the most appropriate varieties of cotton in terms of yield, quality and maturity.

Develop suitable irrigation systems for commercial scale cotton production.

Introduction:

The cotton trials at Katherine are jointly funded by the Cotton CRC, the Cotton Research and Development Corporation and DBIRD. The project is based on the use of transgenic cotton grown in the dry season to minimise insect problems that contributed to the collapse of the Ord cotton industry in the 1970s.

The successful establishment of a cotton industry in the NT will depend on the availability of suitable land and irrigation water. It will also need the development of an integrated agronomic and entomological package for the successful production of the crop that will meet strict environmental guidelines.

General progress in 2002:

The first season of large-scale entomology trials under our 27.5 ha centre pivot was in 2000. Crops for various other trials were planted in the sub-surface drip irrigation area (2.7 ha) and in the lateral move irrigated area (13 ha). Of the total area, 2.5 ha was a conventional refuge crop (Siokra 1-4) with the remainder being transgenic Ingard® cotton (Sicot 289i and Siokra V16i). Unfortunately, yields were unsatisfactory.

Disease and nutritional factors as well as the cold weather and late sowing of the crop resulted in low yields. The 2002 dry season was the coldest since records began in 1957. Cotton yield and quality are markedly depressed by cold weather during the flowering period. The late sowing caused flowering to commence near the beginning of the cold period (Figure 1).

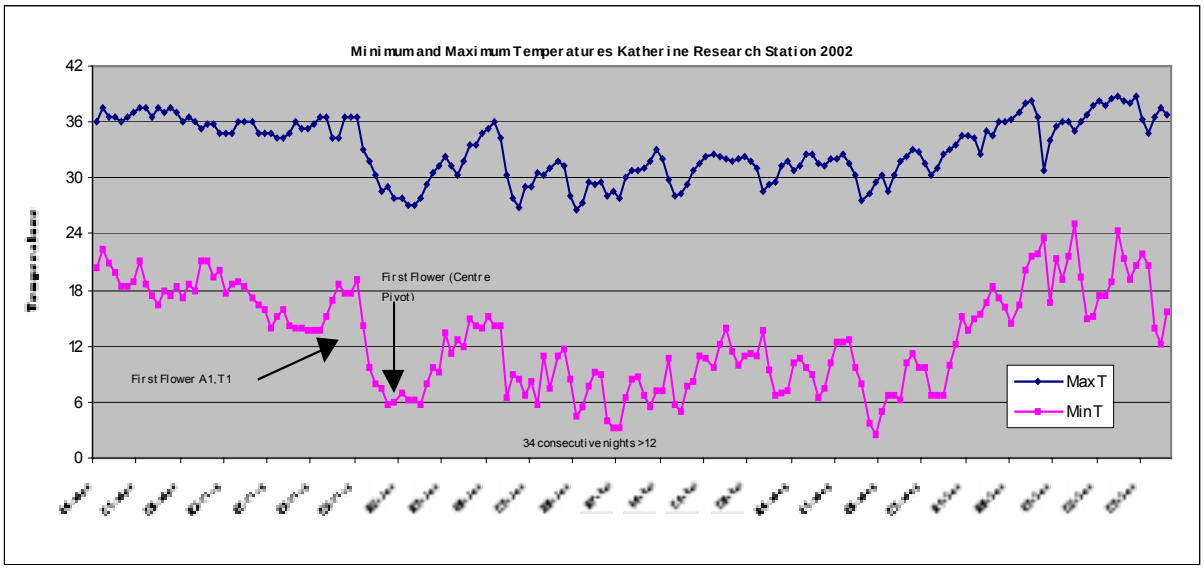


Figure 1. Time of flowering and the minimum and maximum temperatures during the 2002 cotton-growing season at Katherine Research Station

Both the high incidence of *Alternaria* leaf spot disease, and premature leaf senescence brought about by potassium and phosphorus deficiencies, considerably reduced green leaf area, and thus photosynthesis and lint yield. In the 2003 season we increased the rate of potassium application with little success. Next season supplementary foliar applications of potassium will be tried.

Experiments:

Variety trial

In the 2002 season there were 26 varieties in our trial, nine Bollgard II® varieties, 16 Ingard® varieties and a conventional standard. The results are shown in Table.1. Lint price is discounted for fibre lengths below 1.09 inches and micronaire values outside 3.5 to 4.9.

Table 1. Variety trial results

Variety	Type	Yield bales/ha	Turnout %	Length (inches)	Strength (tex)	Mic	*Alt* lesions per leaf
97421-152	Ingard	7.2	42.58%	1.04	24.53	4.75	5.8
96456-185	Ingard	6.18	40.88%	1.07	28.85	4.55	9.2
NuCOTN 37	Ingard	5.98	42.30%	1.02	25.40	5.13	8.1
NuCOTN 38	Ingard	5.84	42.63%	1.02	26.05	5.10	9.0
97606	RR Ingard	5.8	41.43%	1.02	26.23	4.35	10.7
DP 01Q40B	Ingard	5.67	39.20%	1.07	27.38	4.35	9.5
96480-71	Ingard	5.54	37.95%	1.11	29.45	4.18	6.4
Sicot 289i	Ingard	5.29	40.03%	1.08	27.35	3.95	11.3
DPX 99Q50B	Ingard	4.87	42.78%	1.01	26.15	4.55	7.1
Sicot 189	Conventional	4.79	40.18%	1.11	28.50	3.73	10.1
Siokra V-16i	Ingard	4.79	40.25%	1.02	25.25	4.58	7.2
NuPEARL	Ingard	4.72	40.68%	1.03	24.55	4.55	11.8
DPX 99Q51B	Ingard	4.63	41.55%	1.02	24.73	4.78	9.3
96425-32	N Ingard	4.60	40.60%	1.06	27.43	4.75	6.6
NuOPAL	Ingard	4.34	40.45%	1.07	26.43	3.98	10.6
95443-9	HG Ingard	4.32	39.73%	1.09	27.65	4.28	N/A
20405	Bollgard II	4.26	36.95%	1.07	25.25	4.45	10.0
20415	RR Bollgard II	4.2	37.18%	1.06	26.13	4.43	5.6
99425-68	Bollgard II	4.13	34.90%	1.06	24.75	4.60	6.8
20404	Bollgard II	3.64	36.68%	1.07	24.85	4.55	7.5
20414	RR Bollgard II	3.31	36.63%	1.05	24.50	4.15	6.7
DPX 99Q48D	Bollgard II	3.25	33.68%	1.09	24.05	4.00	7.6
DPX 99Q51D	Bollgard II	3.16	34.03%	1.05	24.70	4.40	7.4
20413	RR Bollgard II	3.13	34.78%	1.05	24.80	4.70	10.1
20401	Bollgard II	3.07	33.43%	1.04	24.08	4.80	7.0
NuTOPAZ	Ingard	2.75	38.88%	1.07	26.40	4.35	9.5

RR = Roundup Ready, N = Nectariless, HG = High Gossypol

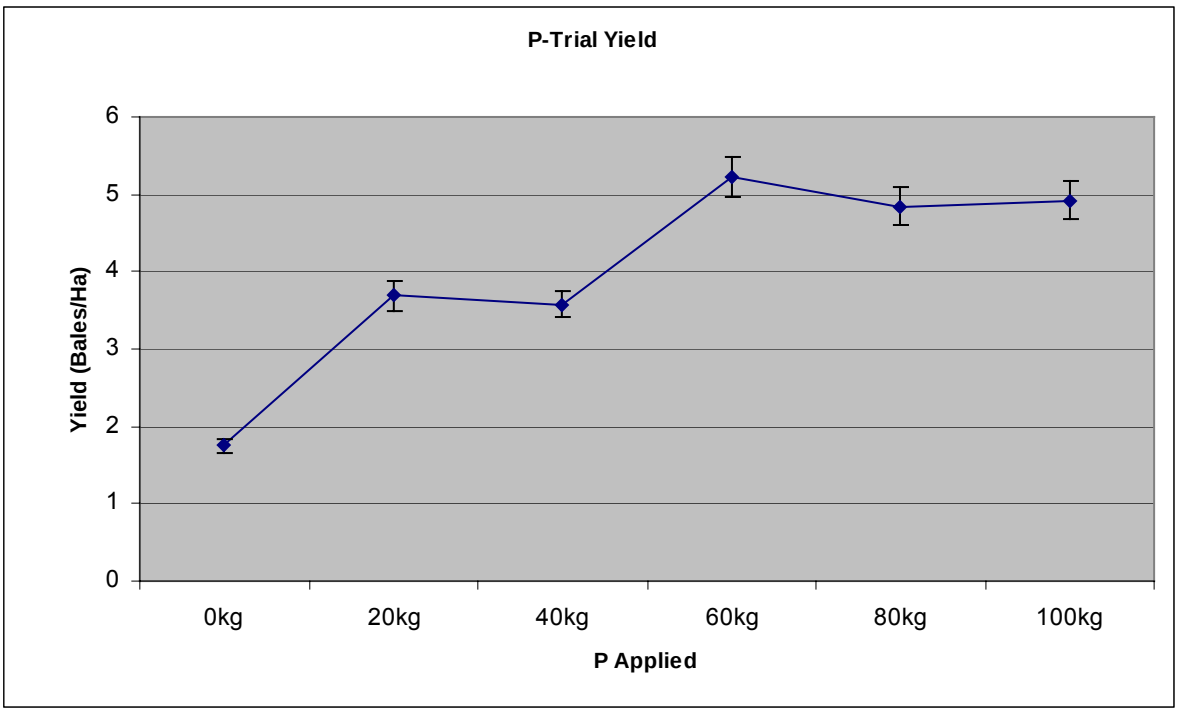
The data shows that only four varieties produced a satisfactory fibre length illustrating the detrimental effect that cold weather has on fibre quality. Generally micronaire was satisfactory. A number of varieties have been tried for three seasons (Table 2). The data suggests that the CSIRO variety 96480-71 is a good performer in fibre length and yield at Katherine.

Table 2. Yield and fibre length data from three seasons of variety trials at Kununurra

Variety	Mean yield (bales/ha)	Mean fibre length (inches)
97421-152	7.1	1.095
96480-71	6.5	1.11
NuCOTN37	6.4	1.06
96456-185	6.3	1.1
Siokra V16i	6.2	1.045
Sicot 289i	5.9	1.11
95443-9	5.8	1.11
96465-32	5.7	1.07
NuPEARL	5.5	1.07
99425-68	5.0	1.09
Sicot 189	3.3	1.115

Phosphorus (P) nutrition trial

A nutrition trial with six levels of P was conducted on some recently cleared country under the centre pivot. The aims of the experiment were to establish the economic rates of P required for cotton on virgin soil and to calibrate plant tissue analysis tests. Soil tests showed that Colwell P levels in the virgin soils were below detectable limits which provided an excellent opportunity for a phosphorus-rate trial Results are shown in Figure 2. Maximum yield was obtained at 60kg/ha of elemental P. The experiment needs to be repeated to confirm this result.



The vertical bars represent the confidence intervals at P<0.05

Figure 2. Yield results from the 2002 phosphorus nutrition trial

Progress in 2003:

Research has expanded off-farm in 2003 with 30 ha planted at the Peanut Company of Australia farm on the outskirts of Katherine. This crop is a replicate of an IPM experiment with the other replicate at the KRS pivot. The P nutrition trial has been done for another season and a new trial on potassium nutrition has been imitated. As in previous years, a variety trial has been conducted with CSIRO including Deltapine varieties.

PROJECT: Insect Dynamics of the Cotton Ecosystem in the Northern Territory

Project Officers: A. H. Duale, C. Martin, D. Owens and K. Lowndes

Location: Katherine Research Station

Objectives:

Benchmark the ecology of the key pests and beneficial insects that are likely to impact on a future cotton industry in the Katherine area before assessing preliminary integrated pest management systems.

More specifically the objectives of the project in 2003 were to:

Monitor the seasonal abundance of lepidopteran pests (Helicoverpa armigera, H. punctigera, Spodoptera litura and Pectinophora gossypiella – pink bollworm) weekly using pheromone traps at eight sites.

Assess the role of a companion crop (Lablab) in cotton IPM.

Determine the refuge requirements for Bollgard II cotton.

Develop early and late season thresholds for the control of sucking insects attacking Bollgard II cotton.

Make preliminary assessments of trap crops suitable for use in the Northern Territory.

Rear and identify beneficial insect species and rank their status in the NT and link data to biodiversity studies.

Progress in 2003:

The field work associated with the entomology program will finish with the crop harvest in September. Preliminary results showed that Bollgard II provided good control of *Helicoverpa* throughout the season with no spray required. Spodoptera damage was apparent early in the season but dropped to a very low level towards the end of July, probably because of the cold nights experienced from late June. With Bollgard II, sucking insects are probably the most significant insect pests in Katherine. Potential problem pests are the silver leaf white fly (*Bemisia tabaci* type B) and cotton aphids (*Aphis gossypea*) as they were found in surrounding horticultural fields.

Significant progress was made towards meeting the research objectives outlined above. The findings of this research are as follows:

1. A pheromone trap network established in April 2002 covering a total of eight sites was monitored weekly. Sites were selected to cover established agricultural areas, wet bush environs and dry bush environs. In addition to trap sites, a number of farms were visited to assess the situation of insect pests. Of the four insect species monitored, the most abundant were *Spodoptera litura* with a peak in May 2003 of over 200 and 170 catches at Campbell's field and KRS, respectively. They were followed by *Helicoverpa armigera* with a peak in May 2003 of over 170 and 120 catches at Campbell's field and KRS, respectively. Virtually no *Pectinophora gossypiella* and very few *H. punctigera* were caught.

2. Although the number of Heliothis eggs and larvae collected were relatively low, more Heliothis larvae (mainly first or second instars) were found on the Bollgard II cotton grown alone than on Bollgard cotton grown with lablab as a companion crop. Higher numbers of sucking pests and mirids were recorded from the Bollgard II cotton grown alone than on Bollgard II cotton grown with a companion crop (lablab). Lablab was an effective companion crop because in association with Bollgard II it decreased the number of pests in cotton. The probable reason was that lablab attracted beneficial insects (parasitoids and predators) which spread to cotton.

3. The refuge field of conventional cotton supported *Helicoverpa* spp. not exposed to Bt toxins as shown by the incidence of large larvae and moths. In contrast, no large larvae and moths were recovered from the Bollgard II fields. In short, we have had zero *Helicoverpa* populations from Bollgard II and a sufficient number from the refuge conventional crop ready to cross-breed and prevent the build up of resistance.

   At KRS pupal production under Bollgard II was minimal with only eight *Helicoverpa* moths being recorded from the emergency traps. At Campbell's 10 m of row were checked weekly by digging; only two Helicoverpa armigera pupae were found. Emergency traps will be used in all locations next season. Other species recorded from these trials included *Spodoptera litura* and *Anomis flava*.

4. Preliminary results from the early season sucking pest thresholds indicated that overall insect pressure was light resulting in high fruit retention. The unsprayed control treatment reached a population density of 1.65/m towards the end of the experiment. The threshold treatments of 0.5/m and 1.0/m plots required spraying once on 16 and 20 May, respectively (Figure1).

   Trichogramma parasitism of *Helicoverpa* was assessed by collecting eggs from the Bollgard II fields between June and July after which egg numbers declined markedly. Parasitism levels were very low and even dropped to zero from late July.

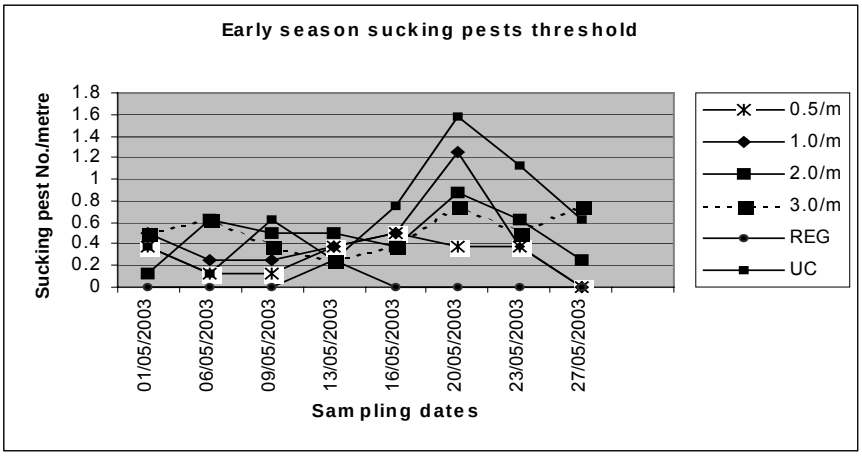


Figure 1. Threshold for sucking pests

The spectrum of pest and beneficial insects present in cotton and trap crops such as peanuts, seed sorghum and lablab were determined visually and by suction sampling twice a week. Beneficial insects that were identified included spiders, ants, lady beetles, red and blue beetles, damsel bugs, brown smudge bugs, stilt bugs, big eyed bugs and wasps. Tricogramma, Microplitis and tachinids have also been reared from eggs and larvae collected from the cotton grown at Katherine. Additional sampling has been undertaken in the broader environment to determine potential sources of beneficial and pest insects.

Future Directions

Work to be conducted over the wet season will focus on the population dynamics of the key pest and beneficial insects with special emphasis on the sources of these insects for the following cotton crop. High level of silver leaf white fly infestation was already noted from melon and peanut farms surrounding KRS.

In 2004 the following work is proposed:

1. Continue to monitor key lepidopteran pests four weekly using pheromone traps at eight sites.
2. Continue resistance testing and develop a resistance management strategy for *H. armigera* and Aphis *gossypii.*
3. Reduce resistance to Bt genes through refuge crops.
4. Continue to assess the suitability of various trap crops for use in the NT.

5. Assess the impact of sucking insects on cotton grown in the NT.
6. If not present, introduce *Trichogramma pretiosum* from Kununurra.
7. Rear and identify beneficial insect species and rank their status in the NT.

SUBPROGRAM: Weeds Management

PROJECT: Weed Management in Cavalcade Production Systems

Project Officers: R. Eastick, N. Hartley and B. Beumer

Location: Mt. Keppler, Adelaide River

Objective:

Evaluate integrated weed management strategies in a Cavalcade production system.

Background:

This project commenced at Mt. Keppler in the 1997-98 wet season, at which time herbicide efficacy on conventional sown Cavalcade was evaluated. The inclusion of no-till-sown Cavalcade in following years allowed evaluation of the interaction between tillage and herbicide treatments on weed dynamics. Weed invasion and the necessity for rotation of chemical groups to avoid development of herbicide resistance led to the inclusion of a grass rotation (*Digitaria milanjiana* cv Jarra), sown in the 2000-01 wet season, and retained in 2001-02 during which broadleaf weeds were successfully selectively controlled. In the 2002-03 wet season, half of the Jarra area was re-sown to Cavalcade to determine if the grass rotation effectively reduced the weed burden in the Cavalcade crop.

The method, results and discussion are presented for the 2002-03 Cavalcade production season.

Method:

Cattle continued to graze the Jarra over the dry season, then were removed in November to allow the vegetation to recover prior to application of glyphosate on the designated no-till area in early December. A large amount of grass was unused, so mulch levels were higher (4 t/ha) than desirable (2 t/ha) which made sowing difficult. Similarly, the designated conventional till area had a large amount of dry matter, which was burnt, and then the area was cultivated.

Senna and calopo were the major weeds emerging in the Jarra area. To target these broadleaf weeds, a herbicide mix (*Brushoff*® at 20 g/ha and *Amicide* 625® at 1 L/ha with *Chemwet* at 0.2%) was applied on 20 December 2002.

The area was sown with Cavalcade and the post-plant pre-emergent *Spinnaker*WDG® (140 g/ha) was applied on 10 December 2002.

A schematic representation of the applied treatments is given in the figure below (*Spinnaker*® is designated as HBC).

<table>
<tr><td colspan="2">CONVENTIONAL TILL</td><td colspan="2">NO TILL</td><td rowspan="2">JARRA</td></tr>
<tr><td>NO HBC</td><td>HBC APPLIED</td><td>HBC APPLIED</td><td>NO HBC</td></tr>
</table>

Plan of *Spinnaker* / tillage treatments applied in 2002-03 wet season

Biomass harvests were collected at three times: 7 January (27 DAS), 11 February and 14 April 2003. Two quadrats (0.5 m x 1 m) were cut in each of the treatment areas. Weed species, which were present at each time, were also recorded.

The area was mown and the material was baled at the end of May, as in a commercial situation to provide a realistic scenario with respect to removal of dry matter and seed.

The treatments applied for this 2002-03 season were intended primarily as a demonstration area, but data analyses were conducted using a general linear model to quantify trends in weed dynamics.

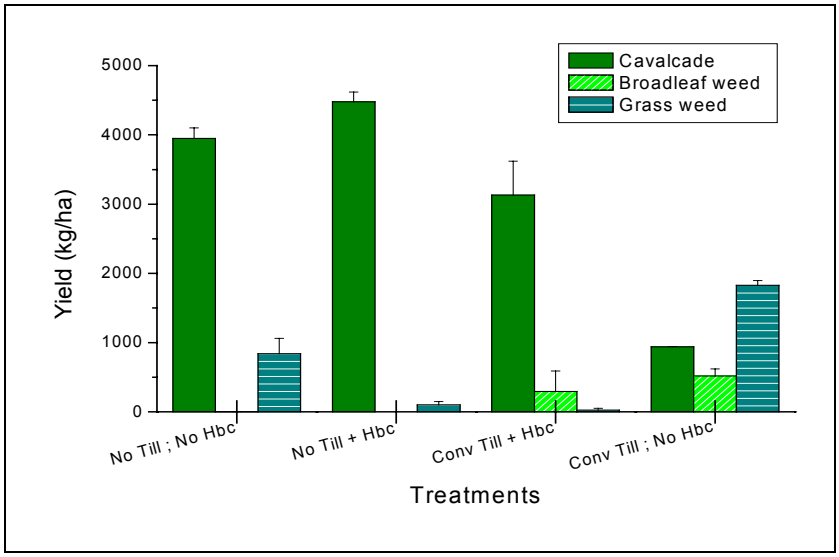
Results and Discussion:

There were no statistically significant differences due to large errors associated with the low sample size, but there were considerable biological trends.

Herbicide effects: Spinnaker® in both conventional and no-till treatments effectively reduced the emergence of the broadleaf weeds (*Sida* spp, pigweed and *Ludwigia* during early crop establishment, but the calopo and Senna were not significantly affected. Similarly, *Spinnaker*® was effective in reducing *Pennisetum pedicellatum* and Jarra grass emergence, although it appeared to have little effect on crowfoot grass (*Eleusine indica*). This verifies that *Spinnaker*® applied pre-emergence is a valuable option for weed control, except for some legume weeds. In a grass pasture rotation where subsequent invasion of grasses in the Cavalcade phase may be a concern, application of *Spinnaker*® may reduce the need for post-emergent application of a grass selective herbicide.

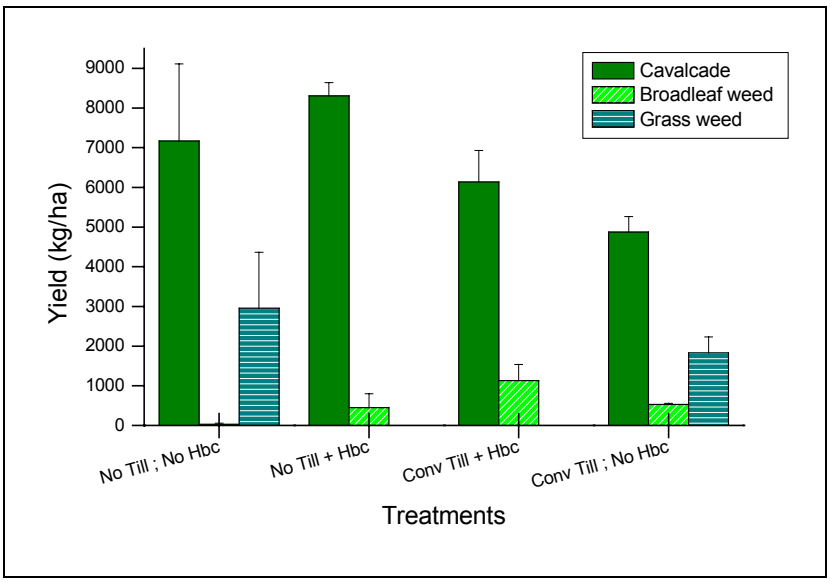
Tillage effects: There was more broadleaf weed biomass at final harvest in the conventional tillage treatments than in the no-till treatments. The major broadleaf weeds were Senna and calopo, which are recognised as having a large proportion of hard seed, for which soil disturbance has been observed to stimulate germination. Consequently, cultivating the soil effectively enhances the germination of these weeds, both of which are difficult to selectively control in Cavalcade by in-crop herbicides.

The interaction between tillage and herbicide treatments at the initial harvest indicated that in early Cavalcade establishment, the no *Spinnaker*® treatments had the greatest amount of weeds, predominantly pigweed, (*Portulaca* sp.) and this was higher in the conventional till than in the no-till plots (Figure 1). The pigweed died off over the duration of the Cavalcade growing season, effectively reducing the relative biomass of broadleaf weeds to Cavalcade. The no-till areas produced the highest Cavalcade yields by the time of final harvest, with the *Spinnaker*® applied treatment (8t/ha) better than the area where no *Spinnaker*® had been applied (Figure 2).



Error bars include standard error

Figure 1. Yields (kg/ha) at second harvest, 11 February 2003



Error bars include standard error

Figure 2. Yields (kg/ha) at third and final harvest, 14 April 2003

Conclusion:

No-till sowing of Cavalcade followed by pre-emergent application of Spinnaker® is the optimum strategy to minimise weed burden in a Cavalcade crop, particularly that of broadleaf weeds which are difficult to selectively control using in-crop herbicides. Integral to this strategy is the incorporation of a grass rotation which enables a reduction over time in the broadleaf weed seed bank through herbicide rotation and grazing management, and provides suitable mulch levels as a precursor to no-till production systems.

PROJECT: Weed Management in Cotton Production Systems

Project Officers: A. Dougall, R. Eastick and N. Hartley

Location: Katherine Research Station, Berrimah Farm

Objective:

Evaluate a range of herbicides for control of weeds in a cotton production system.

Background:

The formulation of weed management strategies appropriate for sustainable cotton production in the Top End of the NT is a continuing research priority. A sustainable production system would likely include crops grown in rotation with cotton, and based on no-till farming. In the absence of cultivation there is more reliance on herbicides for weed management, particularly effective "over-the-top" herbicides which allow weeds in the plant line to be targeted. *Stomp*® (pendimethalin) applied pre-emergent (4 L/ha) and *Verdict*® (haloxyfop) forms the basis of current chemical weed control, and was considered as the best-bet strategy. *Staple*® (pyrithiobac) is an option for post-emergent control. The advent of new chemical formulations requires assessment of these chemicals under northern irrigated cropping systems. We aimed to compare an existing over-the-top herbicide, *Staple*® with a recently developed herbicide, tryoxysulfuron (TS) for efficacy against weeds, and phytotoxicity of cotton.

A number of prevalent weeds in northern Australia are not commonly found in temperate cotton production systems. Potential rotation crops with cotton are Cavalcade or peanuts, which could

subsequently become weeds in a cotton crop. We required additional information on the efficacy of TS and *Staple*® on these weeds, so a specific screening experiment was also conducted.

Method:

There were two components to this experiment:

- Part A: Application of herbicides in a field experiment within the cotton production area.
- Part B: Application of herbicides to specific weeds sown in a pot trial.

Part A

The trial was conducted under the lateral move irrigator at Katherine Research Station using a randomised complete block design. Siokra V-16i was sown on the 15 April 2002, and the herbicides were applied four weeks later with the *Agmurf* ® experimental sprayer, when the cotton crop was 30 cm high (4-8 leaves). Plots consisted of six rows, each 15 m long.

Herbicide treatments were:

1. Best bet/traditional management plus 120 g *Staple®* "over-the-top" spray (100% band).
2. Best bet/traditional management plus 15 g TS "over-the-top" spray (100% band).
3. Best bet/traditional management plus 30 g TS directed spray (80% band).
4. Stomp only.
5. No herbicides and hand weeded (crop only).
6. No herbicides and not hand weeded (crop + weed).

Two observation treatments were applied to single plots; TS 30 g "over-the-top' and *Staple*® 120 g "over-the-top", neither of which had the pre-emergent *Stomp*® applied.

Measurements consisted of:

Damage ratings: Cotton and weeds in each plot were evaluated for herbicide damage on a scale of 0 to 10.

Weed species present: Weed species present in each plot were recorded and the most prevalent three were ranked (1-3).

Damage ratings and weed species were recorded three times:

- 14 May - immediately prior to any post-emergent herbicide treatments;
- 29 May - at two weeks after herbicide application (immediately prior to *Verdict* application).

- 28 June at six weeks after herbicide application.

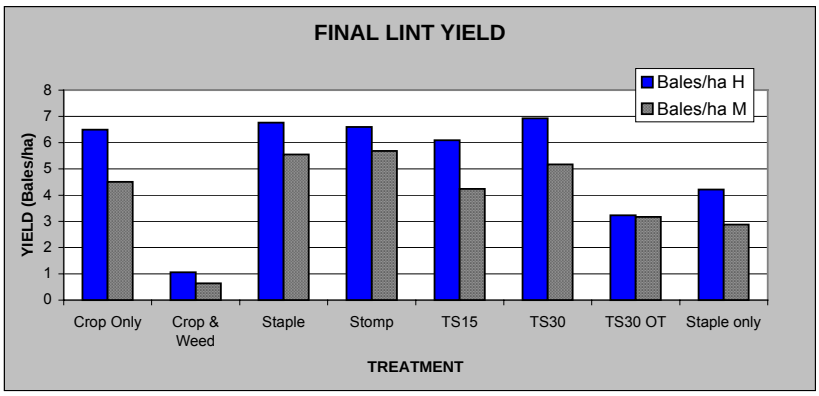
Biomass: Crop (1 m of row by two rows) and weed (1 m x 1 m quadrat of crop inter-row) biomass was collected at two times:

- 28 June at six weeks after herbicide treatments were applied;
- 25 September at five months after herbicide treatments were applied, immediately before defoliation of the cotton crop before harvest.

Crop yield: Cotton yield at final harvest on 4 November was determined by hand harvesting 2*1 m of row, then 2*10 m by machine.

Results:

Trends for the final lint yields are presented in Figure 1. No differences in final yield were noted between any of the herbicide treatments, except for the two observation treatments. Both TS treatments in association with a pre-emergent herbicide provided excellent weed control.



H = Hand-picked; M = Machine picked

Figure 1. Mean yields at final harvest

Part B

This component supplemented the cotton herbicide field experiment conducted at Katherine. The patchiness of weeds in the field required that efficacy of the herbicides on specific weeds be assessed. This was done by sowing a range of weed seeds in a pot.

Method:

A pot trial was conducted at Berrimah Research Farm using a randomised complete block design. Seed was sown on 5 June and herbicides were applied seven weeks later with the Agmurf ® experimental sprayer. Cotton was included to assess damage, and to indicate growth stage when herbicide application would be appropriate.

Herbicides:

1. 120 g *Staple*® "over-the-top"
2. 15 g TS "over-the-top"
3. 30 g TS 'over-the-top'
4. Control (no herbicides)

Weeds:

1. *Senna obtusifolia* (Senna)
2. *Macroptilium lathyroides* (Phasey bean)
3. *Alysicarpus vaginalis* (Buffalo clover)
4. *Crotalaria goriensis* (Crotalaria) #
5. *Hyptis suaveolens* (Hyptis)
6. *Lablab purpureus* (Lablab)
7. *Centrosema pascuorum* cv. Cavalcade
8. *Gossypium hirsutum* (Cotton)
9. *Arachis hypogaea* (Peanuts)

#Crotalaria did not emerge, so was replaced with Tridax Daisy (*Tridax procumbens)*

Measurements consisted of:

Damage ratings: Plants were evaluated for herbicide damage on a scale of 0 to 10, at four times:

- 24 July - immediately prior to any post-emergent herbicide treatments;
- 1 August - 1 week after herbicide treatments were applied;
- 21 August; four weeks after herbicide treatments were applied;
- 5 September - at final harvest.

Plant counts: Plant numbers were also recorded at these times. Mortality was calculated as a proportion of the number of plants present at the time of spraying, as seed from some species continued to emerge after herbicide application.

Biomass:

Plants were harvested on 5 September.

Results:

Means for mortality and damage of surviving plants are presented in Figures 2a and 2b. As germination was erratic for lablab, tridax daisy and buffalo clover, they have been excluded.

The TS demonstrated excellent efficacy on most of the broadleaf weeds examined. Although it did not result in high mortality for Cavalcade, phasey bean and Senna, it severely retarded plant growth and vigour. TS at both rates eradicated Hyptis, although a few surviving plants regenerated by final harvest.

Staple® killed few plants; damage ratings were also low, indicating relatively low efficacy when sprayed on large weeds.

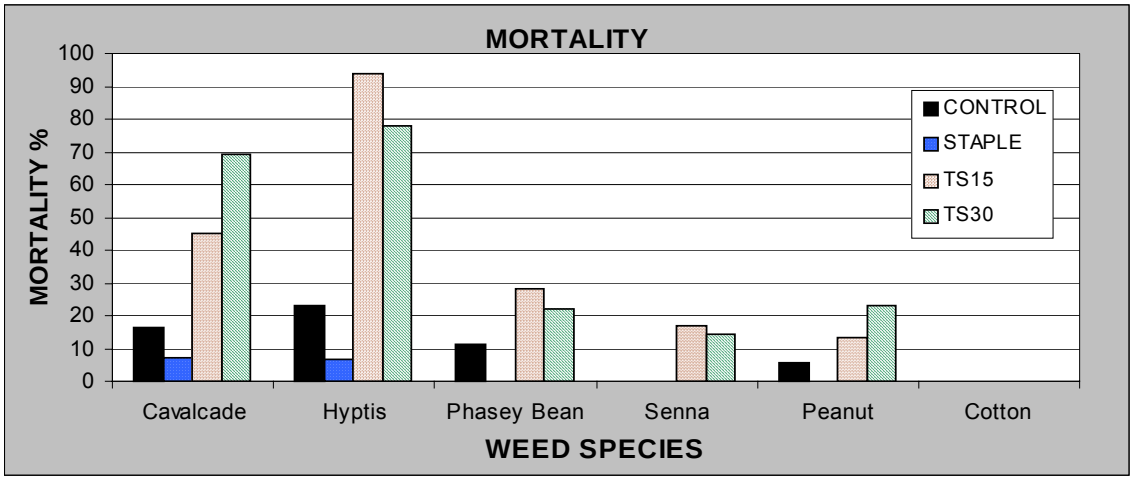
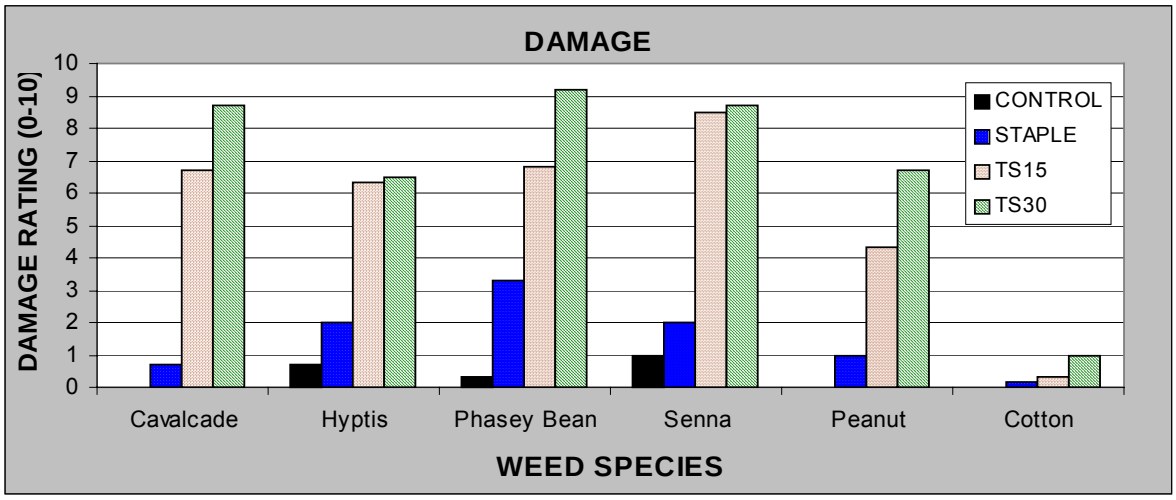


Figure 2a. Mortality of selected weed species at final harvest, three months after sowing



0=no damage; 10=total kill

Figure 2b. Damage rating on selected weed species at final harvest, three months after sowing

Discussion and Conclusion:

Herbicides are an important component of weed management, but must be incorporated in an integrated weed management strategy. However, the emergence of TS, since its registration as *Envoke*®, as an effective herbicide against a number of weeds common in the Katherine area production systems, provides an option of in-crop control.

TS demonstrated that it is a suitable option for in-crop weed-control, particularly at the higher rate as a directed spray for larger weeds on which *Staple* appears to have had minimal impact. However, results from the field experiment for the 2002-03 season indicated that the addition of a post-emergent broadleaf herbicide may not have been cost-effective because there was no effect on yield. This is applicable in this situation, where grass weeds were the dominant weeds, and were managed with *Verdict* ®. We have little information on weed thresholds.

The advent of *Round-up Ready*® for cotton cultivars provides another option for in-crop weed control. However, further work was required to evaluate the fit of *Round-up Ready* within a cotton production system. Such work was initiated in the 2003 cotton production season, in association with evaluation of a number of other chemical control options. Results from this experiment will be presented in next year's report.

SUBPROGRAM: Agroforestry

PROJECT:	**Species Testing and Genetic Improvement of Forest Trees for the Northern Territory (RIRDC/LWRRDC/FWPRDC) Joint Venture Agroforestry Program**
Project Officers:	**D. Reilly, B. Robertson, with Dr. G. Nikles and K. Robson of the Queensland Forestry Research Institute (QFRI)**
Location:	Top End of the NT and two sites in Northern Queensland.

Objectives:

Develop a farm forestry industry in the Northern Territory by providing information on the adaptability and potential growth rates of existing high quality native and exotic genotypes on a range of sites in the region.

Develop facilities suitable for genetic seed production and selection of superior plants for further breeding work.

Maintain the acacia and eucalypt genetic facilities of QFRI in North Queensland.

Improve the expertise of DBIRD staff in genetics and tree breeding.

The methodology for this project was based on a staged approach for the rapid development of high yielding forest tree varieties. These stages include:

- Parallel testing of 'best bet' taxa (species, provenances and hybrids).
- Development of commercial varieties matched to sites from the superior taxa identified in trials.
- Infusion of new genetic material including various locally produced hybrids.
- On-going breeding for refinement of superior varieties.

The approach also incorporates best practices in all aspects of the project, and maximises the publicity and effective 'take up' of the results.

Method:

Trees were planted for a taxa trial in the Darwin River region and a seedling seed orchard at Howard Springs during the 2000-01 wet season. The 1.7 ha area at Darwin River was planted with 32 different species, provenances, hybrids and clones of hardwood trees for evaluation in the NT environment (see Table 1 for species composition). At Howard Springs, the eucalyptus pellita seedling seed orchard was established on a 3-ha site comprising four provenances planted in a randomised complete block design replicated across the site. As the number of families varied between each of the provenances, it was decided to plant two rows of each of the Kiriwo and Goe (PNG) provenances per block and one row of each of the Melville Island and Serisa (PNG) provenances per block. The large number of families in the Kiriwo and Goe provenances is shown below.

- A bulk lot of 30 selected from a Melville Island provenance trial (seed lot 19718).
- A Kiriwo provenance from PNG (seed lot 19206) – 71 families.
- A Goe provenance from PNG (seed lot 19207) – 59 families.

- A Serisa provenance from PNG (seed lot 18199) – 12 families and a Serisa provenance from PNG (seed lot 18955) – 24 families. These two provenances were bulked together.

Seedlings were planted in 16 rows with six rows per block and a total of 36 blocks. The spacing was 4 m between rows and 2 m along the rows, resulting in a stocking rate of 1,250 stems/ha. After planting, 50 kg/ha of phosphorus was applied in a circle around each seedling at both sites. At both the taxa and the seedling seed orchard trials, preparation consisted of deep ripping and mounding rows and a pre-plant application of glyphosate along the rows at 1-2 L/ha. A post-planting spray of Simazine was applied only along the rows, approximately 1 m wide at 6 L/ha for residual weed control. Slashing the inter rows has been maintained at both sites to reduce weed growth. Hand spraying with glyphosate was necessary at both sites to reduce initial weed competition on the seedlings as the Simazine had minimal effect at the rate applied, especially on the heavier clay site.

Table 1. Species and provenance composition in the taxa trial at the Darwin River property

Species	Provenance	Seed lot No./Source	Experiment
Eucalyptus pellita	Melville Island, Serisa (PNG) and Qld SSO	19718, 18199/18955 and 5203	Taxa trial
Acacia crassicarpa	Oriomo (PNG) and Fiji SO	19731 and 20003	Taxa trial
Acacia mangium	Qld SO	10204	Taxa trial
Eucalyptus camaldulensis	Katherine and Thai SO	10537 and 20383	Taxa trial
Eucalyptus cloeziana	Herberton and Koorboora	137 and 10682	Taxa trial
Corymbia citriodora	Hughenden and Glenden	11148 and 10895	Taxa trial
Eucalyptus tetradonta	Darwin collection	Local Darwin region	Taxa trial
Corymbia nesophila	Cape York Qld	North Queensland	Taxa trial
Eucalypt hybrid clones	*E. camaldulensis x E. grandis* (C x G)	Kleinig collection clones No. 9,10,11 12,13 and 20	Taxa trial
Eucalypt hybrids seedlings	*E. urophylla* x *E. pellita* and *E. urophylla* x *E. grandis*	M1677 x lep6-034, M1677 x lep7-015, 012 U X G (B5993) and (B10509)	Taxa trial
Khaya senegalensis	Darwin collection		Taxa trial
Khaya anthotheca	Darwin collection		Taxa trial
Pterocarpus dalbergioides and P. macrocarpus	Darwin Collection		Taxa trial
Chukrasia tabularis	Thanh Hoa Vietnam	20035	Taxa trial
Swietenia humilis	Central America		Taxa trial

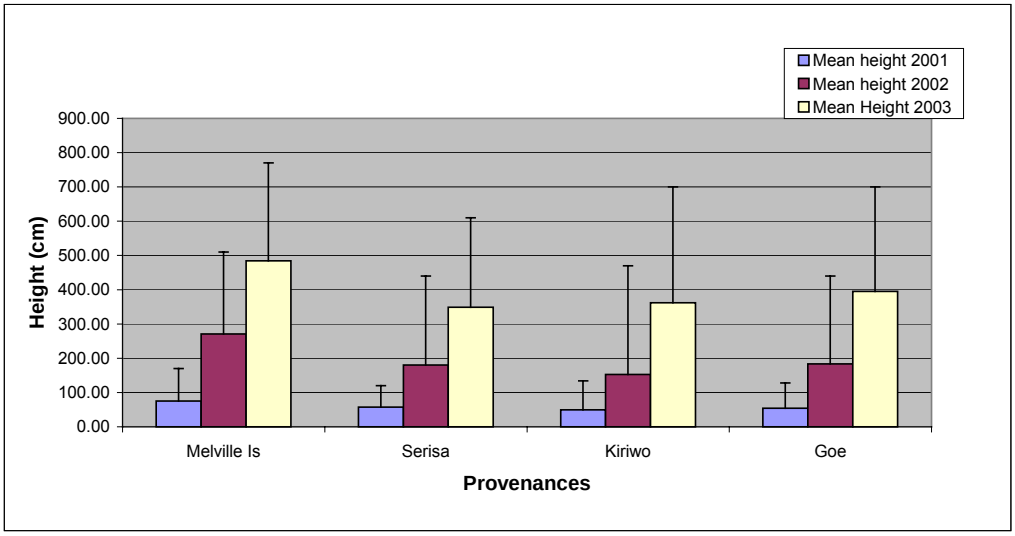
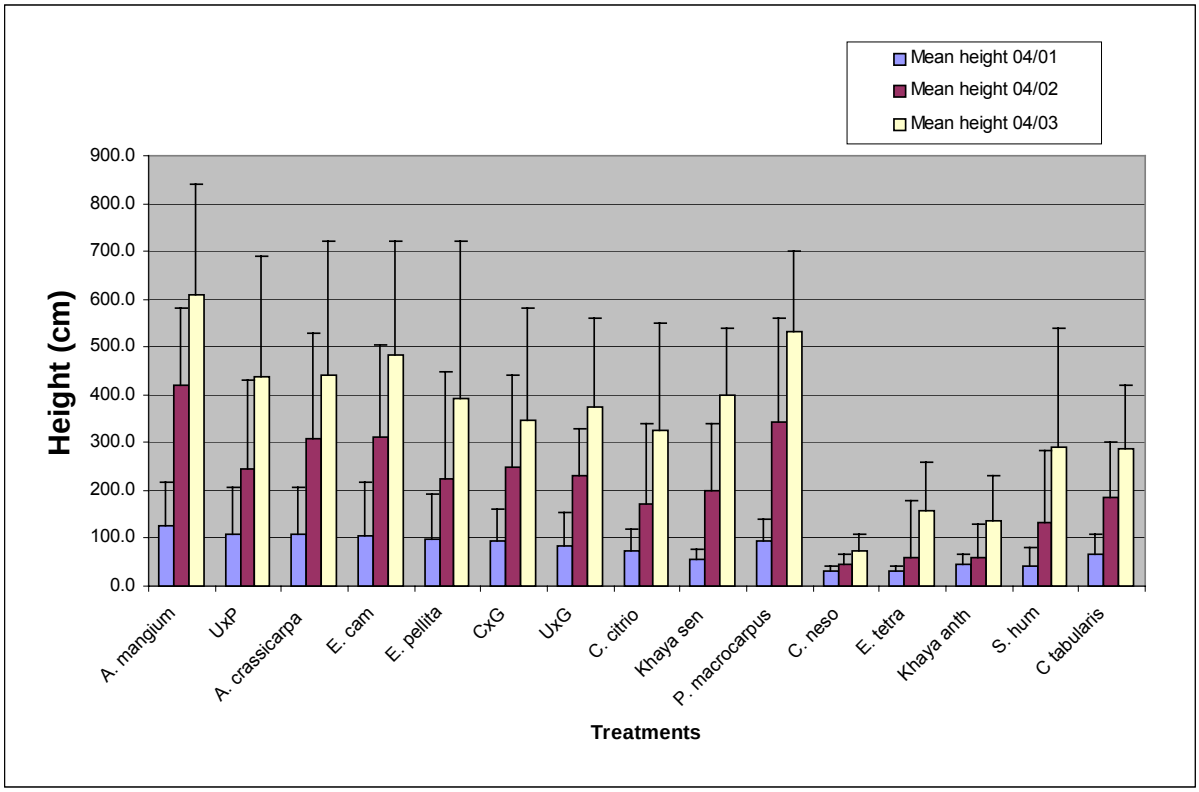


Figure 1. Mean height of *E. pellita* provenances at Howard Springs at 4, 15 and 27 months



Error bars indicate maximum heights

Figure 2. Mean height of species in NT taxa trial at the age of 4, 16 and 28 months

Figures 1 and 2 indicate very promising results for some species and provenances. In the *E. pellita* SSO the best performing provenance was the Melville Island provenance with an average height just under 5.0 m and maximum heights of over 7.5 m. The Goe provenance is next with an average height of 4.0 m with Serisa and Kiriwo having average heights over 3.5 m. Survival across the seven selected blocks (that were refilled after deaths) that are measured is very good but survival across the whole block is poor due to termite attacks that have now been controlled with the assistance of the Termite Group. Some trees have already been observed with seed at only three years of age. However, seed will not be collected until inferior trees are thinned so that only the best trees in terms of growth and form contribute to the breeding program.

The results of the taxa trial at 28 months are somewhat disappointing in that the genetically improved hybrids and clones are being out-grown by the unimproved pure species of *E. pellita* and *E. camaldulensis.* These species are both components of the G x U and U x P hybrids and the G x C clones. The best performing species is the fast growing *Acacia mangium* with an average height of over 6.0 m. The exotic species, *Pterocarpus macrocarpus* is the next in terms of growth and is the tallest of all the high value hardwood species with an average height over 5.2 m in 28 months.

In the second year of the project, it was decided that the African mahogany, *Khaya senegalensis* warranted further work to improve the form of the species and to conserve the genetic resource of a series of provenance trials at Gunn Point. There is uncertainty about the future of these valuable plantings at Gunn Point site due to wild fires, land tenure changes and development proposals in the area.

Khaya senegalensis or the dry zone mahogany from the Meliaceae family is a large semi-deciduous tree to 35 m in height and over 1 m in diameter. The timber is considered to be of very high quality and its uses include furniture making, plywood, counter tops, joinery, turnery and carving. In Africa it occurs in riverine forests and higher rainfall savannah woodlands. Its distribution is from Senegal on the west coast, to Sudan and Uganda on the eastern side of the continent. Khaya is adaptable to a wide range of soil types and will tolerate seasonal water logging. During the first year of growth, the

tree develops a strong, deep taproot, which makes it the most drought-hardy of all the Khaya species - hence the common name, “dry zone mahogany”.

To satisfy the needs of a number of prospective growers interested in planting and developing plantations of the species, we should be in a position to provide them with good genetic material. During 2001, we selected superior candidate trees on the Gunn Point site. Each selected tree was allocated a number and coordinates and measurements were recorded. Scion material was collected from these superior trees and grafted onto rootstock, (previously collected as striplings and grown in the nursery). Enough grafted clones were produced off a range of selected trees within each provenance to establish a 384 tree clonal seed orchard at Howard Springs and a 192 tree clonal seed bank at Berrimah Farm in the 2001-02 wet season.

Table 2. Provenances of *Khaya senegalensis* represented by year of planting at Gunn Point

(The number of selected trees from each provenance are in brackets)

Seed code	Provenance	1970/71 (EP 363b)	1971/72 (EP388)	1972/73 (EP420)
D391	Central African Republic	(7)	(1)	-
D407	Uganda	(5)	-	-
D408	Uganda (West Nile)	(3)	-	-
S9620	Uganda (West Nile)	(2)	(3)	-
S10053	Uganda	-	-	(4)
D411	Togo	(6)	-	-
D415	Upper Volta	(4)	(4)	-
D416	Upper Volta	(4)	(5)	-
D417	Senegal	(5)	(4)	-
S9392	Senegal (69)	(5)	-	-
S10066	Senegal	-	-	(5)
S9368	Sudan	(2)	-	-
S9687	Sudan	(5)	(5)	-
D477	New Caledonia	-	(3)	-
D487	New Cal.(ex Ivory Coast)	-	(6)	-
D522	Noumea New Caledonia	-	-	(4)
S10050	Ivory Coast	-	(5)	-
D480	Nigeria (Jos)	-	(6)	-
D486	Nigeria (Yola)	-	(5)	-
D500	Ghana	-	(5)	(6)

After planting, assessments for health and survival have been undertaken at regular intervals. Further height measurements in July 2003 indicated the top clones common to both the CSO and CCB were:

Clone No.	Seed lot No.	Provenance
8	D522	New Caledonia (ex Ivory Coast)
14	S10066	Senegal
17	S10066	Senegal
22	D480	Jos Nigeria
25	S9687	Sudan
34	D500	Ghana

The final taxa trial established in the series of genetic improvement trials was funded by RIRDC and located on a site at Howard Springs.

The second of the taxa trials was established over two days, on 31/12/02 and 2/1/03 on government land at the Howard Springs site adjacent to the *E. pellita* SPA. The design consisted of eight treatments with four replications. An individual tree application of 200 g of NPK fertiliser (6:14:14.2) was applied on 6/1/03. Superimposed on top of this in replications 1 and 3 was an application of agricultural lime at a rate of 3858 kg/ha applied into the deep ripped lines before planting. This rate was calculated so as to bring the soil optimum calcium level to 600 ppm. The initial soil test indicated a soil pH of 5.3 and the application of lime was intended to raise the pH to about 6.0

Overall survival at the April measurement (age four months) was good except for *E argophloia* (17%) and the Corimbia hybrid complex (67%). The two outstanding species for height growth were *A.crassicarpa* (mean height 148.5 cm) from the Fiji seed orchard, and *Pterocarpus indicus* (mean height 150 cm). Since the April recording there have been some losses to *Mastotermes darwinensis* (giant termite). A baiting program has commenced. The *E. pellita* SPA has similar termite problems, but seems to have slowed down after a concentrated baiting program.

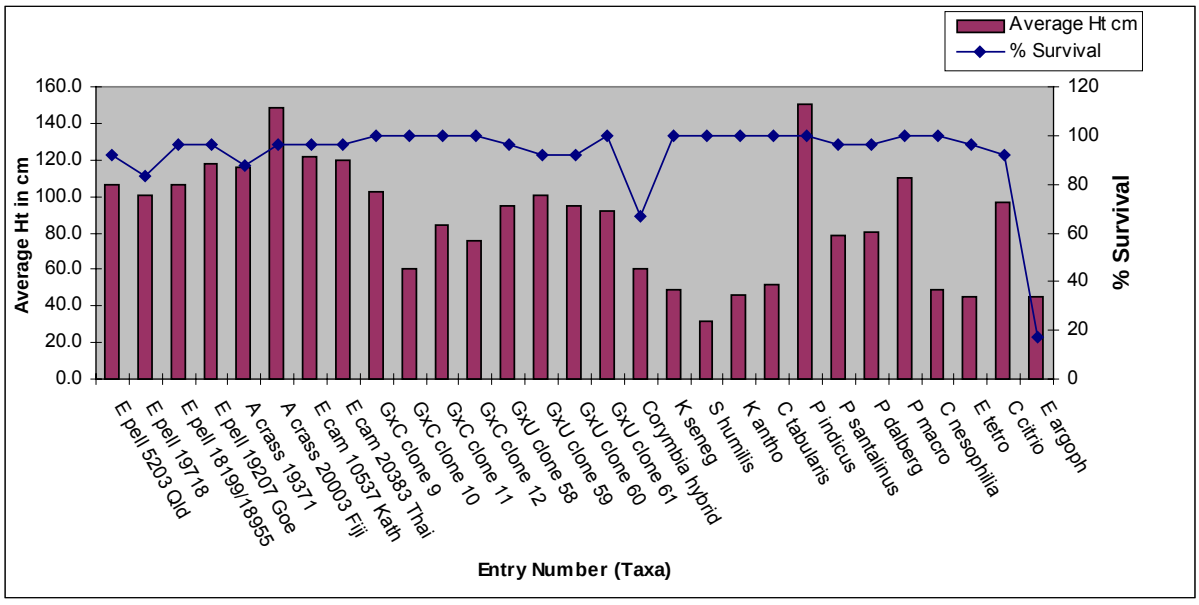


Figure 3. Howard Springs taxa trial - height (cm) and survival (%) at the age of four months

PROJECT: Evaluation of Teak (*Tectona grandis*)

Project Officers: D. Reilly and B. Robertson

Location: Douglas Daly Research Farm

Objective:

Evaluate a number of propagation methods to determine the most suitable for teak when planted in Blain soil type.

Introduction:

Recently there has been considerable interest in growing teak in the NT and to discover the most suitable propagation method and soil type for its growth. In its natural state in Asia where it grows in mixed deciduous forests below 1000 m, teak is becoming a diminishing resource as reflected by its rapid decline due to high demand and ever-increasing price. Teak was included in many trials in the early years of forestry research in the NT. The trials were established on sites now known to be unsuitable for teak and where the risk of termite attack was very high. One such trial was established nearly 30 years ago at the coastal plains fringing forest near Fogg Dam for provenance screening. The nine provenances are still there despite poor survival of some trees within provenances, may be due to fire over the years.

Method:

DBIRD staff collected seed off the ground from this trial in mid 1998 and stored all seed together, as it could not be determined which tree produced which seed. The seeds of the nine provenances were bulked together, treated repeatedly with cool water and allowed to dry off for 10 days before sowing in open boxes filled with a mixture of sand and coco-peat. Seedlings were then allocated to three treatments for planting. One group was propagated in 1 L plastic bags, another group was transferred to “Plantek” seedling trays, (capacity of each cell was 270 cc) and the third group was ‘open rooted’ where the shoots and roots are trimmed and the remaining stump is planted straight into the ground.

The trees were planted in blocks of 5 x 5 in the three different treatments and replicated three times. A two-row buffer was planted around the outside of the trial area using the same seed source. Trees were planted into ripped rows that had previously been sprayed with herbicide for pre-planting weed control. The rows were ripped at 3-m intervals and the trees were planted every 2-m within the rows. Planting took place on two separate occasions. The first was on 17 December 1998 and the second on 28 January 1999. On 3 February 1999 each tree received 200 g of mixed fertiliser with trace elements. Measurements were first taken in August 1999 for survival and growth. Survival and initial growth was good in the treatments with 1-L bags and ‘Plantek’ trays - 100% and 95%, respectively. In the ‘stumped’ treatment, survival was only 81% and this was attributed to the poor quality of available planting material. Many of the stumps were too small to be planted out but as the wet season progressed, time was running out for establishing a rain-fed trial. The poor growth in the treatment is shown in Figure 1.

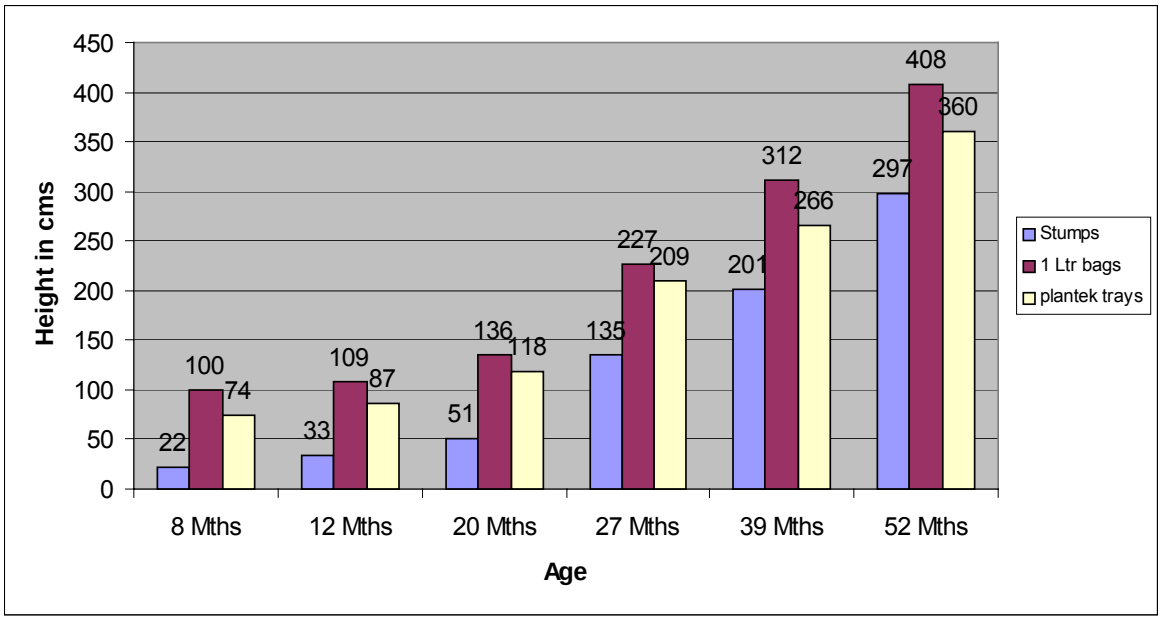


Figure 1. Mean growth of teak over a 39-month period at Douglas Daly Research Farm

SUBPROGRAM: Livestock Management

PROJECT: Tenderbuff Development and Supply Project

Project Officers: B. Lemcke, E. Cox, L. Huth and BHF Staff

Location: Beatrice Hill Farm (BHF)

Objective:

Supply and promote the TenderBuff quality assurance program for local and interstate markets.

Background:

The TenderBuff program was initially started to provide higher returns to the producer whose buffalo numbers were small, post - BTEC. It was seen as a serious substitute for the feral fillet market to restaurants using a much larger range of cuts. The Department runs the project with the NT Buffalo Industry Council and provides the personnel to do quality assurance and branding of carcasses at the abattoir. The price paid to the producer remains at $3.10/kg hot standard carcase weight (HSCW). There are five specifications that a carcase must meet to receive the TenderBuff strip brand.

Animals now come mainly from commercial properties and BHF. With its extensive floodplain and ponded pastures, BHF is able to fatten stock all year round and is only 45 minutes by car from the Litchfield abattoir, which is ideally placed to supply the market. Several producers are now upgrading with suitable pastures to supply quality animals directly to this market

Since March 2001, BHF has concentrated on producing only TenderBuff, sending stock that does not meet the standard to Brunei for the supermarket trade.

TenderBuff has lower cholesterol and fat than beef, two positive factors that can be used for marketing. Some ¾ River crosses are exhibiting increased fat on the rump and ribs, but there is no evidence of an increase in intramuscular fat.

Method:

The current specifications are:

1. 150-300 kg HSCW.
2. 3-12 mm fat at p8 site.
3. No permanent teeth.
4. Electrically stimulated carcase.
5. Muscle pH after 18 hours must be below 5.8.

Departmental staff monitor TenderBuff animals through the abattoir on slaughter days and conduct chiller assessments on the following days.

The producer pays $70/animal for abattoir services. The discount grid determines the sale price to the wholesaler of animals that do not meet the five specifications.

We castrated all purchased and home-grown bulls that are not suitable for sale as breeders. This appears to have reduced problems of too little carcase fat in the dry season.

We either castrated year-old bulls or cryptorchided them (testicles forced up adjacent to the abdomen by using a rubber castrating ring to shorten the scrotum). This management procedure also stops unwanted pregnancy in heifers as they reach mating weights, which are much lower than required turnoff weights. Our policy is to purchase stock that need to put on at least 100 kg live-weight before turnoff. The preferred live-weight at turnoff is over 400 kg.

Results:

Table 1. Carcase parameters for TenderBuff

	July-December 2001	**January-June 2002**	**July-December 2002**	**January-June 2003**
No of animals	29	39	33	31
Mean HSCW (kg)	200.6	217.2	216.1	239.3
Mean eye muscle area (cm^2)	52.6	56.5	57.0	60.8
Mean pH	5.62	5.62	5.58	5.52
Mean carcase length (cm)	102.0	103.6	103.6	103.2
Mean gross ($)	579.38	635.69	655.95	733.63
Mean grid ($/kg)	2.90	2.92	3.05	3.07
Mean p8 fat (mm)	6.7	6.3	6.5	9.2
Mean dressing (%)	48.9	50.2	51.0	51.7
% River cross	8/29=27.6%	2/39=5.1%	2/35=5.7%	7/31=22.6%

Demand and consumption of TenderBuff were reasonably stable during the year. Despite a drop in numbers of animals by four between 2001-02 and 2002-03, the amount of meat produced during the two periods was virtually identical due to the heavier mean weights of animals during 2002-03. Other pleasing trends are the increasing values for eye muscle areas, increasing carcase size and reduced pH levels. There is also an increase in mean grid price and a 6.7%increase in gross value of the carcases. Dressing percentages are also steadily rising over recent years and probably relate to the increasing turnoff weights and possibly also to the change from bulls to steers.

Table 2. Comparison between Swamp and River crossbred animals of all parameters for July 2002 to June 2003

	Swamp	**River Crosses**	**% Difference over Swamp**
No of animals	55	9	
Mean HSCW (kg)	224.4	245.5	+9.4%
Eye muscle area (cm^2)	57.1	69.7	+22.0%
Mean pH	5.55	5.54	-0.18%
Mean carcase length (cm)	104.5	106.4	+1.8%
Mean grid ($/kg)	3.07	3.00	-0.5%
Mean p8 fat (mm)	7.4	10.2	+37.8%
Mean dressing (%)	51.4	51.6	+0.4%
Mean price/animal ($)	687.00	733.78	+6.8%

The usual differences in values between Swamp and Crossbred River progeny are again evident in Table 2. This particularly highlights the value of crossbred carcases in earning greater returns per head. It is hoped that recently learnt skills by BHF staff to maintain low stress during stock handling will be reflected in better TenderBuff in future. Lower stress should keep carcase pH at or below 5.8 for TenderBuff

PROJECT: Riverine and Crossbreeding Buffalo

Project Officers: B. Lemcke, E. Cox, G. Jayawardhana and BHF Staff

Location: Beatrice Hill Farm (BHF)

Objectives:

Determine the merits of crossbreeding and upgrading to Riverine buffalo for the NT buffalo industry.

Distribute suitable progeny from the program to industry for breeding or for the supply of TenderBuff

Demonstrate sustainable buffalo production systems.

Background:

It was the long held dream of pioneer buffalo researcher Don Tulloch to introduce Riverine blood into the Australian swamp buffalo population. The dream became reality in 1994 when two bulls were imported, followed over the next three years by a further four heifers and two more bulls. A crossbreeding program was started and progeny performance is monitored. The progeny are used for TenderBuff. The number of purebreds has increased to 36 at BHF. Two of the original imported bulls died, one accidentally and the other from TB four years ago.

The aim is to produce purebred River buffalo from both directions, by using the purebed cows to increase their numbers from within and also by crossbreeding then backcrossing to purebred through ¾, 7/8 and 15/16 generations back to purebred Riverine.

It is expected that during this process we will be able to identify all those mixtures of the two breeds that will best suit the various meat, export and dairy produce markets in Australia and overseas

Method:

All animals are held at BHF. Half bred cows and heifers are mated to the imported bull OJ and swamp cows are mated to the imported bull Hillary. The imported bull Bill was afterwards destroyed because exposure to TB infected cows. Before that it was trained to an artificial vagina and subsequently about 1200 straws of semen was collected from it and frozen in liquid nitrogen for later use. Bull 5775 was the sire of all the 7/8 calf group, plus some of the purebred calves. OJ was used to sire the balance of the purebred group. Some semen of Italian milking buffalo has also been imported. Semen from three bulls has been used in AI projects. Some of the purebred cows and ¾ heifers have been inseminated with Italian semen.

Results:

Table 1. The composition of Riverine and crossbred buffalo groups at BHF, June 2003

	Imported bulls	**Local bulls**	**Cows**	**Yearling bulls**	**Yearling heifers**	**Male calves**	**Female calves**	**Total**
Purebred Riverine	2	2	16	1	1	4	10	36
Swamp		-	34	1	0	7	6	48
F1		-	27	1	0	0	0	28
3/4			25	7	4	9	15	60
7/8		2*	3	9	9	10	6	39
15/16				1	0	0	0	1
TOTAL	**2**	**4**	**105**	**20**	**14**	**30**	**37**	**212**

There were pleasing numbers of purebred calves this season because every cow produced a calf. Because of several AI attempts the calves were born later in the wet than usual. This group has not been mated this season to allow for more AI attempts.

Controlled mating has now been going for two seasons and breeders will now start to stabilise their calving patterns. Results of pregnancy testing in June after the end of mating are shown in Table 2.

Table 2. Pregnancy results

Breeder group	No. pregnancy tested	Pregnancy (%)	No. wet cows/ % wet cows pregnant
Swamp cows	37	32.4	14 / 0
F1 Cows	27	48.1	23 / 39.1
¾ Cows	34	50.0	17 / 41.2
7/8 Cows	3	66.7	0 / 0

There is plenty of room for improvement in the pregnancy outcomes. The swamp cows performed the worst, despite the use of two different bulls during the season.

One of the 7/8 Italian AI bulls (806) is to go to Laurel Park in Millaa Millaa, North Queensland to be used as a clean-up bull after AI attempts have finished. There were 13 births in the 30 heifers that went to Queensland last year and they were producing 350 litres of milk per week for cheese making. The owners would like to boost the quantity to 500 litres so that they have enough milk for two cheese batches weekly. Eleven crossbred heifers are to be sent to North Queensland from Mabuhay Farm to boost herd numbers.

PROJECT: Pasture Species Evaluation under Grazing at DDRF

Project Officers: B. Lemcke, P. Shotton, N. Hartley, L. Huth and DDRF Staff

Location: Douglas Daly Research Farm(DDRF)

Objectives:

Evaluate pasture species and mixtures under a continuous grazing regime on Blain soil at DDRF.

Determine their persistence, productivity and contribution to the performance of cattle.

Background:

Promising pasture introductions are evaluated under grazing at DDRF to determine their long term potential in the Douglas Daly environment.

Method:

The pastures are grazed in 4 ha paddocks by five Brahman weaner steers per paddock (1.25 animals/ha). The exception is paddock 49, which had five extra animals to increase the stocking rate to 2.5 animals/ha to attempt to utilise the excessive amount of grass that had built up in the paddock in recent years. Steers are allotted to paddocks in June/July (post weaning) and remain in the grazing trial until the following June.

Paddocks are top-dressed annually with a phosphorus-based fertiliser. This year *Goldphos 20*® plus trace elements was spread on the paddocks at 50 kg/ha. During the wet season, various weed control measures were undertaken where required, usually spot-spraying for broadleaf weed control. Some

grass-only paddocks are boom-sprayed with *Starane/2.4-D* mixtures if broad leaf weeds are prominent. Paddock 52 (Oolloo/Arnhem) was sprayed to control sida, but Oolloo was eliminated as well. A single application of 90 kg/ha urea was made to paddock 44 (pangola), paddock 45 (pangola), paddock 46 (sabi) and paddock 47 (Jarra) because they had shown symptoms of nitrogen deficiency in previous years.

The animals are supplemented with ad-lib *Uramol*® blocks during the dry season and with *Phosrite*® blocks in the wet season. Intake was recorded monthly.

Cattle were weighed monthly, given a condition score and P8 (rump) fat was measured, starting in late December and continuing till the end of the grazing season in June 2003.

Pasture composition and yield were assessed twice during the year, in early wet season, during December 2002. A post-wet season assessment was made in May 2003.

Paddock 50 was sown with a range of legume species to determine the most appropriate to complement the existing buffel grass (see Project - *Pasture Species Evaluation under Grazing at DDRF* - Paddock 50).

Paddock 50 contains four blocks of multiple plots of five legumes sown into an existing buffel grass stand during December 1999. It was grazed continuously throughout the period July 2002– June 2003

First grazing of re-established paddocks 48 and 50 commenced in July 2000. Paddock 48 contains three rows of Cunningham and three rows of cv Taramba leucaena, which were slashed in November 2000 to a height of 30 cm and destocked till January 2001. Again in December 2001 the rows were again slashed low, and the stock remained in the paddock. Each leucaena row is half the paddock in length. No leucaena slashing was carried out in the past 12 months.

A new paddock (No. 42) was established during 2002 with Wynn Cassia. It was treated for grass and broadleaf weed control to maintain a high proportion of Wynn Cassia. Grazing commenced in March 2002. This is one element of a district PIRD project on Wynn Cassia productivity. Destocking during January and February was required for weed and grass control purposes.

Because of increasing broadleaf weed problems around the leucaena rows, paddock 44 was rehabilitated by removing all the leucaena and re-establishing pangola runners in the row spaces.

At the same time paddock 45 was planted with five rows of three varieties of leucaena. This paddock was de-stocked until the new weaners were introduced in June 2002. Some destocking was deemed necessary during the 2003 wet to allow the leucaena rows to bulk up at a greater rate than the cattle were allowing when stocked.

In 2003, another new paddock (41) was added to the system, which was sown with Tully and no stocking was allowed through till the end of June to allow maximum establishment.

Table 1. Mean cattle live-weight gains (kg/head)

Paddock No.	Pasture type	July 02-Oct 02 Late dry	Oct 02 - April 03 wet season	April 03-June 03 Early dry	TOTAL July 02-June 03
42	Wynn Cassia	-1.2	86.8	36.6	122.2
43	Higane (P. atratum)	19.8	106.2	31.6	157.6
44	Pangola + urea	23.6	116.6	47.2	187.4
45	Pangola/leucaena	28.0	97.0	42.7	167.7
46	Sabi/+ urea	-2.9	126.5	27.8	151.4
47	Jarra/+ urea	17.4	130.2	32.6	180.2
48	Kaz setaria/sabi/leucaena	18.0	126.0	45.3	189.3
49	Buffel/blue pea	-1.9	119.1	33.6	150.8
50	Buffel/legumes	13.2	132.4	43.6	189.2
51	Strickland/Wynn	15.4	141.8	36.8	194.0
52	Arnhem/Oolloo	17.0	113.8	25.8	156.6
531	Buffel/sabi/LNT blocks	20.4	139.8	36.4	196.6
532	Buffel/sabi/4 seasons	11.6	138.0	38.4	188.0
533	Buffel/sabi/Wynn	8.6	127.4	48.6	184.6
534	Leucaena/buffel/sabi	9.2	117.6	48.2	175.0
All paddocks	Mean live-weight change	12.8	121.6	38.7	173.1

Table 2. Mean cattle live-weight gains per head for five years

Year	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003
Live-weight gain (kg)	190.4	187.7	176.1	173.0	173.1

Again paddock 49 had the highest production per hectare of all the paddocks in the trial area. Whilst the higher stocking rates are depressing individual animal gains (only around 150 kg/head, compared with 180 kg/head with other buffel paddocks), the paddock production is still rising. This year it reached 377 kg/ha compared with 385 kg/ha last year when overall means of all paddocks remained the same as last year. These gains per hectare would probably be achievable in other species paddocks as well if they were stocked to maximise production per hectare. The long term problems of overstocking cannot be overstated and therefore conservative stocking rates are used in this trial for comparison purposes. There has been a steady decline in the amount of feed in paddock 49 with the increasing stocking rates, but it is not yet at a critical level to cause concern about its longevity. Weeds have not increased yet in this paddock.

Block consumption

In the dry season, *Uramol*® was fed from 28 June to 13 November 2002 and in the wet season, *Phosrite*® was fed from 13 November 2002 to 18 June 2003 to animals in all paddocks. Blocks were provided to Paddocks 531 and 532 on 13 November 2002.

Table 3. Dry and wet season daily consumption rates of supplement

Paddock	**Dry season consumption (*Uramol*) g/head/day**	**Wet season consumption (*Phosrite*) g/head/day**
Period	**138 days**	**222 days**
42	62.9	90.1
43	108.4	72.0
44	124.8	24.2
45	155.8	Not stocked
46	98.4	27.4
47	89.7	77.7
48	65.8	82.2
49	59.3	84.4
50	94.9	94.2
51	158.0	92.2
52	186.7	49.7
531	106.5	63.4
532	170.2	167.0
534	49.7	88.6
Mean 02/03	**108.3 g/head/day**	**79.5 g/head/day**
Mean 01-02	92 g/head/day	101 g/head/day
Mean 00-01	78 g/head/day	85 g/head/day
Mean 99-00	81.8 g/head/day	75.5 g/head/day
Mean 98-99	102.0 g/head/day	89.3 g/head/day
Mean 97-98	134.3 g/head/day	119.3 g/head/day

Consumption rates per head of *Uramol*® increased slightly over the previous three years, whilst for *Phosrite*® there was a 20% decrease over last year's intake.

Block comparisons
Again this year an attempt was made to compare blocks from different manufacturers. The Four Seasons Company supplied dry and wet season formulations to compare with *Uramo*l® and *Phosrite*® previously used over the long-term in this trial. *Pro90*® was used in the dry season for the group with number 532 ear tags. Their wet season block was *Big P*®. The *Big P*® blocks produced similar live-weight gains to the *Uramo*l block despite double the consumption rate per head. The *Pro90*® dry season block group produced half the weight gain of the *Uramol* group (+11.67 kg live-weight gain vs 20.4 kg live-weight gain for the total dry period) but had a 70% higher consumption rate than that of the *Uramol*® block. This increased consumption rate has been consistent over all the years tested.

Wet season consumption of blocks by the two groups was of a similar pattern between the two brands with *Phosrite* being consumed at a rate 38% of the amount of the *Big P*®. The live-weight gains were similar for both groups. *Uramol*® consumption rates for the control group were only slightly lower than the mean for all the groups using *Uramol*.

The average cost of block for the year at the average consumption rates per head were as follows:

Wet season	$18.45	8 months
Dry season	$12.02	4 months
Total	$30.47	12 months

Based on prices per tonne of *Phosrite*® - $961.00 and *Uramo*l® - $925.00.

PROJECT: Soil to Plant Uptake of Radioactivity

Project Officers: P. Shotton (DBIRD) and J. Twining (ANSTO*)

Location: Douglas Daly Research Farm(DDRF)

* Australian Nuclear Science and Technology Organisation

Objective:

Determine the amount of radioactivity that may be taken up by cultivated plants used for animal and human consumption.

Introduction:

The field sampling components of a four-year study of the transfer of radioactive elements from soil to plants was completed at DDRF. Chemical and radiological analyses of the samples are continuing and will be followed by comprehensive statistical analyses and interpretation of the results.

The rationale for the study was that little was known of the behaviour of radioactive materials in tropical regions of Australia and the rest of the planet. This was of concern as it is expected that, over the next few decades, there will be an upsurge in the use of nuclear power in the tropics in response to increased socio-economic development and the need to reduce greenhouse gas emissions. As a consequence, unplanned releases of radioactive material may occur and it is appropriate to understand how they might behave in a variety of environments but particularly in the human food chain. The soils at Douglas Daly were excellent in this regard in that they were representative of a class of soil (red earths) that are widely distributed across the Top End of Australia and most of the productive agricultural areas of tropical regions of the world.

Outline of the study

Radioactive cesium-134 (Cs), strontium-85 (Sr) and zinc-65 (Zn) were applied to small plots on two soil types, Blain and Tippera. Crops of sorghum and mung bean were grown on these plots, using standard agricultural practices for the area and annual crop rotation. At the end of each growing season, soil and plant samples were collected for analysis. The objectives of the sampling were to determine the gradual penetration of the radioactivity from the soil surface down through the soil profile, the degree of bioaccumulation into grains and leaves of the plants and how that varied in response to changes in soil parameters and with time.

Results to date:

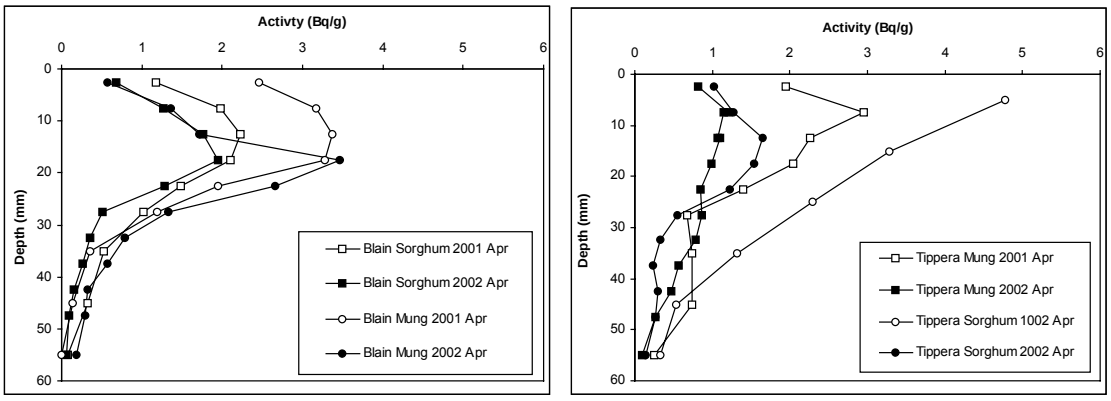
In relation to soil penetration, there was little movement of Cs and Zn over the period of the study (Sr has a short half-life and was added fresh each year). No long-term trend was observed. Figure 1 shows the information on soil penetration by Cs in both soils to 2002. As expected, the sandier Blain soils show greater movement than does the Tippera but the maximum concentrations have only moved about 1.5 cm into the soil profile over the two and a half years since labelling. It is apparent that, if fallout should occur, the material will stay in the surface soils and hence not contaminate ground water. This is also good evidence to indicate the low erosion rates occurring under zero-till planting in these soils.

In relation to plant uptake, the concentrations of Cs and Sr accumulated into the grains and beans are generally consistent with expectations based on similar studies from more temperate regions of the planet. Accumulation of Zn was substantially greater than expectations. The degree of bioaccumulation of all radionuclides is declining annually as the radioactive elements become more strongly bound to the soil particles (Figure 2). The increased uptake of Zn in this study is hypothesised to be related to two factors. These are the relative deficiency of Zn in the soils and the increase in soil fungal populations over the growing period from December to March. Regarding Zn deficiency, the soils are measured to have very low levels of natural Zn yet the plants have healthy concentrations of this metal in their tissues. Hence, there must be some physiological mechanism by which the plants acquire Zn from the soil against the high bioaccumulation gradient. One of the factors that can enhance metal uptake is the presence of soil fungi, particularly vesicular arbuscular mycorrhiza (VAM). These microbes act to effectively increase the root surface area of plants and so enhance trace metal

uptake, as well as changing the soil microchemistry to make metals more soluble and, hence, more easy to absorb.

Conclusions:

The study has successfully identified the degree of bioaccumulation of important radionuclides from red earth soils into two tropical crops. Further chemical and radiometric analyses with statistical interpretation are required to conclude the study. Nonetheless, some obvious results are now apparent. The uptake behaviour of Cs and Sr isotopes is similar to those experienced in temperate parts of the planet, but Zn uptake is higher than expected. The time since contamination and soil pH were found to influence the uptake of radioactive elements. In addition, nutrient deficiency and the presence of VAM fungi are probably affect trace metal uptake.



Blain activity – depth profiles

Tippera activity – depth profiles

Figure 1. Cesium radioactivity depth profiles for each of the study sites

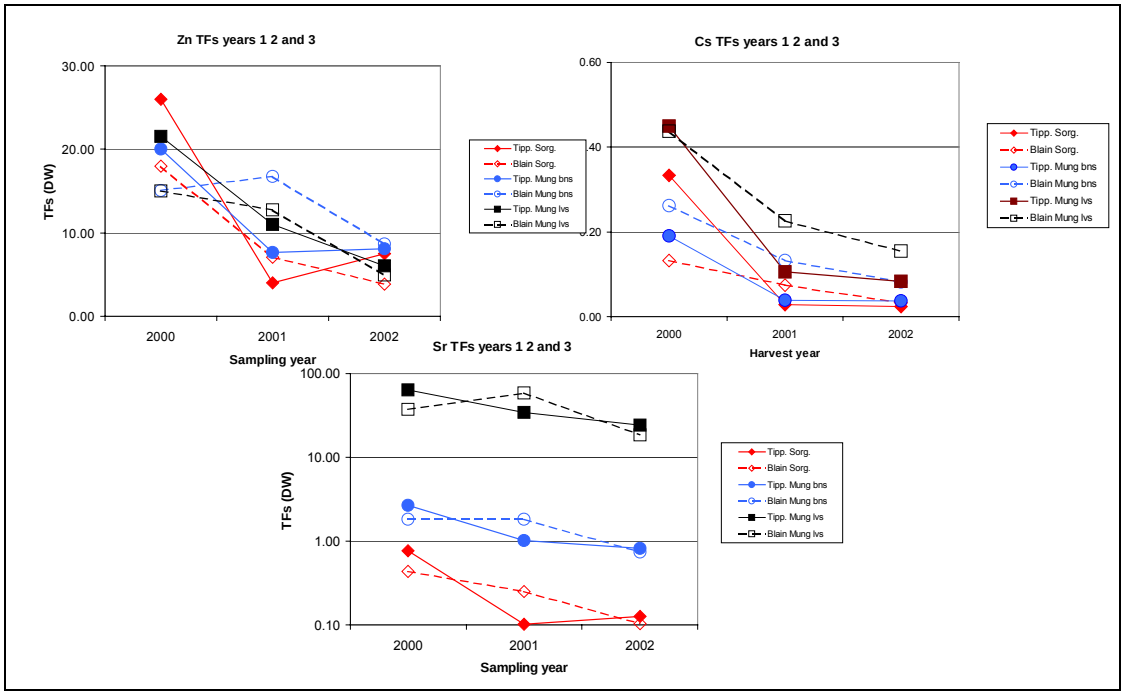


Figure 2. Bioaccumulation of Cs, Sr and Zn into sorghum grain, mung beans and mung leaves over the first three years of the study

PROJECT: Weed Control using Herbicide Wipers

Project Officers: P. Shotton and C. Hazel

Location: Douglas Daly Region

Objective:

Trial, monitor and record the short and long term effectiveness of weed control methods in pastures and fodder crops using herbicide wipers.

Background:

The control of grass and broad-leaf weeds in pastures is an ongoing concern, particularly where selective herbicides are not available or economic. With the use of selective herbicides, various grasses and broad-leaf weed species can be controlled in pure stands. However, the control of weeds in mixed pastures such as grass weeds in grass pastures and various broad-leaf weeds in legume pastures is more difficult with few selective herbicides available (to our knowledge), and their high prices.

Herbicide wipers are one method being used for managing taller weeds and sucker re-growth in crops, pastures and forestry all over the world, with varying success depending on location, weed species, application methods and chemicals used. The benefit of herbicide wipers is that the chemical is applied only to the target weed, reducing waste and eliminating spray drift.

A number of replicated and non-replicated trials have been conducted in the Top End using herbicide wipers with many different chemicals and adjuvants.

The major contributing factor to effectiveness is the height and density of the weed mass and the speed of application. Generally, the taller and more leafy the weeds are, the greater is the chemical contact and better are the results.

The most universal chemical mix found to date has been *Glyphosate* with 1% adjuvant of *LI 700*® and non-ionic 100% wetter. The solution of 1 part chemical (*Glyphosate 450*®) to 10 parts water controlled most actively growing broad-leaf and grass weeds in mixed pastures and legume hay crops.

Sucker re-growth in improved pasture areas has been a concern to pastoralists in the Douglas Daly district. A herbicide wiper would be a relatively cost-effective way of controlling sucker re-growth if a suitable chemical mix could be found.

Method:

A non replicated trial was undertaken on Bonalbo Station NT (13^0 59' S 131^0 '19E) in April 2003 where native sucker re-growth in an improved pasture paddock was herbicide rolled using three chemical products at two application rates. The two application rates were a single pass over the target plants and a double pass where the target species were wiped from both directions.

Results to date:

The treatment using a single wipe of *Glyphosate 450*® (G1) controlled approximately half of the Bloodwood (*Eucalyptus latifolia*) and killed thee from the four plant species of Stringybark (*Eucalyptus tetrodonta)* and broad-leaved Carbeen (*Eucalyptus confertiflora)*. Ironwood (*Erythrophleum chlorostachys*) suckers showed signs of severe damage two weeks after wiping with leaves and stems turning black and near 100% leaf defoliation; however all ironwood suckers later recovered.

The treatment using a double wiping of *Glyphosate 450*® (G2) did not improve the control rate and gave similar results as the G1 treatment. Most ironwoods, *Hakea arborescens* and *Grevillea mimosoides* were not controlled. Half or more of the three *Eucalyptus* spp. were controlled using the G2 treatment.

The two *Garlon*® (600 g/L Triclopyr) treatments controlled very few suckers. No bloodwood was controlled and only the odd suckers of kapok (*Cochlospermum fraseri*), sandpaper fig (*Ficus opposita*), *Grevillea mimosoides* and nut tree (*Terminalia grandiflora)* were affected. The results did not indicate any benefit of double wiping with *Garlon*® compared with the single application.

The single treatment of *Grazon* ® (100 g/L picloram and 300 g/L Triclopyr) controlled a number of suckers wiped including most ironwood, bloodwoods, stringybarks and terminalias. The double wiping of *Grazon*® controlled all species wiped, except for one ironwood sucker, indicating the double wiping was worthwhile.

Discussion:

The herbicide wiper will only affect the plants it comes into contact with and the taller and larger the leaf area, the more chemical that will be transferred onto the target. As chemical translocation is often slow through the plants, final ratings should be made several months after application. Applying the chemicals when plants were most actively growing and during a cooler part of the day may have improved results.

PROJECT: Pasture Species Evaluation under Grazing at DDRF - Buffel/Legumes

Project Officers: P. Shotton, B. Lemcke and L. Huth

Location: Paddock 50, Douglas Daly Research Farm (DDRF)

Objective:

Monitor the value of a companion legume with buffel grass in terms of nitrogen availability, pasture quality, quantity and the persistence of the legume species.

Background:

Buffel grass is a commonly used improved pasture in the Top End, south of and including the Douglas-Daly region. As established buffel grass pasture tends to grow in clumps, a favourable legume companion species would be beneficial to help utilise the area between the buffel plants and ideally provide nitrogen to the grass resulting in higher quality and better yielding pastures. A higher protein diet for cattle due to the legume, would be an added bonus.

The project follows an ungrazed plot trial in 1996-1998 that evaluated the benefits of six tropical pasture legume species as companions to buffel grass *(Technote* 110).

Method:

On 6 January 2000, seeds of five pasture legume species were planted into a 4-ha paddock (paddock 50) at DDRF. The legumes were Wynn Cassia *(Chamaechrista rotundifolia),* Verano stylo *(Stylosanthes hamata),* Oolloo *(Centrosema brasilianum),* Maldonado *(Macroptilium gracile)* and Milgara blue pea *(Clitoria ternatea).* The legume treatments and control - buffel only (*Cenchrus ciliaris)* were replicated four times, randomised with a plot size of 12 m x 130 m.

In December of 1999 and of 2000, 50 kg/ha of *Goldphos 20*® was applied and 75 kg/ha in December 2001. In December 2002, 70 kg/ha of *Goldphos 20*® with T/E was applied.

No grazing was allowed during establishment in the first wet season to allow legumes to set seed. The paddock is stocked with five Brahman weaner steers at 1.25 animals per hectare for a 12-month period. Steers are kept for 12 months and are changed over late June each year. Cattle weights, condition and fat score are recorded monthly.

The animals are supplemented with *Uramol*® blocks during the dry season and with *Phosrite*® blocks in the wet season. Intake was recorded monthly with all seasons having similar consumption. An

average intake of 93.6 g/head/day occurred on *Uramol*® over 140 days and 92.6 g/head/day of *Phosrite*® over 189 days during the 2002-03 season.

Broad-leaf weeds were controlled with *Starane*® as a post planting/pre-emergent herbicide in January 2000. Some hand weeding and spot-spraying was done each year for broad leaf weeds mainly spiny head sida *(Sida acuta)*, flannel weed *(Sida cordifolia)*, hyptis *(Hyptis suaveolens)* and Senna (*Cassia obtusifolia)*.

Pasture composition and yield were assessed twice each year in December and May using *Botanal*®. Soil and plant samples were taken from each plot to compare the differences in soil and plant nutrients. The cut quadrats also provided actual vs. estimated yields to construct regression equations for *Botanal*® determinations.

Results:

During the first two seasons, all legumes established well. The most prolific were Milgara blue pea, Oolloo and Maldonado. Wynn Cassia and Verano stylo were less prolific than the twining legumes. Verano, Wynn and Blue pea seeded well with Oolloo and Maldonado seeding poorly, although all legumes seeded well in the second year. Results from the April 2001 biomass harvest indicated the greater the legume content, the higher the overall yield, although grass yields in the Oolloo treatments were lower indicating the Oolloo legume was competing with the buffel grass.

During the three years the trial has run, the percentage of legumes has decreased with only the Oolloo showing signs of sustaining a grass/legume mix (see Table 1). During the 2002 – 03 wet season very few blue pea or Maldonado plants were found and only some small plants of Wynn and Verano.

Plant analyses results suggest that the higher the proportion of legume content, the higher the nitrogen in the companion buffel grass. This could be visibly seen throughout the wet season and early dry when the buffel grass with Oolloo was a darker green in colour, flowered earlier and had a denser looking stand of pasture.

Average cattle live-weight gains for the 2002–03 12-month period were 189.6 kg per head; for 2001-02, 176.1 kg per head and for 2000-01, 208 kg per head.

Table1. Species and total yields of Paddock 50 buffel/legume

Treatment	Date	Yield (kg)	% Legume	% Grass	% Other
Maldonado	Dec-00	2890	6	94	trace
	May-01	9240	54	46	trace
	Dec-01	4570	trace	100	trace
	Aprl-02	5470	trace	98	2
	Dec-02	3016	0	99.5	0.5
	May-03	4790	0	99.9	0.1
Verano	Dec-00	3940	1	97	2
	May-01	6370	5	90	5
	Dec-01	3660	3	96	1
	Aprl-02	5060	6	90	4
	Dec-02	2656	1.7	97.7	0.6
	May-03	4169	0.5	98.8	0.7
Oolloo	Dec-00	3480	16	84	trace
	May-01	9210	60	37	3
	Dec-01	5200	8	91	1
	Aprl-02	6090	35	64	1
	Dec-02	3513	6.4	93.4	0.2
	May-03	5621	2.5	97.4	0.1
Wynn	Dec-00	3080	12	84	4
	May-01	8040	37	57	6
	Dec-01	3910	3	96	1
	Aprl-02	5070	8	90	2
	Dec-02	2759	1.3	97.4	1.3
	May-03	4763	0.7	98.7	0.6
Milgara	Dec-00	3340	8	92	trace
	May-01	7340	14	83	3
	Dec-01	4340	trace	99	1
	Aprl-02	5440	1	95	4
	Dec-02	2923	0.1	99.1	0.8
	May-03	4763	0.1	99.5	0.4
Control	Dec-00	3030	0	99	1
	May-01	6530	3	95	2
	Dec-01	3870	1	98	1
	Aprl-02	5120	6	93	1
	Dec-02	2672	0	96.3	1.7
	May-03	4308	trace	99.5	0.5

PROJECT:	**Evaluate the Benefit of Wynn Cassia as a Pasture Feed and Fodder Species in the Douglas Daly District**
Project Officers:	**Douglas Daly PIRD Group, P. Shotton, F. O'Gara and B. Lemcke**
Location:	Paddock 42 and 10A - Douglas Daly Farm

Objectives:

Monitor the performance of cattle when grazed on a pure stand of Chamaechrista rotundifolia (Wynn Cassia) in terms of weight gain, condition change and fatness.

Monitor the persistence of the pasture and the suitability of Wynn Cassia as a fodder.

Background:

Through farm walks and general discussion, producers in the Douglas Daly district have expressed concerns about Wynn Cassia as an improved pasture species. Because there was no distinct answer to many of the questions asked about the species, the district producers and community started a producer initiated research and development (PIRD) project to look at some of the issues.

The main issues being raised were:

1. The palatability of Wynn Cassia.
2. The benefit as a companion legume for nitrogen fixation.
3. The ability to fatten cattle.
4. The threat of becoming a weed.
5. Feed quality.
6. Potential yields for grazing and fodder production.
7. Fertiliser requirements.

Method:

As part of the species evaluation trial, a 4 ha paddock (paddock 42) was set up as a pure stand of Wynn Cassia to monitor the performance of Brahman weaner steers over a 12-month period. The area was sprayed with a knock down herbicide in November 2001 and planted with Wynn Cassia at 6 kg/ha in early December using zero till planting methods. *Goldphos* 20 fertiliser was applied at 150 kg/ha pre-planting and 50 kg/ha muriate of potash was applied post-planting. A further 50 kg/ha of *Goldphos 20*® with T/E was applied in December 2002.

Spinnaker® and *Verdict*® herbicides were used to control grasses and broadleaf weeds during the 2001–02 and the 2002–03 wet seasons. Herbicide wiping and hand weeding were also used to control broad leaf weeds.

Grazing:

On 07/03/02, five steers with live weights between 284 – 336 kg were put into the now pure stand of Wynn Cassia. All animals were weighed each month. Body condition was estimated and P8 fat was also measured and recorded. On 28/06/02 the original five steers were replaced with five weaner steers as part of the standard 12 month grazing change-over for the trial and they remained until 18 June 2003.

Results:

The establishment of the Wynn pasture was slow, eventually thickening up later in the wet season.

During the first month of grazing the steers put on weight averaging 0.8 kg/head/day. The following two months showed little or no weight gain and the last weighing found four of the five steers had lost 5 to 15 kg over the 28 days.

The 2002 steers on average remained at a similar weight from June 02 to December 02. Between December 02 and the end of May 03 the mean weight gain over six months was 123 kg per head, the lowest of all the species grazed (see Table 1).

On 20 January 2003 approximately half the paddock was applied with 900 kg of Katherine lime to see if the five steers would favour these areas. No differences in grazing patterns were noted between limed and non-limed areas.

Discussion:

The palatability of a pure stand of Wynn Cassia and Wynn hay appears low. Over the two years the trial was conducted, weight gains, animal condition and fat measures were low compared with animals on other pasture species at the same stocking rates. Pasture biomass was adequate throughout the seasons but utilisation of available feed was obviously low. The Berrimah Farm trial that determined the feeding value of Wynn hay and pellets as a feed to penned steers compared with Cavalcade and pangola hay also found that consumption and weight gains on Wynn hay were low.

Table 1. Steer live-weights

Paddock 42 monthly steer live weights (kg)												
	Steer ID											
	711	**779**	**802**	**811**	**870**	**Mean**	**904**	**940**	**945**	**1023**	**1053**	**Mean**
Mar 02	336	332	306	292	284	310						
April 02	353	356	332	314	306	332						
01 May 02	354	350	330	320	306	332						
29 May 02	358	359	335	323	310	337						
Jun 02							192	191	206	172	209	194.0
Jul 02							186	194	219	174	213	197.2
Aug 02							185	192	216	179	211	196.6
Sept 02							183	193	208	175	201	192.0
Oct 02							186	200	216	173	207	196.4
Nov 02							184	194	201	173	198	190.0
Dec 02							177	204	209	176	193	191.8
Jan 03							195	218	228	195	215	210.1
Feb 03							217	251	258	226	257	241.8
Mar 03							246	280	276	260	289	270.2
Apr 03							257	288	286	277	310	283.6
01 May 03							270	303	306	292	333	300.8
29 May 03							288	314	335	306	356	319.8
Jun 03							283	320	338	300	358	319.8

PROJECT: Douglas Daly Research Farm Weather Recording

Project Officers: P. Shotton, DDRF Staff and Bureau of Meteorology

Location: Douglas Daly Research Farm (DDRF)

Objective:

Observe, monitor and record daily weather information from the Douglas Daly Research Farm manual and automatic weather stations.

Method:

Manual meteorological observations include evaporation, wind run, wet and dry bulb temperatures, minimum and maximum temperatures and rainfall.

The automatic weather station records wind run, wind speed, gusts and direction, wet and dry bulb temperatures for humidity and dew point, minimum and maximum temperatures, rainfall amount and intensity and barometer pressure.

Results:

All past DDRF weather information has been recorded and is available on request. Daily weather data is also sent to the Bureau of Meteorology. Table 1 shows monthly weather data for Douglas River NT, compiled by the Bureau of Meteorology Darwin

Table 1. Douglas River weather data

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
Main daily max temp	33.8	32.9	33.7	34.5	33.0	31.5	31.7	33.6	36.5	36.6	36.7	34.7	
Highest temperature	38.6	37.1	37.6	37.6	38.4	36.6	36.6	38.7	40.6	40.4	41.5	40.0	
Mean no. days over 30°C	22.0	22.3	24.9	25.6	25.1	20.7	24.0	27.3	26.7	28.9	28.7	24.8	
Mean no. days over 35°C	8.5	5.3	7.4	10.9	5.1	1.4	1.8	7.6	23.4	25.2	23.8	12.7	
Mean daily min temp (°C)	23.8	23.7	23.0	20.9	16.2	13.6	13.1	14.4	18.3	22.3	23.2	23.7	
Lowest temperature (°C)	19.5	19.5	11.6	10.0	5.5	4.0	2.0	2.5	4.5	11.5	14.2	16.4	
Mean 9 am temperature (°C)	27.4	27.1	27.1	26.6	23.8	21.2	20.4	22.9	26.8	28.8	29.2	28.5	
Mean 3 pm temperature (°C)	31.7	31.4	31.7	33.2	31.8	30.1	30.1	32.5	35.1	35.4	35.1	34.1	
Mean 9 am relative humidity	84.2	85.2	84.6	73.2	61.9	60.1	58.2	61.9	63.3	68.6	72.0	79.0	
Mean 3 pm relative humidity	64.9	65.9	62.3	45.1	37.6	31.6	28.9	27.0	25.3	36.4	42.3	51.1	
Mean daily pan evaporation	5.7	5.4	5.5	5.9	6.4	5.9	6.3	7.1	7.7	7.4	6.7	6.0	
Mean monthly rainfall (mm)	276.8	276.4	234.7	44.4	9.0	3.2	3.6	0.6	4.3	41.0	118.6	192.6	1205.2
Highest monthly rainfall (mm)	786.6	572.0	636.4	229.0	96.8	86.8	47.7	7.4	37.6	124.8	241.6	464.0	
Lowest monthly rainfall (mm)	106.3	77.4	63.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.4	30.0	
Mean number of rain days	17.6	17.8	15.3	4.8	1.2	0.3	0.4	0.2	0.8	4.4	9.8	13.5	86.1
Highest number of rain days	27	28	29	16	13	4	6	1	4	14	14	24	
Lowest number of rain days	10	11	7	0	0	0	0	0	0	0	5	5	

PROJECT: Multibreed Composite Assessment

Project Officers: **G. Jayawardhana, the late T. Olm, P. O'Brien, C. Hazel, S. Izod, R. Muirhead, D. Cherry, J. Cherry, B. Lemcke, K. Levey, E. Cox, L. Humphris and J. Stevens**

Location: Douglas Daly Research Farm (DDRF), Beatrice Hill Farm (BHF) and Victoria River Research Station (VRRS)

Objective:

Measure the relative growth, reproductive performance and carcase characteristics of the progeny of some tropically adapted multi-breed crossbred bulls mated to Brahman cows, compared with the progeny of Brahman bulls mated to Brahman cows.

Background:

Multi-breed composites retain larger amounts of heterosis (hybrid vigour) in future generations than do the old-style two-breed animals such as Droughtmasters, Brafords and Charbrays. They also combine the good points of the more different cattle types. Most of the large cattle companies such as Napco, the AA Company and Stanbroke are shifting to multi-breed composites.

Method:

A composite of 56.3% Brahman, 12.5% Africander, 12.5% Tuli, 6.3% Shorthorn, 6.3% Hereford and 6.3% Charolais is being compared with the Brahman at DDRF. This cross gives a mix that is 81% tropically adapted and 19% un-adapted *Bos taurus* and can be expected to retain about 64% of

heterosis in the second generation onwards. Brahman cows were crossed with half Belmont Red, quarter Tuli and quarter Charbray bulls, which were obtained from Geoff Maynard's Mt Eugene stud in Queensland.

Results:

Table 1. Some of the preliminary results of the comparison

	Brahmans	**Composites**	**Difference**
Birth weight (kg)	27.5	26.8	-0.7
Branding weight (kg)	160.8	170.7	9.9
Weaning weight (kg)	199.9	209.6	9.7
Yearling weight (kg)	224	240	16
Yearling testicle size (cm)	22.8	26.3	3.5
Normal sperm at yearling (%)	5.6	28.1	22.5 (5 times the % normal of Brahmans)
Yearling pregnancy (%)	37.8	68.3	30.5
Pregnancy in lactating 2 year old animals (%)	50.0 (3/6)	82.8 (24/29)	32.8
Two year steer weight (kg)	380.7	413.6	32.9
Carcass weight (kg)	227.8	237.2	9.4
Eye muscle area (cm^2)	73.3	78.4	5.1

The first cross composites were born lighter than the Brahmans but gained weight faster. Their weight and reproduction figures have been consistently superior to those of the Brahmans. We are currently collecting carcase data on the steers with initial figures indicating that eye muscle area per kg carcase weight is superior in the composites.

The first of the second-generation calves from the yearling mating have been weaned but numbers are too small for a realistic comparison. The performance of the second-generation is more important than that of the first cross as the loss of heterosis in a composite occurs between these generations.

The production phase is continuing at VRRS while the comparison phase is taking place at DDRF and BHF. When enough first cross females are produced, they will be run at VRRS.

The initial group of Maynard bulls is now at Jindare, a commercial property in the Top End. Their first calves are being currently weaned. Information on the performance of this cross, under more extensive conditions, will be available soon.

SUBPROGRAM: Farming Systems

PROJECT: Sesame Industry Development

Project Officers: M. Bennett, R. Sunnerdale and G. Routley

Location: Katherine Research Station

Objective:

Identify and develop new sesame genotypes suitable for northern New South Wales, central Queensland and northern Australia.

Background:

With the release of cultivar Edith potential yields of high quality seed have been increased by 10%. However, Edith does not have capsule characteristics that minimise seed loss as the crop matures and capsules dehisce. A breeding program was established in 1993 to transfer the strong seed attachment characteristic of Hnani 25/160 to Edith. Five lines were identified in 1997 as having strong seed attachment. A further five lines were identified in 1998. These lines presented a range of phenotypes, early, mid and late maturing, suitable for northern NSW, central Qld and northern Australia, respectively. Self-pollinated seed of each line was produced, grown and the best individual plant selections identified. Commencing in 1997-98, experiments were undertaken to identify and develop new superior sesame genotypes for the sesame growing regions of Australia. These experiments were completed in 2002-03. It is anticipated that successful application for Plant Breeders' Rights (PBR) will take a further two years.

Method:

This wet season two replicated experiments evaluated 16 selections at three sites, Katherine (NT), Biloela (Qld) and Trangie (NSW). During the season various plant characteristics were measured. Characters were then scored on a scale 0 to 10. Various characters were given weighting according to their importance. A total score for the characters measured were determined. Selections with the highest score and similar physiological maturity (PM) were identified for further evaluation. The remaining selections were discarded.

Progress Report:

The superior selections identified this season are presented in Table 1. The selections for northern NSW and central QLD will proceed to PBR application while the selections identified suitable for northern Australia will be evaluated for a further year before a final selection is chosen for PBR application.

Table 1. Superior sesame selections identified at KRS in 2002-03

	Potential location for commercial development		
	northern NSW[1]	central QLD[2]	northern Australia[3]
Selections	E97W:65g	E9717:40	E9817:29
			E9817:64
			E97W:65/8
			A717:48/4
			A717:31/2

[1] PM = < 1050 day degrees (early maturing)
[2] PM = 1050 – 1250 day degrees (mid maturing)
[3] PM = >1250 day degrees (late maturing)

SUBPROGRAM: Meeting Market Specifications

PROJECT: Backgrounding Commercial Brahman Weaners on Mitchell Grass in the VRD

Project Officers: P. Ridley and D. LaFontaine

Location: Black Gin Bore, Mt Sanford Station

Objective 1:

Measure, analyse and report on the effects of weaning weight range (4) and sex (2) on growth and value-adding potential of first weaning round commercial Brahman weaners at the end of their first post-weaning wet season.

Background:

The basic management system used in this project comprised:

- A sustainable stocking rate (20 animals/km^2);
- *Ad libitum* supplement in the dry (N) and the wet (P).

The sustainable stock numbers (20 animals/km^2) were estimated by:

- assuming an initial empty live weight (ELW) of 180 kg at weaning and 150 kg/animal gain by the end of the first post-weaning wet (N. MacDonald, pers. comm.);

- using the British metabolisable energy (ME) system (MAFF,1984) with adjustments recommended by Corbett et al. (1990) to allow for the effects of energy expended while grazing and the lower maintenance energy requirements of *Bos indicus* cattle;

- assuming values for the ME/kg dry matter for pasture in the wet and the dry season relevant to the assumed performance;

- assuming that the sustainable level of pasture intake/unit area was no more than 25% of what grew in 70% of years (R. Dyer, pers. comm.);

- estimating historical levels of annual pasture growth from historical rainfall records (R. Dyer, pers. comm.).

Two 6 km^2 replicate paddocks (Finch and Quail) were stocked with first and second weaning round (WR) weaners from Mt Sanford Station shortly after they were weaned (in June and September 1998, respectively).

The population structure was set up to mimic the sex, weaning weight and weaning round distribution of an annual calf crop from a herd using the best bet breeder management package developed at Kidman. There were four weaning weight ranges for steer weaners but only two (the lightest) for heifers because the heavier heifers were required as replacement breeders and were not included in this population.

Table 1 shows this population structure, the initial stocking rates in the dry (17.8 animals/km^2) and the wet (23.4 animals/km^2) and the average weaning weights (169 kg at WR1 and 156 kg at WR 2).

Table 1. Numbers of weaners, initial grazing pressure (kg/km^2) and average weaning weights

WR	Sex	Finch			Quail		
		N	kg	kg/head	n	kg	kg/head
1	S	71	13050	184	72	12949	180
	H	36	5155	143	36	4892	136
	total	105	18205	173	108	17841	165
2	S	21	3290	157	23	3905	170
	H	12	1727	144	12	1648	137
	total	33	5017	152	35	5553	159

WR = Weaning round S = Steer
N = Number of weaners H = Heifer

Results:

Table 2 contains data only from WR 1steer weaners. The first element (n) shows the numbers for which full data was available. For a variety of reasons (such as escapes, failure to muster, lost tags and unconfirmed deaths) it was not possible to obtain data for analyses for all the weaners initially allocated to the two replicates.

In the second element, weaning weight (WW) was used to estimate the weaning age (WA) at WR 1, for each subset assuming an average birth weight of 30 kg and a pre-weaning growth rate of 0.85 kg/day. The estimated WA in months is given in brackets. There was good agreement in the mean values for these two variables between the two replicates for each weaning weight range.

In the third element (dry growth), ELW changes in the dry in all four weight range subsets were significantly different ($P< 0.05$), with the lightest WW range weaners unexpectedly performing best (+ 3.2 kg/animal) and the heaviest weaners worst (-19.1 kg/animal). There was a significant negative correlation between WW (x) and weight loss in the dry (Y).

$$Y = - 0.19 x + 27.9 \qquad r^2 = 0.41 \qquad P < 0.001$$

The fourth element (wet growth) shows that during the wet there was no significant effect of WW range on growth (i.e. compensation did not appear to occur).

In the fifth element (total growth) over the whole year, there was a significant effect of WW range on growth ($P < 0.05$) with the two lower WW range groups different from both each other ($P < 0.05$) and the two heavier groups ($P < 0.05$). The two heaviest WW range groups did not differ significantly in total growth over the 11-month period.

The final element (Table 2) provides the turn-off weight and age (in months) for the cattle in this data set. The final weighing occurred 11 months after weaning and final age was obtained by adding 11 to the weaning age estimates obtained from the weaning weights.

Table 2. Results for WR 1 steers (1998-99)

Variable	WW Range (kg)	Finch	Quail	Av	Sig
Number	100-140	16	11	27	**NR**
	141-180	18	14	32	
	181-220	15	17	32	
	221-260	14	16	30	
	Total	63	58	**121**	**NR**
WW (kg)	100-140	127 (3.6)	123 (3.6)	125 (3.7)	**NR**
Age (months)	141-180	163 (5.1)	163 (5.2)	161 (5.1)	
	181-220	202 (6.7)	205 (6.9)	204 (6.8)	
	221-260	239 (8.2)	237 (8.1)	238 (8.2)	
	Av	182 (6.0)	182 (6.0)		**NS**
Dry growth (kg)	100-140	+2.3	+4.1	+3.2 ^{A}	**P < 0.05**
	141-180	+1.8	-6.7	-2.5 ^{B}	
	181-220	-0.8	-10.9	-9.5 ^{C}	
	221-260	-16.0	-22.2	-19.1 ^{D}	
	Av	-5.0	-8.9		**P < 0.05**
Wet growth (kg)	100-140	130.8	119.8	125.3	**NS**
	141-180	122.9	121.8	122.4	
	181-220	122.4	118.0	120.2	
	221-260	128.6	120.3	124.2	
	Av	**126.2**	**120.0**		**P < 0.01**
Total growth (kg)	100-140	133.1	123.9	128.5 ^{A}	**P < 0.05**
	141-180	124.7	115.1	119.9 ^{B}	
	181-220	114.4	107.1	110.8 ^{C}	
	221-260	112.6	98.1	105.4 ^{C}	
	Av	121.2	111.1		**P < 0.001**
Final W (kg)	100-140	260 (14.8)	247 (14.6)	254 (14.7)	**NR**
	141-180	284 (16.1)	278 (16.2)	281 (16.1)	
Age (months)	181-220	316 (17.7)	313 (17.8)	314 (17.7)	
	221-260	352 (19.2)	355 (19.1)	343 (19.1)	
	Av	**303 (17.0)**	**293 (17.0)**		**NR**

Values with a different alphabetic superscript within a cell are significantly different (P< 0.05). NR = not relevant NS = not significant

Figure 1 provides the maturity type growth (MTG) curve for Brahman steers derived in project 8.4.4. An estimate of the value-adding potential of the 100-140 kg WW range set at the end of its first post-weaning wet has been obtained in Figure 1 assuming:

- a 20-day delay between final muster on the property of origin and commencement of feeding at the destination feedlot in SE Asia;
- zero carcase weight loss during transportation (property of origin to SE Asian feedlot);
- an ELW growth rate of 1 kg/d in the SE Asian feedlot.

The weight/age at feedlot turnoff for this weaning weight range set is the point of intersection of the hypotenuse of weight x age triangle (1.0 kg/d) with the p8 = 10 mm MTG line (i.e. at 348 kg/18.3 months). This provides the following slaughter estimates for this WW range set:

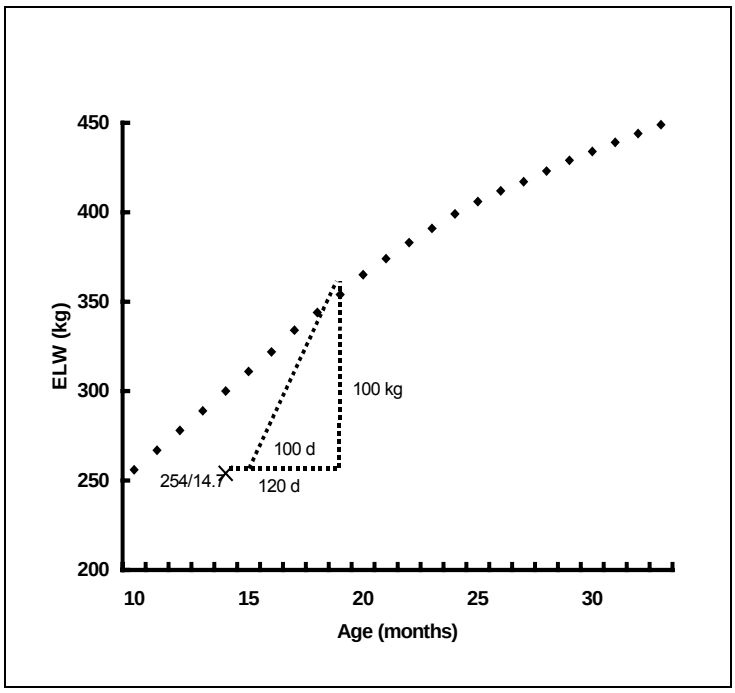


Figure 1. Braham steer MTG curve (p8 = 10 mm)

Value adding potential = 348-254 kg = 94 kg
End-use specifications
p8 = 10 ± 5 mm
ELW = 350 ± 30 kg
HSCW = 190 ± 15 kg (ELW x .54)

HSCW = hot standard carcase weight.

Figure 2 shows the ELW/age co-ordinates at turn-off from property of origin (X) and ELW/age at feedlot turnoff (▲) for all four weaning weight range sets, using this approach.

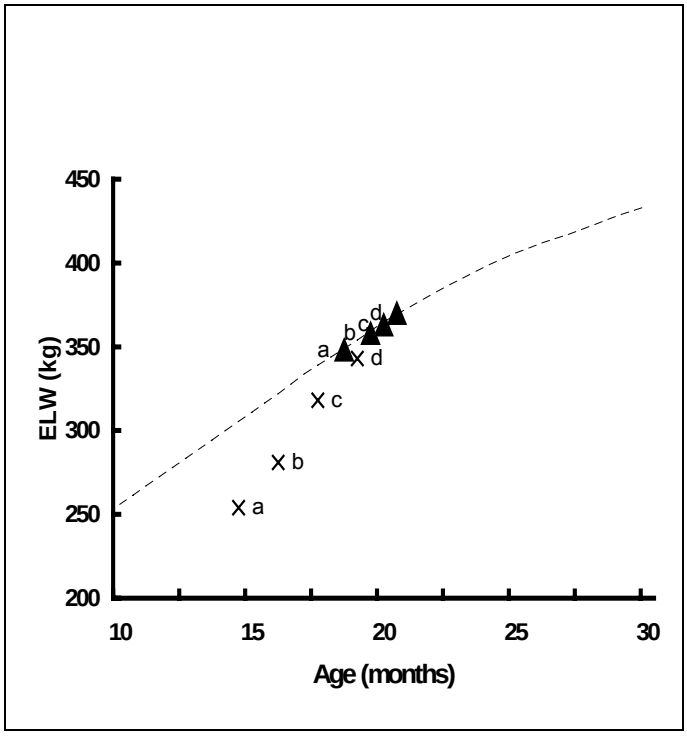


Figure 2. Braham steer MTG curve (p8 = 10 mm)

Table 3 provides the numerical values for the co-ordinates in Figure 2 and the estimated value-adding potential for each weaning weight range set.

Table 3. Estimates of value-adding potential

WW range (kg)	Point on the figure	Turn-off ELW (kg)	Turn-off age (months)	Feedlot ELW (kg)	Feedlot age (months)	Value-adding (kg)
100-140	a	254	14.7	348	18.3	94
141-180	b	281	16.1	358	19.4	77
181-220	c	318	17.7	363	19.8	45
221-260	d	343	19.1	370	20.5	27
Av		**299**	**16.9**	**360**	**19.5**	**61**

Value-adding potential equals ELW at feedlot turn-off minus ELW at property of origin turn-off. In this case value-adding potential in kg is equal to the period in the feedlot in days because the least cost ration has been assumed to result in growth of the feeder cattle at 1.0 kg/day.

Table 4 shows the number of WR 1 steer and heifer weaners in the two lightest WW range sets, their total growth for the year and their value-adding potential as determined using the method outlined above. Steers grew at 12.1 kg or 9.7% (P< 0.001) more than heifers and had 34.5 kg (68%) more value-adding potential at the end of their first post-weaning Wet.

Table 4. The effect of sex and WW range on annual growth and value-adding potential in young commercial Brahman steers and heifers at the End of their first post-weaning wet

WW range kg	Steer				Heifer				Sig
	n	Wean age (months)		Value-adding (kg)	n	Wean age (months)	Total gain (kg)	Value-adding (kg)	
100-140	27	3.7	129.4	94	29	3.8	117.1	60	
141-180	34	5.2	120.4	77	35	5.4	108.5	42	
Av			124.9	85.5			112.8	51.0	P< 0.001

Conclusions:

- By the end of their first post-weaning wet, the WR 1 steer weaners in this calf crop gained 116.2 kg/head, grew 12.1 kg/head (10.7%, P< 0.001) more than heifers and had an estimated residual 61 kg/head value-adding potential for the next (feedlot) phase of production. There was a negative relationship between weight and value-adding potential at the end of the first post-weaning wet.

- There was an unexpected and highly significant (P< 0.001) negative relationship between weaning weight and weight change in the dry (e.g. the lightest WW range weaners gained a 22.3 kg/head advantage over the heaviest WW range set in this period). There was no apparent compensatory growth in the wet. This suggests that there is no justification for the view that calves lighter than 140 kg should not be weaned at WR 1 because they will not thrive in the dry.

  Furthermore, in the case of the 100-140 kg WW range steer weaners, data from Kidman suggests that if they had not been weaned at WR 1 they would have gained about 90-100 kg/head suckling their mothers through the dry. Assuming that they grew at 100 kg/head in the wet after weaning then they would average 120 + 95 + 100 = 315 kg/head. Most would be heavy enough for the boat trade to SE Asia and this is what motivates not weaning them as 100 -140 kg weaners, at the end of WR1. If the two alternative weights are plotted on the Brahman steer MTG curve with p8 fat depth at 10 mm, it can be seen that the early weaning option provides a lightweight feeder (254 kg) with 94 kg/head value-adding potential. However, the delayed weaning results in an average weight of 315 kg with negligible value-adding potential. This is another reason for not delaying weaning. Unfortunately, there are as yet no premiums for higher value-adding potential feeder cattle to act as an incentive, primarily because of the absence of a value-based description system.

- There was also an important negative relationship between WW range and estimated value-adding potential in both sexes, and heifers had significantly lower (34.5 kg/head or 40%, P< 0.001) value-adding potential than steers of the same initial WW range.

PROJECT: Backgrounding Commercial Brahman Weaners on Mitchell Grass in the VRD

Project Officers: P. Ridley and T. Schatz

Location: Black Gin Bore, Mt Sanford Station

Objective 2:

Measure, analyse and report on the relative post-weaning growth and value-adding potential at the end of their first post-weaning wet of three weaner genotypes from the Kidman breeder genotype comparison and commercial Brahman weaners from Mt Sanford.

Background:

Two 6 km^2 replicate blocks (Finch and Quail) were again available for use in 1999-00 when the first weaners from the Kidman breeder genotype comparison became available.

Each paddock contained weaners from this genotype comparison and also Mt Sanford Brahman weaners in a weaning weight (WW) range comparison that will not be reported here.

The genotype comparison comprised three weaner genotypes from Kidman (Droughtmaster, Brahman and 1/4Charolais) and similar aged commercial Brahman weaners from Mt Sanford Station. Earlier work at DDRF (Project 8.4.1) had demonstrated that it was unlikely that there were significant differences in the growth potential of commercial Brahman weaners between stations in the VRD and so the Mt Sanford Brahmans were a proxy for VRD commercial Brahmans in general and they were the control.

Table 1. WR 1 weaner numbers and initial weights in 1999-00

Comp	Geno	Finch			Quail		
		n	kg	kg/head	n	kg	kg/head
Geno	**DM**	10	1950	195	10	1975	198
	Bra K	10	1865	187	9	1665	185
	1/4Ch	10	2050	205	10	2075	208
	Bra MS	9	1740	193	10	1940	194
	total	**39**	**7605**	**(195)**	**39**	**7655**	**(196)**
Weight range	**Lo**	18	2176	121	19	2324	122
	Hi	21	4700	224	20	4628	231
	total	**39**	**6876**	**(176)**	**39**	**3952**	**(178)**
	Total	**78**	**14481**	**(186)**	**78**	**14607**	**(187)**

DM = Droughtmasters 1/4Ch = ¼ Charolais x ¾ Brahman
Bra K = Kidman Brahmans Bra MS = Mt Sanford Brahmans
Values in brackets are means

Table 2. WR 1 weaner numbers and initial weights in 2000-01

Comp	Geno	Finch			Quail		
		n	kg	kg/head	n	kg	kg/head
Geno	DM	10	1864	186	10	1917	192
	Bra K	11	2226	202	10	2152	215
	1/4Ch	8	1832	229	10	2020	202
	Bra MS	10	2124	212	10	2191	219
	total	39	8046	(206)	40	8280	(207)
Weight Range	Lo	26	3365	129	25	3359	122
	Hi	20	4804	242	23	6100	231
	total	46	8169	(178)	48	9459	(197)
	Total	85	16515	(194)	88	17739	(202)

Tables 1 and 2 show the WR 1 numbers and weights in the two replicate blocks each year. Only WR 1 weaners were included in these analyses because of the low number of WR 2 animals.

In 1999-00 there was a major disruption to grazing in the middle of the wet when much of the water reticulation pipeline became clogged with limestone deposits and stock had to be removed from their plots for several weeks while the pipelines were renovated.

In 2000-01 the experiment was again disrupted, this time by major flooding which again necessitated a period of de-stocking of the plots.

In both years, the main effect on the genotype comparison was the loss (disappearance) of some of the Mt Sanford animals and as a consequence it was decided to use the Bra MS weaning weight range comparison animals as the control.

Results:

Table 3 shows the number of animals available for analysis (n), the WW averages for all genotypes and the estimates of weaning age (WA). This was derived by assuming all birth weights were 30 kg and that wet season growth rate was 0.85 kg/d. The Kidman weaners were weaned a month earlier than the Bra MS.

Table 3. ELW (kg) at weaning and estimated age (months) at weaning

Geno	Year						Average		
	1999-00			2000-01					
	n	WW	WA	n	WW	WA	n	WW	WA
DM	14	198	6.6	`15	198	6.6	29	198	6.6
Bra K	19	186	6.1	18	209	7.0	37	197	6.6
1/4Ch	16	207	6.9	15	201	6.7	31	204	6.8
Bra MS	61	176	5.7	77	186	6.1	138	181	5.9

Table 4 shows that both year ($P < 0.001$) and genotype ($P < 0.001$) had significant effects on growth in the dry. There were also significant differences between genotypes ($P < 0.05$) in their average dry season growth. The Bra K and DM genotypes showed a similar response to improved nutrition. The Bra MS only showed half the response shown by the Bra K. The 1/4Ch showed nearly twice as much.

Table 4. The effect of year and genotype on dry season growth of weaners

Geno	Year		Diff. (kg)	Average (kg)	Sig
	1999-00 (kg)	2000-01 (kg)			
DM	+2.0	+14.9	12.9	+8.5[a]	**P < 0.001**
Bra K	-7.2	+ 5.8	13.0	-0.7[c]	
1/4Ch	-9.0	+15.4	24.4	+0.2bc	
Bra MS	+0.5	+7.0	6.5	+3.8[b]	
Average	**-3.4**	**+13.1**			**P < 0.001**

Values with different alphabetic superscripts are significantly different (P < 0.05).
Diff = the difference between the worst and best year.

Table 5 shows that genotype had a significant effect (P < 0.001) on wet season growth with all four genotypes being significantly different to each other (P < 0.05). The 1/4Ch performed best in both years and grew 14.8 % or 16.4 kg more than the control (Bra MS). There was no significant year effect.

Table 5. The effect of year and genotype on wet season growth of weaners

Geno	Year		Average (kg)	Sig
	1999-00 (kg)	2000-01 (kg)		
DM	113.1	115.1	114.1c (103)	**P< 0.001**
Bra K	118.6	115.2	116.9[b] (105)	
1/4Ch	134.7	119.9	127.3[a] (115)	
Bra MS	110.3	111.5	110.9[d] (100)	
Av	**119.2**	**115.4**		**NS**

Values in the column with different alphabetic superscripts are significantly different (P < 0.05).
Values in brackets provide the difference in percentage terms between the control (Bra MS) and the alternative genotypes from Kidman.

Table 6 shows that both year (P < 0.01) and genotype (P < 0.01) significantly affected total annual growth with DM and 1/4Ch being similar and significantly better (P < 0.05) than the two Brahman samples (which were nearly identical).

Table 6. The effect of year and genotype on annual growth of weaners

Geno	Year		Average (kg)	Sig
	1999-00 (kg)	2000-01 (kg)		
DM	115.1	130.0	122.6[a] (107)	P< 0.01
Bra K	111.4	121.0	116.2[b] (101)	
1/4Ch	125.7	135.3	127.5[a] (111)	
Bra MS	110.8	118.5	114.7[b] (100)	
Av.	115.8	128.5		P <0.01

Values in columns with different alphabetic superscripts are significantly different (P<0.05).
The values in brackets provide the difference in percentage terms between the control (Bra MS = 100) and the alternative genotypes from Kidman.

Table 7 shows treatment combination means for final p8 fat depth. There was a small but significant (0.7mm, P< 0.05) difference between years but no significant genotype effect (range 0.6 mm with 1/4Ch leanest and the control Bra MS fattest). Ultrasonic p8 measurements below 3 mm are not very reliable.

Table 7. Final p8 fat depth (mm)

Geno	Year		Average	
	1999-00 (kg)	2000-01 (kg)	(kg)	Sig
DM	3.7	2.6	3.2	NS
Bra K	3.1	3.0	3.1	
1/4Ch	3.2	2.5	2.9	
Bra MS	3.8	3.1	3.5	
Average	**3.5**	**2.8**		**P< 0.05**

Table 8 provides the treatment combination means for final ELW, age and value-adding potential at the end of the first post-weaning wet. The age estimate was obtained by adding to the weaning age estimate in Table 3, the time that elapsed between start of the experimental grazing each year and turn-off at the end of the first post-weaning wet.

Value-adding potential was estimated as described in Figure 1 in the first data set (1998-99) reported here. Value-adding potential is the potential feedlot weight gain (at a specified growth rate) before the group reaches an average p8 fat depth of 10 mm. This value can be obtained from the maturity type growth curve for the relevant breed and sex, as shown earlier in this report (see Figure 1 under Objective 1).

Table 8. Final ELW, age and value-adding potential

Geno	Year				Average		Value adding
	1999-00		2000-01				
	kg	mo	kg	mo	kg	mo	kg
DM	313	17.6	328	17.6	320	17.6	50[a]
Bra K	297	17.1	330	18.0	313	17.6	50[a]
1/4Ch	332	17.9	330	17.7	331	17.8	90[b]
Bra MS	287	15.7	307	16.1	297	15.9	50[a]
Sig							P< 0.001

Values in columns with different alphabetic superscripts are significantly different (P<0.05).

The value-adding potential of the 1/4Ch cattle in Table 8 was significantly greater than that of the other three genotypes (+40 kg or + 80%, P< 0.001). As a consequence the 1/4Ch had a significantly higher potential ELW at slaughter (331 + 90 = 421 kg) relative to the other three genotypes (347-363 kg). This favourably affected the end-use suitability of the 1/4Ch for the SE Asian supermarket trade.

Finally in Table 9 the actual ELW of the cattle from the two Brahman sources is compared with the estimates of ELW derived from a prediction equation (r^2 = 0.92) developed in Project 8.4.4. This equation predicts ELW from P8 fat depth and age. There is very good agreement between the actual and estimated values in Table 9 and this suggests that the two herds are very similar in mature size.

Table 9. Actual *vs.* estimated ELW

Source	P8 mm	Age mo	Actual ELW kg	Estd ELW kg
Bra K	3.1	17.6	313	316
Bra MS	3.5	15.9	297	299

Conclusions:

- The 1/4Ch genotype gave significantly more annual growth (+ 11% or +12.8 kg/head, P< 0.05) and extra post-weaning efficiency (20 x 12.8 = +256 kg gain/km^2) than the Bra MS, and 80% more (+40 kg/head, P< 0.001) feedlot value-adding potential.

- Relative to the 1/4Ch, the DM provided a lower annual growth improvement (+7% or +7.9kg/head, P< 0.05) and post-weaning efficiency (+158kg/km^2), and no improvement in feedlot value-adding potential, at the end of the first post-weaning wet.

- There was no difference in annual growth, post-weaning efficiency or value-adding potential between the two Brahman genotypes.

- The basis of the growth advantage of the 1/4Ch was their greater response to improved nutrition relative to weaners from the two Brahman sources. This was seen as a 15% (+16.4 kg/head, P< 0.05) growth advantage in the wet relative to the Bra MS and the 24.4 kg/head weight change difference in the dry between the two years. This was nearly four times the between-year difference in the Bra MS (6.5 kg.) and nearly twice the difference that occurred in the other two genotypes (13 kg.).

- The close similarity between actual and estimated empty live weights (ELW) in Table 9 indicates that the two Brahman groups are probably herds of the same mature size. The information from this trial, together with that from earlier work (Project 8.4.1) in which there were no significant property of origin differences in wet season growth rate in groups of 20 or more weaners from 15 properties in the Katherine region, suggests that the Bra K information can be safely extrapolated to commercial Brahman herds in the region without need for adjustment for genetic differences.

PROJECT: Backgrounding Commercial Brahman Weaners on Mitchell Grass in the VRD

Project Officers: P. Ridley and T. Schatz

Location: Mt Sanford Station

Objective 3:

Measure, analyse and report on the effects of gazing management systems (2), weaning weight ranges (4) and stocking rates (2) on growth and value-adding potential of first weaning round commercial Brahman weaners at the end of their first post-weaning wet.

Background:

This experiment set out to measure and report the short-term effects on weaner growth of introducing pasture burning (for woody weed control) and pasture saving (for improved weaner nutrition) in a closed system (i.e. without changing the land area or weaner numbers).

The two grazing management systems were:

Basic (control):

- Sustainable stocking rate (20 head/km^2, see the report of 1998/99 data in this project).

- *Ad libitum* N supplementation in the dry and P supplementation in the wet (in the form of commercially available lick blocks).

Best bet (treatment):

- Stock numbers, pasture area and supplementation as in the Basic treatment.

- Pasture saving for first weaning round (WR 1) weaners to begin at the start of the wet prior to their weaning.

- Pasture saving for second weaning round (WR 2) weaners to begin at the start of the dry prior to their weaning and part of this area to be burned prior to this weaning muster (i.e. in August/September).

In each successive year the wet season saved and dry season saved areas in the best bet treatment were changed so as to ensure that:

- The area chosen for wet season pasture saving was not biased in relative agronomic potential.
- The whole of the 6 km^2 was routinely burned once over a specified period.

The two grazing management systems were replicated, each replicate being 6 km^2 and carrying the same stock numbers within years.

To provide the metabolisable energy needs of the notional weaner population (in terms of their initial average weight) to achieve the notional weight gain (by the end of their first post-weaning wet) and also provide the necessary saved pasture at the start of the dry, it was necessary to save about one third of the whole area in the wet. The best-bet system was therefore subdivided into three equal plots (2 km^2/plot). At any one time only two thirds of the area in the best-bet system was available for grazing.

In the best bet system each annual group of new WR 1 weaners was randomly allocated to either the area that had been grazed in the previous wet or the area that had been saved in the previous wet. This provided data for a valid assessment of the effect of saved pasture on the relative performance of WR1 weaners in the dry (see Table 3).

Half of the WR 1 weaners in the best bet grazed un-saved pasture at the start of the dry, as did all the weaners in the basic treatment. However, the best bet weaners grazed at a 50% higher stocking rate than those in the basic treatment as a consequence of pasture saving. This provided data for a valid assessment of the effect of a 50 % difference in stocking rate in the dry (see Table 4).

Results:

These results are for WR 1 weaners only. Only animals with full data are included in the analyses. Causes for missing data included escapes, failure to muster, lost tags and an unknown number of unobserved deaths. Weaner growth in the first year reported here was within the range of normal expectation. In the second year, in which significant opening rains were delayed by several months, weaner growth over the whole year was only 55% of that recorded in the first year.

Table 1. Effect of management system on growth

Year	Management system	Dry season (kg)	Wet season (kg)	Whole year (kg)	n
2001-02	Basic	8.8	121.9	130.7	196
	best bet	4.4	118.9	123.3	205
	Sig	P< 0.001	P < 0.01	P< 0.001	
2002-03	Basic	-22.9	99.4	76.5	202
	best bet	-17.4	83.3	65.9	189
	Sig	P< 0.001	P< 0.001	P<0.001	

Table 2. Effect of weaning weight range on growth

Year	Weaning weight range (kg)	Dry season (kg)	Wet season (kg)	Whole year (kg)	n
2001-02	100-140	10.1	117.5	127.6	67
	141-180	6.8	119.7	126.5	159
	181-220	5.3	122.2	127.5	108
	221-260	4.5	121.7	126.2	67
	Sig	P< 0.001	P< 0.05	NS	
2002-03	100-140	-7.5^{A}	88.0^{AB}	80.6^{A}	34
	141-180	-11.8^{B}	88.4^{A}	76.5^{A}	67
	181-220	-21.3^{C}	91.0^{AB}	69.7^{B}	132
	221-260	-25.6^{C}	94.2^{B}	68.6^{B}	158
	Sig	P< 0.001	P< 0.05	P< 0.001	

Values in columns with different alphabetic superscripts are significantly different (P< 0.05).

Table 3. Effect of pasture saving on growth (saved vs grazed)

Year	Management system	Dry season (kg)	Wet season (kg)	Whole year (kg)	n
2001-02	Saved	5.0	117.5	122.5	101
	Grazed	3.9	120.3	124.2	104
	Sig	NS	P< 0.05	NS	
2002-03	Saved	-16.3	74.8	58.5	89
	Grazed	-18.3	90.8	72.5	100
	Sig	NS	P< 0.001	P< 0.001	

Table 4. Effect of stocking rate on growth

Year	Management System	head/km^2	Dry season (kg)	Wet season (kg)	Whole year (kg)
2001-02	Basic	1X	8.8	121.9	130.7
	Best Bet	1.5X	3.9	120.3	124.2
	Sig		P< 0.001	NS	P< 0.001
2002-03	Basic	1X	-22.9	99.4	76.5
	Best Bet	1.5X	-18.3	90.8	72.5
	Sig		P< 0.001	P< 0.01	P< 0.01

Actual numbers/system varied between years and between seasons within years and the notation 1X and 1.5X is used here to indicate the 50 % difference in stocking rate between the two grazing management systems.

In the dry:

- Table 1 shows that in the year when weaner performance was worst, the best bet system provided a small but statistically significant benefit (5.5 kg, P< 0.001), while in the "normal" year it resulted in a similarly small and also statistically significant disadvantage (-4.4 kg, P< 0.001).

- Table 2 shows that there was a consistent trend for the lighter (younger) weaners to perform significantly (P< 0.001) better than the heavier (older) weaners with this difference being greatest in the year of least growth (18.1 kg vs 5.6 kg, P< 0.001). This trend was strongest in the year when nutrition was below maintenance and there were significant differences (P< 0.05) between three of the four weaning weight ranges.

- Table 3 shows pasture saved during the previous wet provided a negligibly small and non-significant increase of 1.1 kg in the year of better nutrition and only 2.0 kg in the year of worst nutrition.

- Table 4 shows that there was a small but highly significant effect in both years (P< 0.001) from a 50% increase in stocking rate in weaners grazing pasture that had been grazed the previous year.

In the wet:

- Table 1 shows that in both years the best bet system exhibited significantly (P< 0.01 and P< 0.001 respectively) lower growth than the basic system with the effect being greater in the year with unusually low growth (3 kg vs 6.1 kg),

- Table 2 indicates evidence of some compensatory growth with a significant effect of weaning weight range on growth (P< 0.05) in both years. Statistically significant differences (P< 0.05) occurred between some weaning weight ranges in the wet in the year following the greatest weight losses during the preceding dry, There appeared to be a negative relationship between dry season loss and wet season gain.

- Table 3 shows the difference in growth between weaners grazing plots that had been grazed or saved during the previous wet was the reverse of that which occurred in the intervening dry. Again there appeared to be a negative relationship between dry season loss and wet season gain.

- The effect of a 50% increase in stocking rate was a relatively small (1.6 kg) decrease in wet season growth in the year with the higher growth rate, with a larger (8.6kg) decrease in the low rainfall year.

Over the whole year:

- Table 1 shows a relatively small (7.4 and 10.6 kg, P< 0.001) but significant disadvantage in total growth in the best bet system,

- Table 2 shows no difference between weaning weight ranges in total growth in the good year and surprisingly, consistent advantages in total growth as original weaning weight decreased in the low rainfall year.

- Table 3 shows a highly significant (P< 0.001) difference in total growth between the weaners that grazed the plot that had been grazed the previous wet (72.5 kg) and those that grazed the plot that had been saved the previous wet (58.5 kg).

- The effect of a 50% increase in stocking rate resulted in a relatively small decrease in total growth (6.5 kg and 4.0 kg in the favourable and dry years, respectively P< 0.001 and P< 0.01).

Conclusions:

- While the best bet system (saved pasture) only improved dry season weaner performance (+4.5 kg) in the year with the very late wet season (2002-03), the dry season disadvantage in the more normal year was not large (-4.4 kg/head, P< 0.001). By the end of the year the best bet system had reduced annual growth by 7.4 kg/head or 5.7% (P< 0.001) in the normal year and by 10.6 kg/head or 13.9% (P< 0.001) in the short wet year (2002-03). This effect may be one of the inescapable costs of sustainability.

- Weaning weight range had most effect on post-weaning performance in the dry season immediately after weaning. This effect was greatest in the short season year (2002-03) when there were significant differences between three of the four weight range means (P< 0.05) for dry season weight change. In this year, these effects were still evident at the end of the first post-weaning wet although some statistically significant compensatory growth occurred during the wet. In the normal year (2001-02) compensatory growth in the wet (P< 0.05) eliminated the smaller dry season weaning weight range effects by the end of the wet.

  In both years the lightest weaners (100 -140 kg) performed best in the dry and in the difficult year of 2002-03. Nearly 67% (18 kg) of this advantage was still retained at the end of the wet. Clearly there is no justification for not weaning 100 -140 kg weaners out of fear that they are too immature to thrive in the dry season. There is also a less easily quantified benefit to their mothers from such early weaning. This is in terms of significantly improving their pre-calving body reserves and the consequential effects this has on lactation (growth rate of the next calf) and the inter-calving interval (the time taken to conceive the next calf). The implications of early weaning on value-adding potential have already been discussed in conjunction with the data obtained at this site in 1998-99.

  These WW range effects are consistent with those obtained in 1998-99 at this site.

- The direct effect of saved pasture in the dry season was negligibly small in both years (1.1kg/head in 2001-02 and 2.0 kg/head in 2002-03).

- The direct effect of a 50% increase in stocking rate was a relatively small decrease in growth per animal over the whole year in 2001-02 (-1.6 kg/head, NS) with a larger and significant effect in the low rainfall of 2002-03 (-8.6 kg/head or –8.1%, P< 0.01).

SUBPROGRAM: Improving Breeder Herd Efficiency

PROJECT: Available Soil Phosphorus in the Alice Springs District

Project Officers: **C. Hill, B. Gill and Pastoral Production Officers**

Location: Alice Springs

Objectives:

Sample the soil from DIPE land units under cattle grazing in the Alice Springs sub-districts for available soil P levels.

Categorise the DIPE land units sampled, in terms of the available soil P categories.

Summarise the land units sampled into a broader land classification titled "land types" based on their available soil P levels for use by pastoralists.

Develop a map of available soil P categories for the Alice Springs district.

Promote the use of cost effective and efficient P supplementation in Central Australia by supplying information on available soil P levels during the length of the project.

Produce a booklet for producers titled "A guide to phosphorus supplementation in Central Australia" using the project results.

Background and Method:

Phosphorus (P) deficiency occurs periodically in cattle herds across Northern Australia. Determination of the P level in cattle's diet is important because the profitability of providing P supplements depends primarily on the level of P intake, together with the seasonal P requirements of the cattle. Available soil P analysis measures the ability of the soil to supply P to growing plants, and hence indicates the potential of pasture in the area to provide P in the diet of grazing cattle.

Using DIPE land unit descriptions to classify land types, duplicate grid soil samples are collected from each land unit and analysed by the Colwell P test method to describe the available soil P level (Table 1.). Sampled properties are then mapped in terms of available soil P levels.

The full description of method is reported in the 2001-02 Technical Annual Report.

Table 1. Available soil P level

Adequate	Marginal	Deficient
> 8 mg/kg	7 – 8 mg/kg	< 6 mg/kg

Progress:

Over 80% of pastoral properties with completed DIPE land unit maps have been sampled for soil and mapped in terms of available soil P levels. Sampling has illustrated the varying nature of soil P availability even within a contiguous area. Intra and inter-property variability in available soil P indicates that one standard P supplementation recommendation has limited suitability for an area that contains a number of different land types. Mapping of the soil P status of different land-types on properties will enable more targeted P supplementation and paddock management across the Alice Springs district.

Soil samples will be collected in 2003-2004 from the remaining major land types not sampled. Analysis of these samples will enable completion of an available soil P map for the Alice Springs district, which is a major objective of this project.

Future work:

1. Summarise the land units sampled into a broader land classification titled “land types” based on their available soil P levels.

2. Develop a map of available soil P categories for the Alice Springs district.

3. Produce a guide to P supplementation in Central Australia for pastoralists.

This work will require a review of the results from work on Objective 2, and thus enable documentation of areas of any future required research. Since closure of the soil analysis service at the BARC Chemistry Section, the available soil P test has been undertaken interstate. This places a major financial burden that needs consideration for planning of any future projects.

PROJECT: Near Infrared Reflectance Spectroscopy (NIRS) Validation for Central Australia

Project Officers: C. Hill, J. Coventry, Pastoral Production Officers and AZRI Farm Staff

Location: Alice Springs

Objectives:

Routinely collect faecal and pasture samples from growing cattle for a period of two years.

Provide actual growth rates and faecal samples for NIRS evaluation to CSIRO, to enable calibration equations to be developed for Central Australia.

Gain a better understanding of cattle diet and variation across seasons in the Alice Springs Region

Validate the value of using NIRS technology to assess pasture digestibility and nitrogen content, investigate dietary selection and hence aid with livestock management.

Present intermediate pasture quality information and faecal NIRS growth rate predictions during the length of the project.

Present subsequent recommendations on faecal NIRS, based on formulated CSIRO calibration equations and validation results of the technology in Central Australian conditions.

Background and Method:

The evaluation of forage and prediction of grazing cattle performance assists in more efficient dietary supplementation and management techniques. Compared to traditional (wet chemistry) methods of determining diet digestibility and crude protein content, NIRS technology developed by CSIRO in Queensland offers an alternative means of measuring diet quality (Table 1.) and predicting animal performance.

Table 1. Measurements of nutritional status, calculated using conventional vs NIRS techniques

MEASUREMENT	**TECHNIQUES**		
	Field recording	Wet chemistry	NIRS
Dietary crude protein (nitrogen)	Categorical pasture description	Pasture and faecal analysis by modified Micro-Kjeldahl method	Pasture and faecal analysis by spectroscopy and calibrated equations
Dietary digestibility (energy)	Categorical pasture description	Pasture and faecal analysis by pepsin / cellulase method	Pasture and faecal analysis by spectroscopy and calibrated equations
Proportion of non-grass in diet	-	-	Faecal analysis by spectroscopy and calibrated equations
Animal growth rate	Record cattle weight on RUDDWEIGH platform	-	Faecal analysis by spectroscopy and calibrated equations

This project represents the first stage of investigations into how to establish robust NIRS calibration equations that suit the pastures of Central Australia. This is a requirement that will need to be met before NIRS can be used to improve assessment and management of cattle nutrition, and accurately predict animal performance in this region.

The pilot study using young cattle at the Arid Zone Research Institute (AZRI) involves collection of cattle and pasture data and samples, with comparative analysis of samples by wet chemistry techniques (AZRI Animal Nutrition Laboratory) and NIRS techniques (CSIRO Rockhampton). The full description is reported in the 2001-02 Technical Annual Report.

Progress:

Collection of all field samples and data is complete. Wet chemistry and NIRS results will be finalised in 2003; preliminary descriptive analysis of the data and laboratory results has commenced and will be completed in 2004 (heifers 2001-02; steers 2002-03) with some comparison with concurrent NIRS studies in other regions of the Northern Territory.

Current results indicate a good relationship between NIRS pasture protein % values and wet chemistry pasture protein % values (Figure 1), but a poor relationship between NIRS in-vitro pasture digestibility % values and wet chemistry pasture digestibility % values (Figure 2).

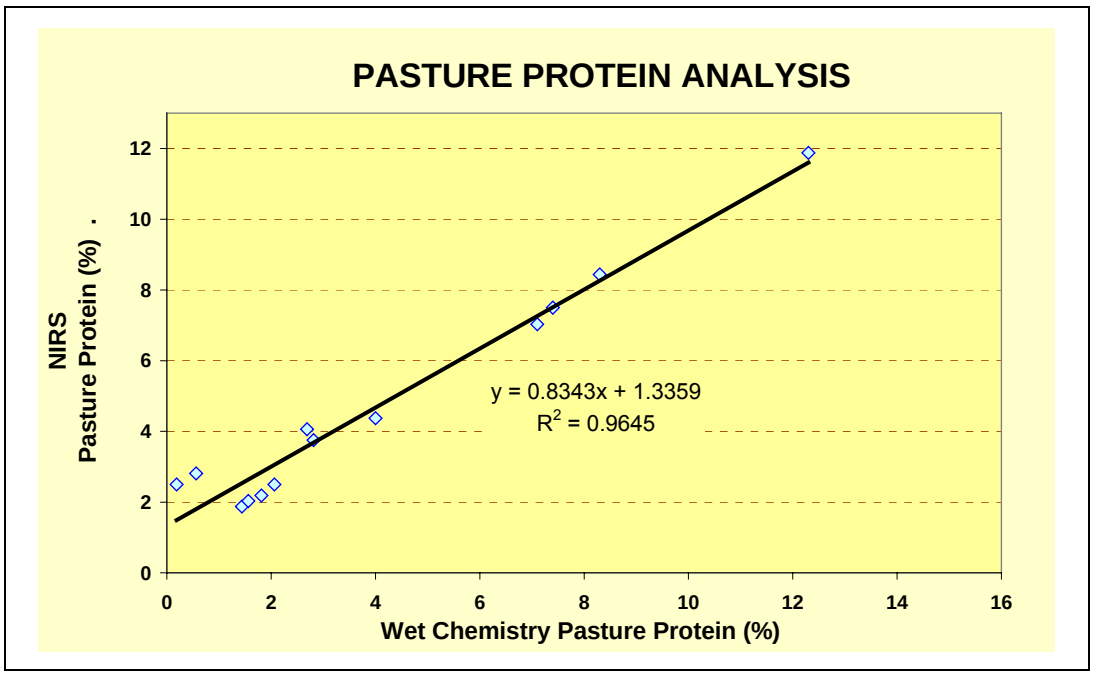


Figure 1. Comparison of pasture protein values – wet chemistry vs NIRS analysis techniques

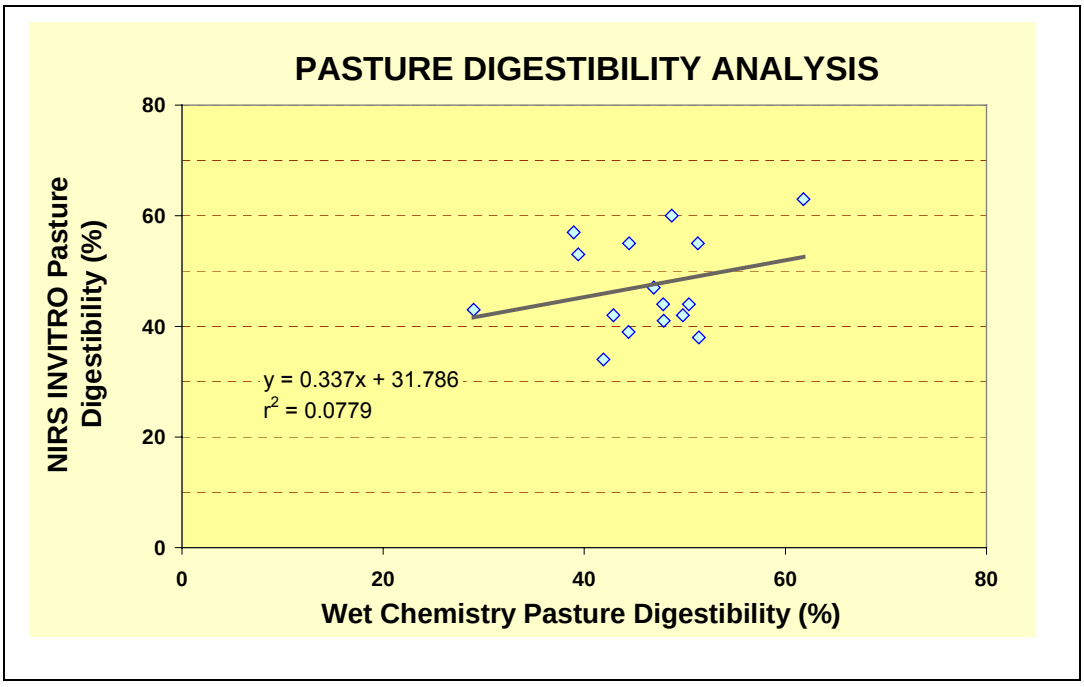


Figure 2. Comparison of pasture digestibility values – wet chemistry vs NIRS invitro analysis techniques

Using wet chemistry techniques as a 'gold standard' for analysis of faecal nitrogen %, NIRS tends to consistently overestimate faecal N at lower concentrations, and underestimate at higher concentrations (Figure 3).

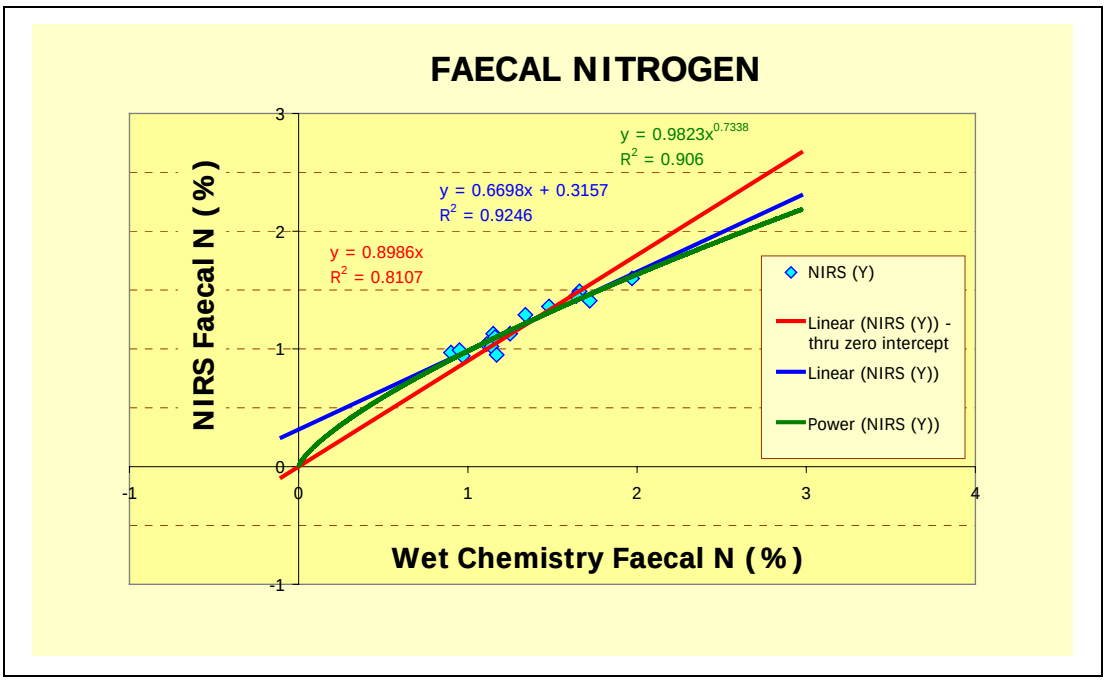


Figure 3. Comparison of faecal nitrogen values – wet chemistry vs NIRS analysis techniques

Technical difficulties with cattle weighing scales largely contributed to an apparent poor relationship between actual live-weight gains and NIRS predicted live-weight gains.

Feedback from CSIRO Rockhampton indicates that inconsistencies seen in dietary predictions based on the analysis of collected pasture or faeces, may be the result of several factors:

- Crude protein predictions for the dry season grass samples (April to November) are low, but non-grass plant material may markedly improve the protein level of the diet of cattle.

- Grass selected by the grazing cattle may have a higher protein level and higher digestibility than cut/plucked grass samples.

PROJECT: Effectiveness of Water Medication to Supplement Breeder Cattle in Spinifex Country

Project Officers: K. Hill and Pastoral Production Officers

Location: Alice Springs

Objectives:

Demonstrate and record productivity improvement in breeders receiving nutrients by water medication systems, compared with unsupplemented breeders on similar country.

Demonstrate a reliable and cost-effective means of providing essential nutrients to cattle.

Demonstrate that marginal country can be utilised and productive all year round.

These objectives have been met and the project is now complete.

Background:

Water medication has long been recognised as an alternative means of supplementing cattle. Technological improvements to the systems that deliver nutrient supplements through the water have greatly improved their safety and cost-effectiveness in recent years. Producer interest has been renewed in this method of supplementation after a long period of scepticism due to early safety problems. Central Australia is well suited to water medication due to the vast majority of stock watering points being troughs rather than uncontrolled surface water. This study was set up to demonstrate to pastoralists, the safety aspects and cost-effectiveness of water medication in marginal country in the Alice Springs district of the Northern Territory.

Method:

This was a two-part producer demonstration site (PDS) with the PDS part 1 (1998 to 1999) using 314 mixed-age breeder cows and the PDS part 2 (1999 to 2001) using 286 first calf heifers. In both parts of the PDS the cows or heifers were drafted into two even groups and put in separate paddocks. One group received nutrient supplement by water medication (treatment group) and the other group received no supplement (control group).

Results and Conclusions:

In both parts of the PDS there was considerable productivity improvement in cattle receiving nutrient supplement through water medication systems, compared with non-supplemented cattle.

Breeder weights, pregnancy rates, weaner weights and weaner numbers, plus the approximated number of breeder cow deaths were considered when analysing the results. In dry years, the paddocks at Narwietooma that were used in the PDS have been unproductive to the point of breeders dying in them. In the PDS Part 1 there was a dry year and 32 more breeder cows were missing (presumed dead) in the control paddock compared with the treatment paddock.

In a cost-benefit analysis of findings recorded over a dry year in the PDS Part 1, there was a net benefit to cost ratio of greater than 9:1 for the treatment group (Table 1). The installation and use of water medication was cost-effective within 12 months.

Table 1. Net financial benefit to treatment group over control group December 1998 - October 1999

+ 11% pregnancy in treatment group (147 head x 11% x $50 per pregnancy)	= $ 809
+ 37 kg advantage in treatment group (147 head x 37 kg x $1.00 per kg)	= $ 5,439
+ 8,201 kg advantage in treatment weaners (8,201 kg x $1.30 per kg)	= $ 10,661
32 more cows missing ('presumed dead') in control group (32 head x 409 kg (av. wt at final weigh) x $1/kg)	= $ 13,088
Gross financial benefit to treatment over control group	= $ 29,997
Less depreciation of the cost of two water medication units with installation at 10% per year ($300 per tank; $1,800 per unit; $400 labour per unit) x 10% per year for 317 days	= $ 434
Less cost of supplement (assuming cows drank 40 L per day) (147 head x 317 days x 5.05c per day)	= $ 2,353
Net financial benefit to treatment over control group	= $ 27,209
The net benefit to cost ratio was greater than 9:1. This is equivalent to a benefit of $ 213 per breeder cow year	

The two years of the PDS Part 2 had exceptional rainfall. Cattle were on water medication for approximately 50% of the time due to the availability of surface water. However the results clearly demonstrated more production from the treatment group compared with the control group through increased numbers of pregnant heifers (Figure 1) plus more and heavier weaners. The advantages seen in the treatment group can be explained by the positive effect of even minimal P supplementation for breeder heifers (Figure 2) in paddocks proven to be P deficient.

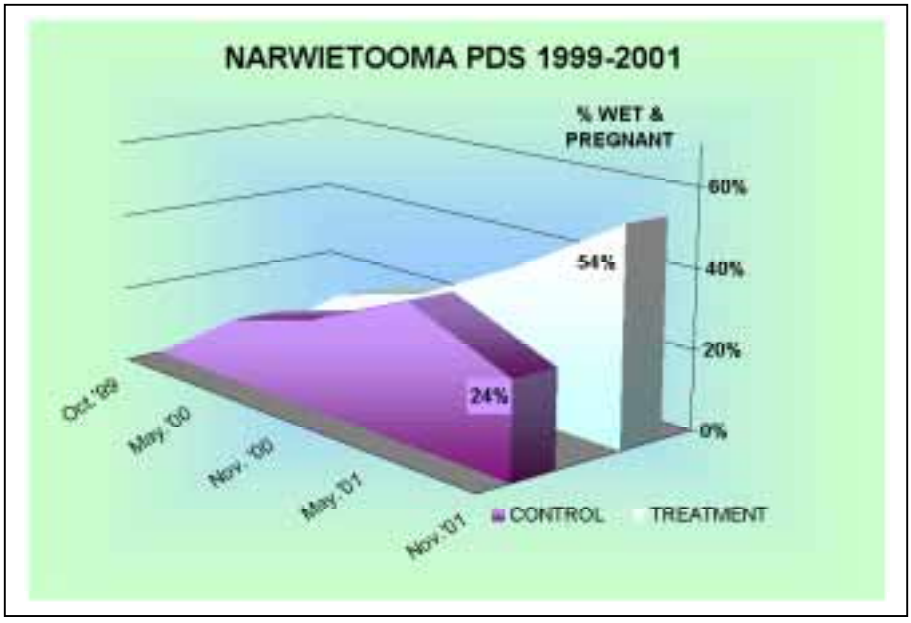


Figure 1. Percentage wet and pregnant (treatment vs control group) October 1999 - November 2001

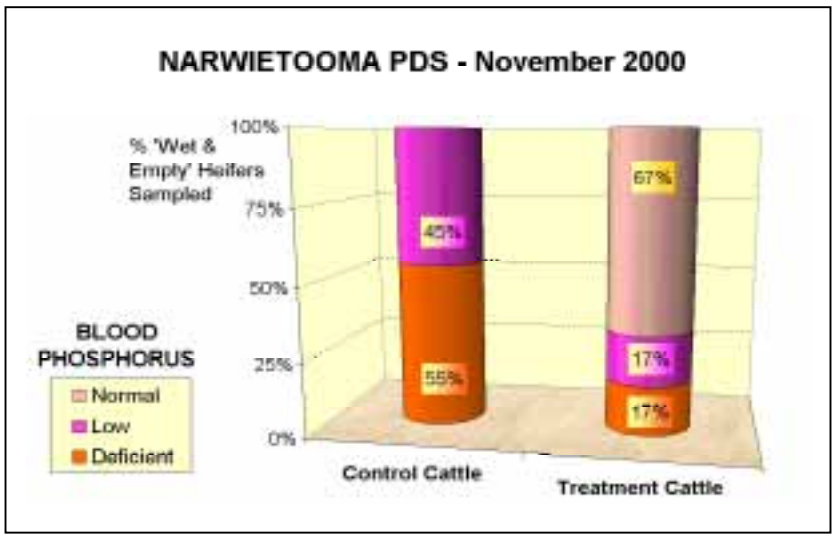


Figure 2. Blood phosphorus results

The reliability of the water medication units was demonstrated over the three-year period. Very few faults occurred with the units during the PDS and those that did were minor. More importantly there were no cattle deaths recorded as being due to urea poisoning.

This PDS demonstrated considerable benefits to breeder cattle production on spinifex grazing country from using water medication.

As a direct result of this PDS, beef producers in the district are beginning to accept water medication as a safe and reliable method of supplementing cattle. The relevance and implications of these results to commercial producers will mean production increases in a district that does not use nutrient supplement extensively at present.

The three objectives of the Narwietooma water medication PDS were met and the full report has been published:

Hill, K. 2003, *Effectiveness of water medication to supplement breeder cattle in spinifex country, PDS 97/10, December 1998 – November 2001*: ISBN 0 7245 4701 0. Final Report, January 2003 NT Department of Business, Industry and Resource Development, Meat and Livestock Australia: 29p.

SUBPROGRAM: Pastoral Production

PROJECT: AZRI Breeder Herd Crossbreeding Project

Project Officers: B. Gill, Pastoral and AZRI Staff

Location: Arid Zone Research Institute (AZRI)

Objective:

Demonstrate the benefits of crossbreeding options that industry could readily adopt to ensure steers are capable of meeting South East Asian and North African live export specifications and North Asian grass and (if lot-fed) grain fed carcase market specifications by December 2009.

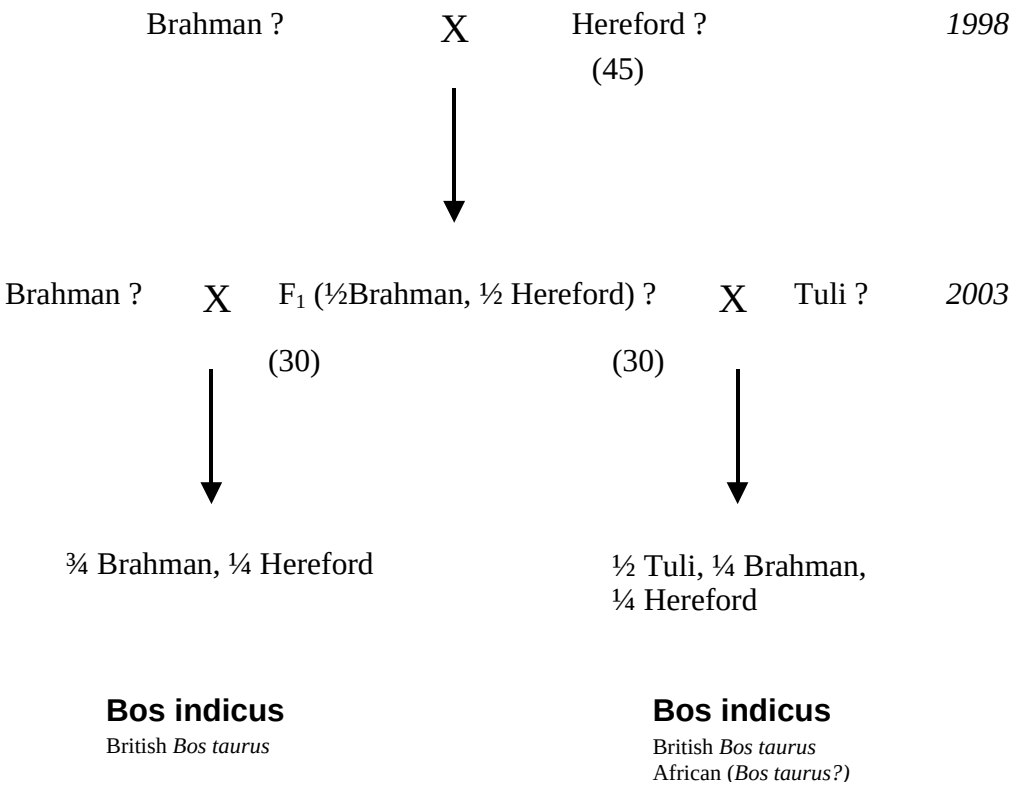
Background*:*

Since the expansion of the live export trade to South East Asia during the 1990s, and more recently North Africa and the Middle East, opportunities now exist for Central Australian cattle producers to supply a wide range of markets. One option for producing animals to suit these markets is crossbreeding to take advantage of hybrid vigour and infuse genes of the Brahman and other tropically adapted breeds.

This project will provide objective local information from a crossbreeding program designed to breed steers that suit a range of markets without compromising female fertility.

Progress:

Details of the crossbreeding project appear in the 2001-02 Technical Annual Report. The current breeding program is shown below.



By 2002 sufficient first-cross Hereford X Brahman females (F_1) had been bred during previous years that mating to the first phase of trial bulls was possible. Sixty empty females (two to four years of age) were stratified by age and weight, then split into two even groups for mating. One group was joined to a red Brahman bull, the other to a pure Tuli bull. Bulls were run with females for three months February to April 2003.

Pregnant cows are due to calve in November 2003. This cohort being the first of the crossbred progeny produced for evaluation.

Note: During the F_1 breeder accumulation phase (1998 – 2001), heifers were joined to a mix of bulls as they reached two years of age. Resultant progeny is not part of this project and no data on them will be reported here.

PROJECT: Grazing Impacts at Exclosed Sites

Project Officer: G. O'Reilly

Location: Alice Springs District

Objective:

Document existing grazing impacts and improved basis for assessing them in the future.

This objective has been met and the project is now complete.

Background:

After the 1960s drought, several long-term cattle exclosures were established around the NT to document range condition and trend over time. Very few remain, but one that is intact is the spinifex bore exclosure (128 hectares) constructed in 1968 on Mt. Riddock station in sandy open woodland. A detailed study at the site between 1973 and 1978 showed few consistent differences between grazed and exclosed areas. By the 1990s, obvious pasture composition differences had developed across the exclosure fence and the present study quantifies and documents these differences.

Results:

Pasture attributes important to cattle production were estimated three times between 1998 and 2001 in a cattle exclosure (128 ha), ungrazed since 1969, and in the surrounding grazed area of a sandy open woodland in Central Australia, grazed since 1954.

The grazed area had consistently higher dry matter production and frequency of occurrence of the perennial grass, *Eragrostis eriopoda*. The annual grasses, *Enneapogon polyphyllus* and *Aristida contorta*, were only significant contributors to production in the absence of grazing. Another dominant grass, *Aristada holathera*, was unaffected by grazing.

There was a significant decline in production by most grasses during the second year of above average rainfall, except for *Aristida holathera*, which increased production across both treatments during this time.

Various forbs and minor grasses showed significant differences in dry matter production and/or frequency of occurrence when seasonal conditions are favorable for their growth. There were no differences in the diversity of pasture species between treatments.

The study showed that nearly all species were able to persist under grazing, but that there were substantial shifts in botanical dominance. Of greatest concern was the ability of *Enneapogon polyphyllus* to contribute significantly to production under grazing in the land type. It remains unclear what strategies might improve production of this important species in Central Australia.

The project was completed with the publication of a Technical Bulletin and an article in the national publication, *Range Management Newsletter*.

PROJECT: Fire as a Pastoral Management Tool

Project Officer: R. G. O'Reilly

Location: Alice Springs District

Objective:

Gain more first hand experience at working with fire and generate new information on the effects of fire in pastorally important land types.

Background:

The long periods between high fire risk conditions in Central Australia precludes a build-up of experience and knowledge about using fire as a pastoral management tool. There are two aspects to the use of fire in Central Australia. Firstly, spinifex vegetation encircles most of the better pastoral country. It accumulates fuel more like a shrub and when conditions are suitable, is an important ignition source for fires that might threaten more productive pastures. Patch or mosaic burning in spinifex is one way to reduce the risk of uncontrolled wild fire. In some of the better rangeland country, trees and shrubs have increased in density in recent decades. There are no economically viable methods of thinning out thick scrub, except perhaps with the use of fire. This project has combined practical fire fighting and controlled burning skills, with more detailed vegetation surveys of burnt and unburnt areas. A literature review also provides a starting point for future fire research.

Results:

The project from 1998 to 2002. Outputs included several controlled burns at which vegetation data was collected. Various newsletter articles, a full colour guide book and a technical bulletin were published. Field day demonstrations and seminars were presented, on-ground support was given for fighting bushfires, and ongoing input was provided for future research directions dealing with fire management.

PROJECT: Benefits and Costs of Water Ponding Banks

Project Officer: R. Dance

Location: Alice Springs Region

Objective:

Record the potential benefits and associated costs of water ponding banks for increased pastoral production in Central Australia.

The objective has now been met and the project is complete.

Background:

Shallow ponding of water has been promoted as a means of improving the productivity of some pastoral land in Central Australia. While there is anecdotal evidence of the benefits, there has been no economic evaluation. During the 1990s the construction of water ponding banks became popular amongst pastoralists in Central Australia. These earth banks intercept surface water flow after rainfall, forming a shallow pond for a short period of time and promoting additional pasture growth. Buffel grass is often sown in conjunction with ponding bank construction.

Summary:

Pasture growth measurements were taken behind selected banks after rainfall. Generally, pasture growth increased two to three times as a result of ponding but responses were quite variable. It is

estimated that the increase in dry matter that would be available for consumption by grazing cattle to be generally less than 624 kg/ha.

Estimates of costs for ponding bank construction varied widely; however it is concluded that only under quite favourable circumstances could ponding bank construction be economically justified if the returns are to come from freely grazing cattle. Where ponding banks are constructed in holding paddocks adjacent to cattle yards the economic situation is greatly improved if the additional pasture that grows is used in place of purchased hay to feed yarded stock.

Individual circumstances vary greatly so that even with careful budgeting, adequate records and appropriate experience, investment analyses need to be undertaken after the event in each situation to ensure that resources have been used in a profitable manner. Tables of investment cost recovery periods and benefit/cost ratios are provided for the range of circumstances that is believed to be likely to occur in Central Australia.

Field assessments and data analyses have been completed. A final project report has been prepared for publication, completing this project.

PROJECT: Green Cover Reporting

Project Officers: R. Dance and C. Allan

Location: Alice Springs

Objective:

Develop and verify seasonal indices of rangeland pasture growth in Central Australia.

This project has ceased.

Background:

The most significant cause of variation in the productivity of the grazing industry, both in space and in time, is recognised as being due to variation in the suitability of climatic conditions for plant growth. Any action which people may take to enhance the utility of rangelands for livestock is secondary to unpredictable, unreliable and uncontrollable weather influences. It follows that to make any intelligent interpretation of the effects of management, quantification of seasonal conditions is essential. There is currently no altogether satisfactory means of doing this. The available information is either expensive to collect, qualitative, spatially sparse, or lacks an adequate interpretation model.

The use of satellite based indices of plant growth provides an opportunity to record production on a regional scale at the “grass roots” stage. This project has previously demonstrated the potential of this approach for Central Australia. Other States and the Commonwealth have also developed expertise in this area, for their own purposes.

Summary:

As this had been on-going work its future depended very much on its relevance to our new directions in Pastoral Production. We have been becoming progressively out of touch with the technology, and it is about to take a leap with new satellite systems becoming operational. To continue this work we would need to catch-up with new technology. The Pastoral Division has decided to discontinue this project.

Image data is no longer processed locally and this activity has ceased. A message to this effect has been placed on the web site and readers are redirected to a Bureau of Meteorology site, which provides a similar national product.

PROJECT: Needlebush Rabbit Control

Project Officer: R. Dance

Location: Alice Springs District

Objective:

Undertake an evaluation of the effect of rabbit eradication on vegetation in the CLMA needle - bush rabbit eradication project.

This objective has been met and the project is now complete.

Background:

The Centralian Land Management Association (CLMA) established a 300-km² rabbit eradication area on Erldunda, Lyndavale and Mt Ebenezer stations. The overall objective of the CLMA program was to show, by establishing a demonstration on an extensive scale, the ecological and economic benefits of combined rabbit eradication and associated grass planting in an area of low and unpredictable rainfall. The role the Department was to measure the vegetation responses over the project period following the removal of rabbits and to calculate the costs and benefits of the control operation.

Summary:

There was a rabbit plague south of Alice Springs, which peaked in about 1990. Between 1990 and 1992 CLMA conducted a campaign of intensive rabbit eradication primarily by warren ripping over about 250 km^2 on three stations south of Alice Springs. Some poisoning with 1080 baits and fumigation with phosgene gas also occurred. Buffel grass (*Cenchrus ciliaris*) was planted in association with the warren ripping. DBIRD monitored rabbit numbers and pasture production until 2000.

In the absence of warren ripping rabbit numbers declined rapidly from about 1991 onwards. It is believed that this was initially due to the onset of unfavourable climatic conditions. Subsequently, from mid 1996 the exotic rabbit haemorrhagic disease (RHD) was reported in the area, and undoubtedly also limited the rabbit population. Rabbit numbers were generally quite low from 1991 onwards even without any control being practised. Where rabbit warrens were ripped eradication of rabbits was not achieved, but their numbers were reduced even further below the level caused by these unplanned factors. The project ended in 2000 without a major increase in rabbit numbers despite a favourable season that under other circumstances might have been suitable for rabbit reproduction and survival. This is attributed to the presence of RHD.

Under the favourable pasture growth conditions in 2000 when the project ended, there was an estimated additional 200 kg/ha of quality pasture growing on the rabbit eradication treatment area. Half of this was attributable to the favoured oat grass (*Enneapogon avenaceus*), and half was due to the planted buffel grass (*Cenchrus ciliaris*). If this pasture production advantage is sustained, we estimate that it represents a potential increase in carrying capacity of about two beasts per km^2.

The cost of attempted rabbit eradication was estimated to exceed \$400/km^2 in 1992. In this project a pasture growth benefit was not realised until 10 years after the rabbit control had been initiated, although under other seasonal circumstances this period could be shorter. Without accounting for the additional capital required for livestock to take advantage of the extra pasture, the benefit/cost ratio for the eradication treatment is not particularly favourable although the benefits (but not the costs) are likely to accumulate with time. After 20 years the benefit/cost ratio was estimated to be between 1.2 and 3.4.

It is concluded that while RHD continues to limit rabbit populations there is little economic incentive for commercial pastoral enterprises to undertake rabbit control. Approximately half of the benefit of control, which was recorded, is derived from the planting of buffel grass, a practice that is not favoured by those wishing to preserve an unmodified natural environment.

Field assessment and dismantling of infrastructure have been completed. A final project report has been prepared for publication, completing this project.

PROJECT: Herd Health and Performance Study - West-side Mount Riddock

Project Officers: J. Coventry and Pastoral Production Officers

Location: Alice Springs

Objectives:

Monitor herd health and production parameters of an Alice Springs district beef cattle herd.

Report findings of monitoring to station management, industry, research organisations and government.

Determine the need for future research, disease prevention and control, and advisory activity.

Background and Method:

There is a lack of objective information on beef cattle herd health, structure, performance and limitations to cattle production in the Alice Springs district. The five-year longitudinal study was undertaken to record the effects of some season variability and long term management strategies by collecting data and samples from an Alice Springs beef cattle breeder herd.

Desired outcomes of this study are production of seasonal and property benchmarks of cattle performance, as guides for improved cattle recording and management in the district, and provision of district-specific, technical advice to cattle producers. This includes:

- normal ranges for biochemical and a haematological values;
- seasonal information on micro-nutrient deficiencies and intestinal parasites;
- correlation of faecal analysis with other indicators of nutritional status; and
- quantification of the effects of seasonal and management variables on breeder cattle performance.

The full details of methods are in the 2001-02Technical Annual Report.

Progress:

Data input in 2002 and 2003 will enable descriptive analyses and reporting of herd health parameters in 2003-04.

PROJECT: Identifying Optimum Levels of Pasture Utilisation on a Commercial Scale

Project Officer: R. Cowley

Location: Pigeonhole Station, VRD

Objective:

Identify the optimal levels of pasture utilisation on a commercial scale.

Background:

The Mt Sanford grazing trial has indicated that pasture utilisation rates up to 20% can be safely implemented, with significant increases in beef productivity and profitability per unit area. This is substantially higher than the industry average of 12.5% in the VRD (based on a DBIRD survey of 12 properties in the VRD in 1997) and suggests there is considerable room for increasing cattle production in the region. However, results from the Mt Sanford trial may reflect the more intensive

development at the research trial with its relatively small paddocks (4-8 km^2) compared with commercially viable scales of intensification. This project aims to test the applicability of higher utilisation rates on a larger scale at Pigeonhole Station, VRD. It is part of a larger joint project between Heytesbury Beef, CSIRO and DBIRD and is funded by Heytesbury Beef and MLA. The trial assesses both pasture condition and cattle production.

Results:

Pasture utilisation methods were tested and observers were trained in October 2002 in a subset of the trial paddocks. The full site (more than 330 km^2) was monitored in May 2003. Site infrastructure is being prepared, before cattle enter the trial paddocks. Vegetation assessment methods will be further refined following analysis of data collected in May.

PROJECT: Developing Sustainable Grazing Management Systems for the Semi-arid Tropics of the Northern Territory

Project Officers: R. Cowley, R. Dyer, L. Café, M. Cobiac and D. Bryce

Location: VRD and Sturt Plateau

Objectives:

Provide pastoral land managers in the VRD and Sturt Plateau regions an increased understanding and knowledge of local pasture communities and basic grazing ecology and management.

Encourage pastoral managers to investigate the economic viability of a range of sustainable grazing management options using a range of decision support systems in a whole-property framework.

Encourage pastoral properties to document current paddock and property stocking rates and develop individual estimates of sustainable livestock carrying capacity.

Make producers aware of the principles and best practice of controlled burning by providing a relevant and practical fire management manual and presenting information at on-property workshops, field days and shows.

Make land managers and administrators aware of the increase in, cause and impact of, and potential cost of woody plants.

Encourage pastoral lease-holders to implement strategic grazing management plans as a result of active participation in whole paddock demonstrations of sustainable grazing management options.

Summary:

Research conducted in the Victoria River District between 1997-2001 and funded by Meat and Livestock Australia, has improved our basic understanding of how the grazing lands function and some guidelines on how to better manage them. A number of valuable tools for researchers and land managers have been developed. Key parameters that drive pasture growth have been identified and pasture growth models have been developed for several key pasture communities.

It has been shown that woody plant growth in the absence of fire will reduce pasture production as a result of increased competition for soil moisture and/or nutrients. Although many woody communities are adapted to periodic burning, the prescribed use of fire has been demonstrated to have an important role in the management of tree-grass balance and pasture condition. Guidelines concerning its use as part of a management system have been developed.

The identification of safe utilisation rates from grazing trials, development of software applications and the use of pasture growth models have contributed to methods for estimating paddock carrying capacity. Factors that determine the distribution of grazing pressure throughout extensive heterogeneous paddocks and means to manage grazing have been investigated.

Activities in 2002-03:

This project is now finished. The main activity this year has been the compilation of a final report for MLA. The fire trials at Kidman Springs are being continued, at a lower level of monitoring intensity. The tree-grass sites at Katherine Research Station are also being maintained to assess long term impacts of tree clearing on production.

PROJECT: Grazing Regimes to Maintain Biodiversity in the Mitchell Grasslands

Project Officers: R. Cowley and C. Materne

Location: Mt Sanford Station, VRD

Objective:

Determine the impact of stocking rate and distribution of grazing pressure on the biodiversity of flora, invertebrates, small mammals and bird species in the Mitchell grasslands.

Formulate best practice stocking and grazing guidelines for the conservation of biodiversity values.

Improve the knowledge and understanding of land managers about maintenance of biodiversity in production systems.

Facilitate appropriate development to enhance profitability and ensure conservation of biodiversity.

Background:

Cattle grazing influences plant and animal diversity in the Mitchell grasslands and in pasturelands generally, in the Northern Territory. However, land managers still lack critical information about management to maximise the conservation of biodiversity within production systems. This currently constrains the development and implementation of integrated management regimes to enhance regional conservation.

Paddock	Average utilisation rate (%)	Year current treatment began
Parrot Creek	12	1993
Budgie	23	1993
Quarrion	34	Oct 2000
Larry Mac	45	Oct 2000

Results:

Plant and bird diversity surveys were conducted in April and October 2002 and April 2003. Ground cover has decreased in the higher utilisation treatments compared with the lighter grazed paddocks, but the effect of this is rarely reflected in the bird diversity or abundances at the site. This is probably due to (1) the good condition of the higher utilisation paddocks prior to start of the current trial and (2) the delay in the effect of altered habitat (due to grazing) on breeding success, which takes a few years to impact on bird numbers. Of interest however, is that aerial insectivores were more likely to be found near waters, while the grassland raptor, the spotted harrier, was more likely to be found in lightly

grazed paddocks, and areas with higher cover. Further surveys are needed to detect long- term impacts of habitat change on bird numbers.

Development:

National Heritage Trust funding has been extended to October 2003.

PROJECT: Risk Management Tools for Grazing Land Management

Project Officer: R. Cowley

Location: Katherine Research Station

Objective:

Develop a property scale decision support and risk management tool for grazing land management.

Background:

Pastoral properties in northern Australia have large numbers of extensive paddocks, often containing many land types. Predicting the impact of a suite of interacting factors (seasonal and spatial variability, stocking rates, fire and access to water), on the risk of overgrazing, is a complex task. The aim of the project is to make it easier for land managers to make sustainable stocking rate decisions on a seasonal and long-term basis. To do this we are developing a property scale decision support and risk management tool. The Queensland Department of Natural Resources Management, Heytesbury Beef, NAPCO, Stanbroke and AACo are collaborating in the development of the tool to ensure relevance and usefulness for stakeholders.

Results:

A workshop was held in May with all participants where the *Tool* functionality, inputs, outputs and structure were developed. It is anticipated that Version 1 of the *Tool* will be developed and ready for evaluation by users by May 2004.

PROJECT: Newcastle Waters Rotational Grazing

Project Officers: P. Clarke and R. Cowley

Location: Newcastle Waters Station

Objective:

Compare the productivity and sustainability of a rotational and a continuous grazing system.

Background:

As demand for cattle grows in northern Australia, particularly in the live export market, cattle producers are looking to increase production, whilst maintaining or improving ecosystem health. Cell grazing and rotational grazing are systems that promise to allow greater carrying capacity through monitoring and rest of pastures. As cell grazing is a relatively new phenomenon in the Northern Territory cattle industry, there is great interest in the workability of such a system in local landscapes.

In 2000, Newcastle Waters Station began to set up cell grazing in two paddocks. This was in response to a perceived need for more intensive handling of stud weaners, and better utilisation of pastures. The sites were old holding paddocks on the Barkly stock route, and have since been used by Newcastle Waters as stud paddocks. Baseline vegetation data was collected prior to cattle entering

the cell. Last year, Newcastle Waters requested DBIRD to assist with the development and continued monitoring of pastures within the cell. Vegetation condition and cattle production are being monitored.

Results:

Vegetation data was collected from four paddocks within the cell and from a control paddock in May 2003. Indicator steers were placed in the cell and a control paddock to compare production from both situations.

Vegetation will be monitored, including pasture composition, yield, ground cover, grazing, and canopy cover twice a year until 2004, in the early dry and late dry. Cattle will be weighed twice a year in May and October

PROJECT: Rangeland Management Courses

Project Officer: P. Clarke

Location: Katherine and Stations within the Katherine Districts

Objectives:

Develop greater knowledge on stations about land management issues.

Assist pastoral stations to develop commitment and motivation in their staff and thereby increase staff retention.

Background:

The Pastoral Division, Katherine developed rangeland management courses in 2001 in response to a perceived need for greater education of station staff about land management issues in the Victoria River District. The courses were thought to be an excellent forum for knowledge and capacity building in the cattle industry for pasture health, weeds management, fire control and use, and infrastructure planning. High staff turnover on stations has been attributed to lack of motivation of station staff. It was thought that greater training would help to increase knowledge, interest and motivation and staff retention. The courses are held on site at the stations, and are designed to be locally relevant.

Results:

Rangeland management courses were held on Victoria River Downs and PigeonHole Station in March 2003. These courses were very successful and enjoyable, with all participants giving very favourable feedback. Participants felt they learnt a great deal from the course, which would help make them more useful and motivated employees. Further courses are planned over the next couple of months. Stations that held courses in previous years have requested that they be repeated at the stations in future.

PROJECT: Stock Course

Project Officers: **T. Oxley, A. Trier, P. Clarke, K. McCosker, S. Hourigan, G. Scott and M. Perez-Ruiz**

Location: Scott Creek Station, Victoria River Downs (VRD)

Objectives:

Provide stock camp members with a greater level of understanding of the industry that they are involved in and an appreciation of the need for a professional approach by all members of the industry.

Create an understanding of the differing roles within the station environment to build a more team-orientated attitude to the day to day activities of station life.

Background:

In 2002 the Katherine Pastoral Industry Advisory Committee advised that it would like to see more courses available to stock camps to increase their industry awareness. This was a result of the success of the rangeland management course that was conducted in 2000 – 01.

A survey was taken of the stock camps from 12 stations throughout the VRD including company and private stations. The objective was to find the gaps in knowledge of current members of stock camps. The rationale was to update skills of those who previously worked in stock camps. Feedback was used to formulate the stock course.

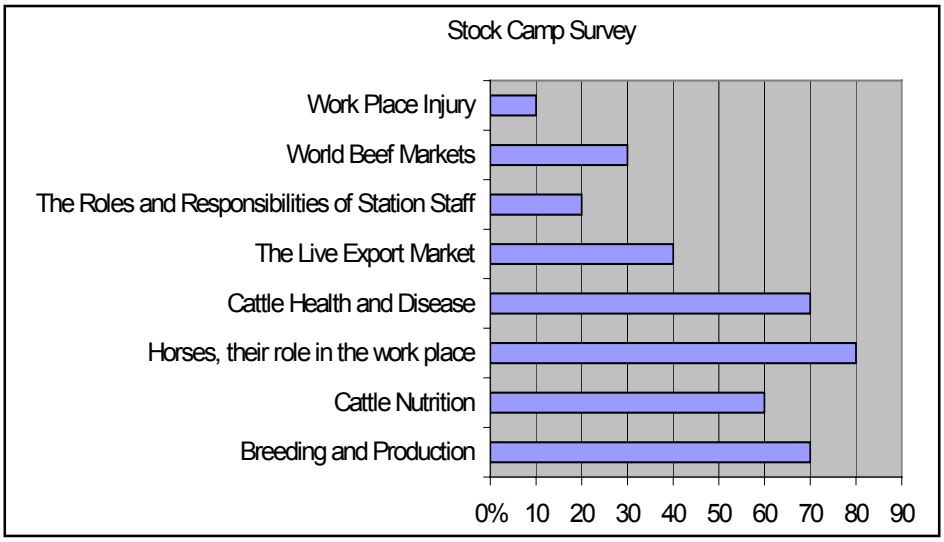


Figure 1. Stock camp survey

Results:

The survey led to the development of the stock camp course. The course consisted of the topics that were part of the survey, and topics that were considered necessary to add, but would not have been nominated by the survey participants, as there was no awareness of their relevance to the industry.

Table 1. Stock course content

Topic	Content
Introduction	An introduction of the facilitators and a brief overview of the day. Participants are given a different position within the station for the day to try to evaluate any given topic from a different perspective
Session One – Emergency animal diseases	A look at the possible emergency animal diseases that could affect the cattle industry, and the consequences of those diseases
Session Two – Post mortem and animal health	A post mortem of an animal to show the digestive tract, the major organs, and a look at the different cuts of meat.
Session Three – Animal breeding, production and nutrition	A general understanding of the reproductive cycle of a male and female Brahman, the nutritional requirements, and an overview of genetics. Also an annual cycle of the nutritional requirements of different animal types through different seasonal conditions.
Session Four – Live exports	An overview of the live export industry, explaining the mechanics, the physical requirements of suitable animals, and the attitudinal requirements needed to ensure the long-term success of the industry
Session Five – Horse health and nutrition	A look at the basic health requirements of horses, the possible diseases that can affect them and preventative measures to take.
Session Six – Practical yard demonstration	A practical demonstration of stock skill use, hygienic yard practice, cattle condition and scoring and some basic cattle handling techniques.
Conclusion	Evaluation and feedback

The pilot course was held at Scott Creek station. Participants included the stock camps of both Scott Creek and Willeroo. Other participants included the bore-men, managers and overseers from both stations. General feedback was positive and a debriefing indicated that with some minor organisational adjustments, the course met its intended purpose.

The course has since been held at VRD in a condensed form. Full courses are booked for Argyle, Rosewood, Newry, Auvergne and Carlton Hill stations later in the year.

Conclusions:

1. The program is an effective way of increasing awareness of young cattle industry members of the major issues affecting the industry.

2. There is a gap in knowledge of young stock camp members that is hard to source from within a station. This is because day-to-day activities are very specific and there is little time available for considering greater industry issues.

3. The style of the program allows participants to gain an understanding of other station roles and their importance. This is explained by independent (departmental) personnel and gives an integrated overview.

4. The program can be effectively delivered by a small number of departmental staff as part of a two-day program, in conjunction with the rangeland management course.

PROJECT: Improved Herd Profitability

Project Officers: R. Mather-Brown and T. Oxley

Location: Kidman Springs and Victoria River Downs Station

Objectives:

By December 2008

Measure and report on the costs and returns of each management package in terms of gross margin per AE after interest

Measure the production differences between each management package in terms of kg of calf weaned per 100 kg of cow mated

Measure the differences in labour requirements between the management packages in terms of full time equivalents

Measure and report on the biological and economic consequences of limiting the mating period in a herd of Droughtmaster cows in the Victoria River District

Background:

In 1990 the best bet management package was formulated for Kidman Springs, Victoria River Research Station (VRRS). It included the use of moderate stocking rates of tropically adapted cattle, vaccination for botulism, annual vaccination of bulls against vibriosis and the use of five bulls per 100 cows. Stock was supplemented all year round with urea in the dry season and phosphorus in the wet; calves were weaned at 100 kg or greater, breeders were culled at 10 years of age, and mustering and weaning were done twice a year (starting in April and September). Heifers were mated at two years and run separately until they weaned their first calves. Fire was used to maintain pasture condition.

As a result the performance of the herd at Kidman Springs improved greatly and mortality rates went down from 12% to less than 2%. Weaning rates rose from 50% to over 80%. This has greatly influenced the region's industry, which has also seen marked improvement in productivity. However, pastoralists have requested modifications to the package that will reduce costs but maintain the improved performance.

An economic model was tried (Breedcow/Dynama) which indicated that the gross margin could be increased by 25% through the development of an Improved profit package by:

1. Changing stocking rates from a constant of seven animals per sq. km to rates calculated on the productivity and resilience of individual land units within the paddock.

2. Decreasing bull numbers from 5% to 3%.

3. Decreasing supplementation from all year round to a strategic supply in the six most critical months of the year.

4. Basing the culling of cows on performance rather than fixed age.

5. Choosing minimum weaning weight of calves based on breeder condition rather than constant weight.

Design:

- Use of two paddocks at Kidman Springs (VRRS) based on the improved profit package, one with good feed and the other with poor feed.

- Use of two control paddocks at Kidman Springs, one with good feed and another with poor based on the best-bet package.

- Use of a commercial paddock 'Rifts Yard' on Victoria River Downs based on the improved profit package.

- Use of Rosewood West paddock on Kidman Springs, which has a Droughtmaster herd, kept under the improved profit package, including controlled mating (which is being considered as a component in the future development in the improved profit project).

Schedule:

The improved profit project commenced in May 2003 and is scheduled for completion by October 2008. The first results will be available in mid 2004.

PROJECT: Edge Coordination

Project Officers: R. Mather-Brown and T. Oxley

Location: Katherine-based but applied NT-wide

Objectives:

Coordinate and promote a course for cattle producers on behalf of EDGE Network (Education section of Meat and Livestock Australia) throughout the Northern Territory.

Act as delivery providers for the 'Grazing Land Management' course and possibly the 'Northern Nutrition' course.

Background:

From 2000 to 2002 the Pastoral Production team at Katherine Research Station along with others in northern Australia were involved in the creation of the generic Grazing Land Management (GLM) course and a Katherine regional version was completed in February 2003. A pilot run was successfully completed with local producers in 2002.

Design:

EDGE Network is the education umbrella of Meat and Livestock Australia. It is a user-pay system that provides a number of courses relating to animal production in Australia, with the two most relevant for the NT being Northern Nutrition and GLM.

Schedule:

EDGE has contracted Trudi Oxley of the Pastoral Production Section as coordinator for all *EDGE* coursed in the NT.

PROJECT: Charolais-Brahman Criss-Cross Herd

Project Officer: K. McCosker

Location: Kidman Spring (VRRS)

Objectives:

Study the mature size and performance of future generations of Charolais-Brahman progeny.

Provide a practical demonstration of a two-way criss-cross breeding system.

Sub-projects:

1. The relative mature size of young Charolais-Brahman and Brahman cattle

2. The relative breeding herd efficiency of the replacement breeder phase of Charolais-Brahman and Brahman cattle.

3. The relative breeding herd efficiency of adult Charolais-Brahman and Brahman cows grazing native pasture in the Victoria River Downs.

Background:

This project is the continuation of a previous trial (1995-2001) *Breeding Herd Efficiency of Alternative Breeder Genotypes*, which dealt with Phase 1 of the two-way Charolais-Brahman criss-cross crossbreeding program (Figure 1). This project has been dealing with the second phase of the crossbreeding program: joining ¼ Charolais cows to both Brahman and F1 Charolais-Brahman bulls and producing 1/8 and 3/8 Charolais progeny (Figure 1).

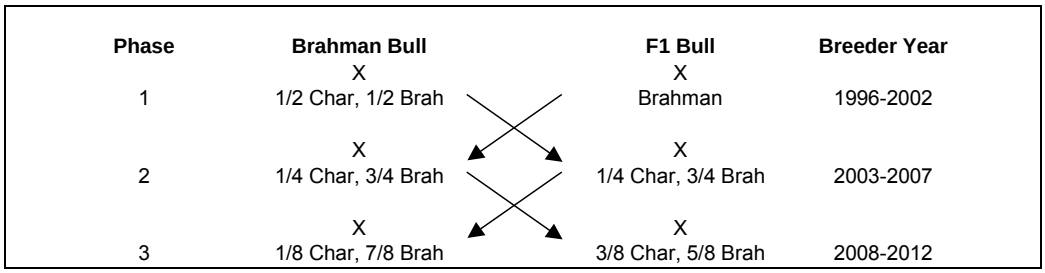


Figure 1. The two-way Charolais-Brahman criss cross crossbreeding program

The breeding herd efficiencies of adult ¼ Charolais breeders and 1/8 and 3/8 Charolais replacement breeders will be measured over the next four years. The production results received for adult ¼ Charolais breeders will be compared with the breeds previously measured in the *Breeding Herd Efficiency of Alternative Breeder Genotypes* trial. The production results received for the replacement 1/8 and 3/8 heifers will support the *Improving Heifer Productivity* trial.

During 2004, a sub-project will deal with calculating the mature size of a progeny subset. Mature size is an adaptation of the concept of standard reference weight and can be used to predict protein and energy requirements. The mature sizes of Brahman (400 kg), ½ Charolais (460 kg) and ¼ Charolais (430 kg) have previously been calculated (Ridley, pers. comm.). It has been found that there is a direct correlation between the Charolais proportion and mature size. Therefore, it has been hypothesised that the mature size of 1/8 Charolais will be 415 kg and of the 3/8 will be 445 kg.

Method:

All breeders are managed under a modified best-bet management system. Stocking rates have been calculated on a land unit basis as opposed to a set stocking rate of seven animals per km^2.

Indicator steers are being used to measure the plane of nutrition of each breeder paddock. The average live-weight gain of Brahman paddocks has been used as the base and the performance of other steers will be compared against this through the calculation of ratios.

Results:

As 2003 is the first year of sampling a full set of results is not available. However, the first round of sampling was completed successfully. A summary of the information collected in June is shown in Table 1.

Table 1. Herd information collected in June 2003

Herd Genotype*	**Brah-Brah**	**1/4 Char-Brah**	**1/4 Char-F1**	**Brah-Brah**
Paddock	Boab	Supplejack	Coolibah	Nutwood
% of breeders lactating	61	91	78	56
% of breeders lactating and pregnant	27	48	20	24
Weaner genotype	Brah	1/8 Char	3/8 Char	Brah
Av weaner weight	170	184	172	173
Av breeder weight**	393	432	448	414

* Dam breed-sire breed

** Breeder weight has not been corrected for pregnancy.

PROJECT: Pasture Sustainability at Kidman Springs

Project Officer: K. McCosker

Location: Kidman Springs (VRRS)

Objectives:

Monitor whether the current stocking rates used at Victoria River Research Station are sustainable.

Determine the pasture differences between paddocks.

Monitor seasonal changes of the pasture.

Background:

The Kidman Springs best-bet management system was implemented in 1990 and the resulting improvement in cattle performance was investigated between 1990-95. Since 1995, this system has been promoted as a safe and profitable way of managing cattle in the region. However, no account was initially made of the effect on the pasture of the improved cattle performance arising from the management system, and hence its long term sustainability. Therefore, the pastures of Conkerberry paddock have been monitored since 1995 using fixed transects and a modified botanal technique.

The other part of this project relates to the change in the method of calculating stocking rates at Kidman Springs in the improved profit package. Carrying capacity is estimated from a pasture growth model GRASP calculated for each land unit in the paddock, modified by different utilisation rates (10-25%) derived from grazing trials, tree density and current land condition. These calculations were summarised in a report by Cowley and Bryce (2002). The net result for several of the Kidman Springs paddocks was a substantial increase in stocking rate. So from this year the pasture assessment effort has intensified to include all the Kidman Springs paddocks and Rifts yard on Victoria River Downs.

Method (for new technique from 2003):

In each paddock, six data points have been selected according to land unit. The number of points per land unit is proportional to the land unit's percentage of the paddock. All observers analyse one

paddock at a time, completing two points per paddock. This has minimised the distance between observers, allowing radio contact to be maintained at all times. Points are located by GPS.

Five sites are investigated at each point. The first site is located 150 m north of the point. The second site is 300 m north of the point. The third site is 300 m north and 150 m east of the point. The fourth is 150 m north and 150 m east of the point; and the fifth site is 150 m east of the point.

At each of these sites, five quadrats are collected. The first quadrat is located 10 paces north of the site. The second quadrat is 20 paces north of the site. The third quadrat is 20 paces north and 10 m east of the site. The fourth quadrat is 10 paces north and 10 paces east of the site. The fifth quadrat is 10 paces east of the site.

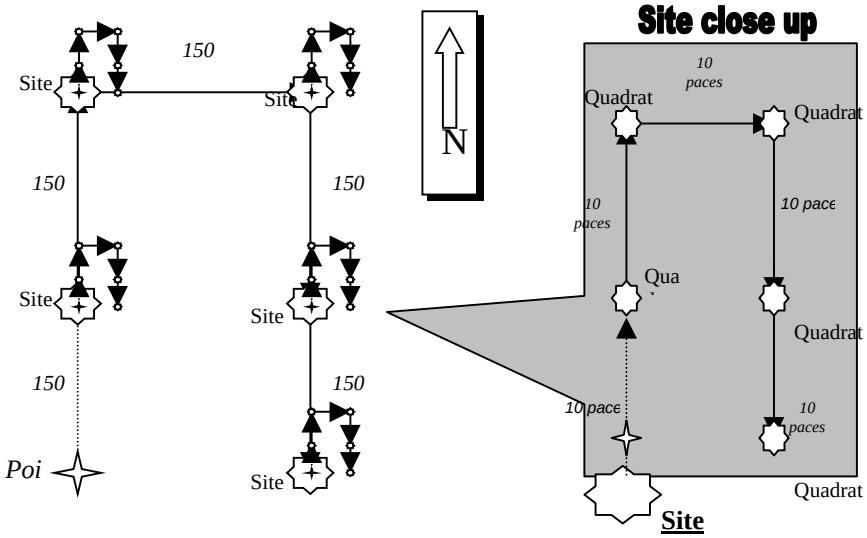


Figure 1. Diagram displaying sampling procedure

The parameters measured at each quadrat are top four species, species % composition, actual yield, total ground cover, soil type (red or black – to the quadrat level), and grazing. Yield estimates are calibrated daily.

Results:

During 2002, the best bet management system data from Conkerberry paddock was analysed, showing a significant interaction between pasture condition and time. The proportions of both perennials/annuals and desirable/undesirable species were influenced by time. The proportion of perennial species increased over time (Figure 2), suggesting that the pasture is becoming more stable, while the proportion of desirable species decreased with time (Figure 3). The decreasing proportion of desirable species is unfavourable, suggesting that the pasture may be overgrazed. The stocking rates used in the best-bet system are considered to be modest and overgrazing is thought to be not likely. Hence, the need for additional investigation.

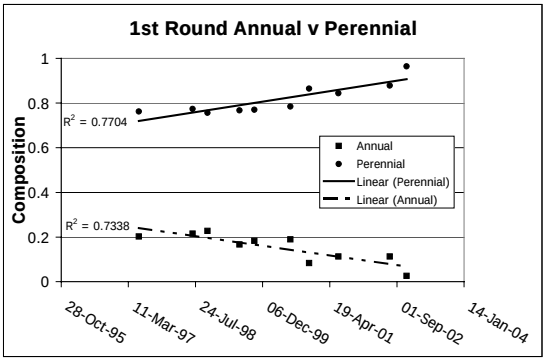


Figure 2. Increase in perennials

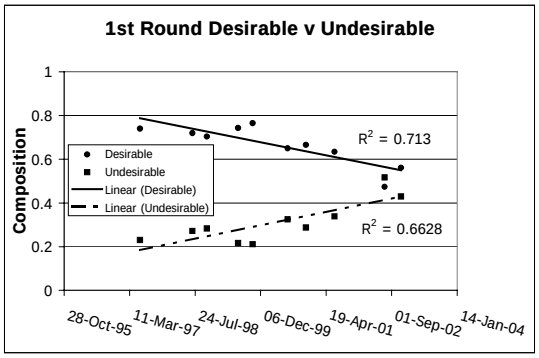


Figure 3. Decrease in desirable plants

As 2003 is the first year of sampling all the other VRRS paddocks' results are not available. However, the first round of sampling was completed successfully.

PROJECT: Carrying Capacity of Different Land Types

Project Officer: N. MacDonald

Location: NT-Wide

Objectives:

Customise methods of estimating long and short-term safe carrying capacity in the major pastoral land systems of the NT

Further develop techniques in areas where the current methodology proves inadequate.

Background:

An improved method to estimate carrying capacity, with an accurate estimation of seasonal risk, would enable producers not only to minimise detrimental effects of grazing, but also to safely increase stocking rates in paddocks with suitable land types. A reliable method of achieving this has been sought for many years.

Over the last few years a method of estimating the carrying capacity of individual paddocks based on the pasture growth model GRASP, has been developed in the VRD. The method uses GIS to calculate the proportion of different land units in the paddock, GRASP to calculate median pasture growth, and pasture utilisation rates derived from grazing trials along with estimates of tree cover and current land condition. Calibration of the GRASP model to the different land systems and locations is the critical step. This has been carried out in a number of VRD locations, notably Mt Sanford, and the resulting estimation of carrying capacity in those locations appears to be reliable.

There is a strong demand from producers, financial interests and land administrators like the Pastoral Land Board for sound objective carrying capacity estimates for the whole of the NT. Since it is not realistic to expect grazing trials on the scale of Mt Sanford or Kidman Springs to be repeated in many locations around the NT, this project sets out to customise and test existing VRD-derived methods in other parts of the Territory. We will then be able to calibrate the model and derive locally appropriate utilisation rates where necessary.

In addition, techniques may need to be radically modified in areas of higher rainfall, where there is a build up of indigestible dry matter, and in arid regions. The project will go on to consider these areas.

Activities this year:

1. This project was one of four activities included in a large CRC-sponsored project called *Developing grazing management tools to improve savanna condition,* which began in April 2003 and is due for completion at the end of 2005. It is a collaborative effort between the NT and Queensland departments and pastoral companies, coordinated by DBIRD.

2. The carrying capacity of Kidman Springs was recalculated and published as an internal report by Cowley and Bryce (2002), which has been widely circulated. Stock numbers at Kidman Springs were increased in May 2003 according to this model. A program of monitoring the pastures to check on the sustainability of this system began in June 2003 and will continue for a number of years.

3. Two student projects were run this year in association with the University of Queensland. Genevieve Nash studied four stations on the Barkly Tableland and Rebecca Anders studied four stations on the Sturt Plateau. Although the projects are not yet complete, it is clear that both were over-ambitious at the start. Results from the models do not seem very realistic, suggesting that extra calibration will be necessary. A lack of alternative data for comparison was a constraint.

The plan for 2003-04 is to go back one step, by studying areas within the VRD, but not the land systems directly used in the calibration.

PROJECT: Mt Sanford Pasture Utilisation Trial

Project Officer: N. MacDonald

Location: Mt Sanford Station, VRD

Objective:

Test the cattle and pasture responses to a wide range of pasture utilisation rates

Background:

The Mt Sanford project has been operating since 1993. Originally it was an NHT-sponsored demonstration of the *Effects of Different Stocking Rates*. One of the main findings was that excellent animal productivity and improved pasture conditions can be combined with high stocking rates if the cattle are able to graze the paddock equally, with small paddock sizes and centrally located drinking water. The site later expanded to include a number of other projects, and in 2001 the stocking rates were increased, and the constant stocking rate treatments were changed to constant utilisation rates. The change to pasture utilisation rates rather than stocking rates was to make the results from the site applicable to a wider variety of properties and seasons. The stock numbers are adjusted up and down each May after the pasture analysis is complete, which gives extra precision to the assessment of utilisation rates.

Design:

Since 2001, the six paddocks in the utilisation trial have been as follows:

Paddock	Size	Utilisation rate
Parrot Creek	8 sq km	11%
Pigeon	6 sq km	16%
Budgie	4 sq km	22%
Wedgetail	5 sq km	28%
Quarrion	8 sq km	35%
Larry Mac	5 sq km	45%

Each paddock is stocked with breeders, plus 13 indicator steers.

Major events in 2002-03:

1. The trial site at Blackgin bore, Mt Sanford, now forms part of the large Heytesbury/DBIRD/CSIRO/DIPE MLA-funded project.

2. Since August 2002, Heytesbury Beef have taken over management of the site on behalf of the partners, with DBIRD assistance in data collection. As a result the DBIRD site manager position at Kalkaringi ceased.

3. Total rainfall on the site in 2002-03 was 673 mm. Although this is above the long-term average, a large proportion fell at once in late February, so pasture growth overall was very poor – the first really poor year since the trial began.

Results:

The trial has shown that pasture yield (of both annual and perennial species) is significantly affected by increasing utilisation rates. Bare ground is also significantly increased and there is a trend at higher utilisation rates towards an increase in the proportion of undesirable plant species (15% less palatable

species in the higher utilisation paddocks although this has not yet been shown to be statistically significant.

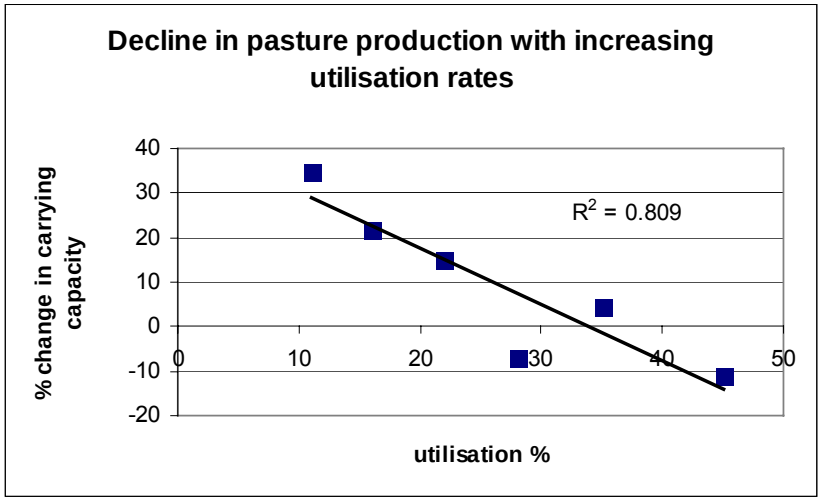


Figure 1. Carrying capacity in 2002

The condition of the wet cows in Larry Mac paddock in October 2002 plus an assessment of feed left in the paddock gave cause for concern. On 25 October it was calculated that without fresh growth, only 60 days' feed remained. In the event, enough rain did fall to prevent the treatment from having to be abandoned, but neither the 45% nor the 35% treatments appear to be sustainable.

Overall standing pasture in April averaged 1301 kg/ha, significantly below the average of 2207 kg recorded since 1994. Cattle numbers were therefore cut in May 2003.

Weaning rates in May 2003 averaged 69% for the lighter and 61% for the higher utilisation rates, which are excellent considering that there are still the October 2003 weaners to be added to give an annual figure. However on the site (and in most of the VRD herds assessed this year) the pregnancy rate of wet cows was well down from the average of 50%. In the lower utilisation rates it was 22% and only 9% in the higher utilisation rates. This will lead to out-of-season calves, an overall reduction of at least 5% in the calving rate of 2004 and some years after that.

Steer growth over the site averaged only 71 kg/head/year, well down from the average of 150 kg. There was no relation between steer growth and utilisation rate.

PROJECT: Improved Heifer Productivity

Project Officer: T. Schatz

Location: Kidman Springs (VRRS) and a commercial Station

Objectives:

By 2008:

Collect accurate data on the interaction between pre-calving weight/fatness of NT Brahman heifers and their subsequent re-conception rates, and make this information available to industry.

Demonstrate on a commercial property a system which overcomes the low fertility problems of heifers.

Compile a best practice manual for heifer management.

Assess current heifer performance on commercial stations in the NT.

Investigate uptake of information from previous heifer work and study reasons why heifer performance appears to be still low.

Background:

Low re-conception rates in first calf heifers have been identified as the main cause of inefficiency in northern Australian breeding herds. DBIRD is planning several research projects to improve production in this area.

Activities in 2002-03:

In 2003 the department changed the management of the heifers bred on VRRS (Kidman Springs). Now all heifers are transferred to DDRF where they grow out for two years on improved pasture. Those heavy enough are mated as yearlings and the rest are mated first as two-year-olds. As well as increasing the number of calves per breeder lifetime, the information collected from these heifers is being used to quantify the relationship between heifer joining weight and conception rates. The aim is to produce a chart that shows the conception rates that can be expected from joining heifers at different joining weights at their first two joinings.

Two applications for funding have been submitted to Meat and Livestock Australia for future heifer research in the NT. One is a collaborative application with QDPI and DAWA. This work will be done on commercial properties. In the NT, the aim of this work is to establish fertility levels in maiden and first calf heifers and to involve producers in a research/extension process, which looks to improve heifer fertility. It will involve demonstration sites and recording of heifer production figures on commercial properties and a survey of managers. At the end of the project a best practise manual for heifer management will be produced.

The other application is for work planned at VRRS. Each year at least 100 two-year-old maiden Brahman heifers will be joined. At the start of the following dry season heifers pregnant with their first calf will be divided into two treatment groups. One group (control) will graze pasture as normal in the pre-calving dry season, while the other (high nutrition) will be managed to gain an extra 50 kg before calving. This will provide heifers with a range of weights/body conditions at their second joining. The data from this joining (over several years) will allow us to generate a model that predicts the pregnancy rates likely from mating lactating first calf heifers at a range of pre-calving weights, P8 fat depths and condition scores. Simple charts will be produced from the model, including for maiden heifers.

PROJECT: Geographical Information Systems (GIS)

Project Officer: D. Bryce

Location: Katherine Research Station

Objectives:

Operate a GIS service to assist with other projects that utilise spatial data

Provide clients with hard copy maps of their property and associated table data to assist with making seasonal management decisions.

Produce maps showing land type data, infrastructure and associated tables showing suitable cattle carrying capacity and distance to water analysis.

Use GIS to visually build and plan a property from scratch complete with suitable stock carrying capacity information, fence line and water point locations and associated table data.

Train staff and clients in all facets of GIS and assist with gaining digital data such as the latest infrastructure, land units/land systems and satellite imagery.

Activities 2002-03:

A GIS operator was appointed in September 2002 for a period of three years. Main activities in 2002-03 included:

1. Creating maps for the Weeds Branch showing river catchments and sub-catchments for VRD, Roper River, Daly, Ord and Keep River catchments and sub-catchments.

2. Training DBIRD staff in ArcView software and GIS concepts.

3. Training a pastoral officer from Heytesbury Beef in ArcView GIS.

4. Creating maps for cattle carrying capacity calculations based on land types (land systems and land units where available) within fenced and proposed paddocks on 10 full properties and 15 smaller projects with a few paddocks.

5. Performing distance to water analysis 3 and 5 km from troughs and any other permanent water sources to find areas within paddocks that are not utilised by cattle.

PROJECT: Barkly Rangeland Management Course

Project Officers: C. Materne and P. Allsop

Location: Barkly Region

Objectives:

Make available to all Barkly pastoralists and their employees a Barkly rangeland management course.

Update and implement courses to improve land management skills of participants.

Stimulate interest of participants in rangeland management and monitoring.

Background:

An enthusiastic wish from pastoralists on the Barkly Tableland for a training package based on natural resource management for station staff has been the basis of this project. The Barkly rangeland management course came to fruition in 1999 and has continued as a series of training days on Barkly pastoral properties.

The project is a joint effort between DBIRD, DIPE, and the Natural Heritage Trust (NHT) and comprises a series of Barkly rangeland management courses to be made available to all cattle stations in the Barkly region. It aims to improve the land management skills of employees in the pastoral industry of the region. The objective of the course is to improve participants' understanding of native pasture dynamics, train them in plant identification and basic monitoring techniques, and stimulate their interest in pasture monitoring when making sustainable land management decisions. The information presented is based on local research and experience, using a selection of DBIRD and DIPE presenters to cover the range of topics.

Developments:

Five courses involving six stations and 55 participants were completed during the 2002-03 period. Participants in the training included the North Australian Pastoral Company, the Australian Agricultural Company and Stanbroke Pastoral Company. All of the six participating stations have expressed interest in annual courses.

Over the duration of the course 96% of participants felt the course met their needs.

The Barkly Landcare and Conservation Association has shown its support for the course by securing an NHT Envirofund grant to develop a biodiversity management component to the existing course. Dates have been set for two more courses in 2003.

Presentation material and handouts are being developed and modified. The main promotional course poster was up-dated and displayed at the National Landcare Conference in Darwin and at the Tennant Creek and Borroloola shows.

Four of the primary presenters completed their Certificate 4 in assessment and workplace training to maintain a high standard of delivery.

PROJECT: Barkly Tableland Burning Trial

Project Officer: C. Materne

Location: Alexandria Station

Objectives:

Measure the impact of low intensity, late wet season fires and high intensity, dry season fires on the Mitchell grasslands and woody plant species in Buchanan paddock on Alexandria station.

Demonstrate the application of prescribed burning in the extensively grazed Mitchell grasslands of Buchanan paddock.

This trial consists of two parts:

- An intensively sampled plot trial to identify the response of Mitchell grasslands to burning at two different times of the calendar year, and its effect on the encroaching woody vegetation.

- A broader paddock-scale trial to demonstrate the use of fire as a pasture management tool.

Background:

Traditionally, pastoralists have considered the Mitchell grasslands of the Barkly Tableland as being too valuable in terms of cattle feed to burn. Research in other regions suggests that Mitchell grasses (*Astrebla* spp.) recover rapidly after burning and that cattle grazing on burnt pasture usually perform better during the wet season, than those grazing un-burnt pasture. This, along with anecdotal evidence suggesting that woody tree and shrub species are beginning to increase and encroach onto Mitchell grasslands, has created the view that there is not enough fire used on the Mitchell grass downs of the Barkly Tableland.

The aim of the Alexandria burning trial is to determine the impact of seasonally prescribed fire on the native tree and shrub species, pasture composition and quality and cattle grazing characteristics of the Mitchell grasslands on the Barkly Tableland.

Developments:

Four sets of three plots contain three different treatments. Pre-burn pasture and shrub data was collected in April 2002, October 2002 and April 2003. Post-burn data was also collected during October 2002 and April 2003. The first low intensive, late wet season burn was undertaken in April 2002 and the second in April 2003. The first high intensity, late dry season burn was undertaken in October 2002 and a second was planned for October 2003.

Implementation of a paddock-scale-burning regime began in October 2001 and was followed up with further burns in October 2002. Further prescribed burning is planned for October 2003. Observations indicate that Mitchell grasslands recover well after burning followed by an average rainfall season. Data was collected from two sites to determine the effect prescribed burning has on the available edible Mitchell grass pasture biomass after one average wet season.

Results:

Two blocks of 10 1-m^2 cuts were taken after the October 2001 demonstration burn and the biomass separated into edible biomass and rank biomass. A t-test was applied to the edible biomass and suggests there is no significant difference between the burnt and un-burnt treatments (P=0.21347) after an average wet season (357.8mm).

Duration: 2001 – 06.

Animal Health Services

Objectives:

Support trade of animals and animal products by maintaining internationally and nationally acceptable standards for animal health assurance.

Maintain a capacity to respond to emergency or endemic diseases of significance. In consultation with industry and with Commonwealth and State/Territory jurisdictions, a nationally consistent endemic disease control policy is in place or is developed rapidly for new diseases.

This component consists of two sub-programs:

- *Livestock Market Access*
- *Disease Surveillance and Emergency Animal Disease Preparedness*

Projects within these sub-programs work together to deliver services to protect and enhance the health and marketability of Northern Territory livestock and livestock products.

A key function is providing health certification for consignments of livestock and livestock products produced in the Northern Territory, so they comply with the requirements of other Australian States and importing countries.

In order to provide credible health certification, the program monitors the disease status of NT livestock by investigating disease incidents and conducting planned surveillance activities. Information is collected on the prevalence, incidence and distribution of bacterial and viral animal diseases, plant toxins and other toxic and deficiency states.

The Berrimah Veterinary Laboratories (BVL) play an important role in gathering objective information on disease status of NT livestock.

The Division maintains preparedness to deal with outbreaks of animal diseases not normally found in Australia, and carries out surveillance to detect such exotic diseases if and when they enter the country.

Programs are also in place to satisfy consumer demands for animal products that are free from disease and chemical residues. Such programs also help protect the community from zoonoses (diseases transmitted from animals to humans).

The Chief Veterinary Officer represents the NT on the national Animal Health Committee (AHC) and the national Consultative Committee on Emergency Animal Disease (CCEAD).

The implementation of the programs depends on a team of professional and dedicated Stock Inspectors, Veterinary Officers and clerical support staff, in close collaboration with BVL staff.

PROJECT: Animal Health Information System

Project Officers: D. Pinch, R. Wilson, BVL Staff and Veterinary Officers

Location: NT Wide

Objectives:

Maintain an efficient and reliable database to store animal health and disease information.

Coordinate the NT component of a national animal health information network.

An accurate and reliable mainframe database called ANDI is used for storing animal health and disease information. ANDI is used both by laboratory and field animal health staff for storing and retrieving investigative details and test results. Quantitative data from ANDI is used for preparing the NT report to the National Animal Health Information System and to the National Arbovirus Monitoring Program, and for any other ad hoc report requests. Significant disease event information is stored on it.

ANDI is used to record and report details and results on all submissions to Berrimah Veterinary Laboratories from a wide variety of clients such as other DBIRD staff in animal production, agriculture and fisheries, private veterinary clinics, livestock exporters and the public.

The Department has decided to remove ANDI from the mainframe. In 2002, the Department of Corporate and Information Services sponsored an initial evaluation to compare the performance of ANDI with that of the Agriculture Western Australia Client and Resource Information System, and the implementation of *Sample-Manager*, a laboratory information management system. The purpose was to determine if they would meet business requirements for managing veterinary laboratory testing and for recording field data, as currently performed by ANDI. As a result it was considered beneficial to develop functional specifications for ANDI. Subsequently, in 2003, an outside provider was contracted to draw up functional specifications for the replacement of ANDI. This was to be finalised in August 2003. The next stage of the project is to replace ANDI.

The NT provides input to two national groups that are working on developing consistent national approaches to, and data standards for, disease management (animal, plant and pest) and veterinary laboratory information.

PROJECT: Animal Welfare Monitoring and Policy

Project Officers: K. de Witte and Pastoral Division Staff

Location: NT Wide

Objective:

Participate in the development and implementation of appropriate national welfare standards for animals.

Departmental officers are primarily responsible for livestock issues under the NT *Animal Welfare Act*. Veterinary staff represent the Territory Government on animal welfare matters in a variety of forums, including those discussed below.

The Animal Welfare Committee has been renamed the Animal Welfare Working Group (AWWG) and now reports to the renamed Animal Health Committee under the restructured Primary Industries Ministerial Council. The terms of reference of the group have been expanded from livestock to dealing with all animal welfare issues of national significance. An example of this type of issue has been the campaign for a national ban on the cosmetic tail docking of dogs, when close liaison occurs with the Minister for Local Government who is responsible for the NT *Animal Welfare Act*. The Territory has supported the ban and will regulate it in 2003.

A major business of AWWG is the national model code of practice for the welfare of animals. Codes of practice that are being revised or drafted include those on cattle, land transport of sheep, land transport of goats, land transport of poultry, ostriches, emu, deer, horses, meat code and destruction or capture, handling and marketing of feral animals. They are at various stages in the process, and some will be available soon. The pig code will be revised in 2004. The revised domestic poultry code (4th edition) is now available and the review of caged layer hen housing and egg labelling is now in the implementation phase.

The Territory coordinated a revision of the camel code in 2003. A major change has been a reduction in resting hump height clearance and pen area that will facilitate live export. A regulation impact statement has yet to be prepared and it is expected that the code will be available in 2004. The Department has worked with the Central Australian Camel Industry Association and the Buffalo Industry Council to develop best practice standard operating procedures for the handling of the species in the live export process.

AWWG is close to producing national statistics on animals used in research and teaching. In 2002, the Department dealt with 15,241 animals. Most of them (12,050) were cattle in observational grazing trials. A small number (91) were involved in surgical procedures and only 58 died.

The National Consultative Committee on Animal Welfare (NCCAW) to the Federal Minister for Agriculture, Fisheries and Forestry-Australia met for the 30th and 31st time in 2002-03. The following issues were relevant to the NT:

Position statements

These serve as policy guidelines. The position statement on managing the unwanted impacts of vertebrate animals was adopted. Topics under discussion include circuses, ritual slaughter standards, drought, fire, dog code and related urban animal issues, caged birds, tail docking of cattle, calving induction in dairy cattle, bobby calves, destruction of pest animals and a national code of practice for zoos. This material is available at www.affa.gov.au/docs/animalplanthealth/animal_welfare/nccaw

National animal welfare strategy (NAWS)

This document has been released for public consultation but the process has stalled. There are three goals:

1. Increase public awareness of animal welfare.

2. Ensure the welfare of animals in Australia meets public expectations.

3. Use the nation's infrastructure effectively for the delivery of animal welfare outcomes.

NCCAW is to assume responsibility for reviews of NAWS and monitoring of its implementation.

Livestock exports

Overall, the live export industry is continuing to improve its animal welfare record despite some problem shipments and adverse media coverage. There have been some useful advances from its research and development programs. Australia's live export standards provide the benchmark for the long distance export of livestock by sea. The action plan for the livestock export industry (APLEI) incorporates the latest research findings and seeks to address problems in the trade to the Middle East. Animal welfare standards in the South East Asian trade remain high.

Other issues that have some relevance to the Territory were discussed. These included the use of electrical devices, the national curriculum for training inspectors, harmonisation of legislation and micro-chipping standards.

The Department is represented on the NT Animal Welfare Advisory Committee. Some issues of concern were a ban on horse 'firing' and changes to the regulations relating to the use of electrical devices on camels and buffalo. Training of inspectors is an unresolved issue, but departmental staff receive some in-house training.

All reported animal welfare incidents were investigated, including starving, injured and perishing stock. Other issues within the Northern Territory have included investigation of the suitability of the 'Duke' soft jaw trap and methods to relocate flying foxes.

PROJECT: Chemical Residues and Hormonal Growth Promotants

Project Officer: M. Perez-Ruiz

Location: NT Wide

Objectives:

Present chemical residue-free animal products to the consumer, and protect and maintain the NT meat and milk markets.

Provide an advisory service on chemical residue issues to industry, government and the public.

Represent the NT on relevant national committees.

The NT animal industries do not have a chemical residue problem. However, there are ongoing programs to monitor the situation and demonstrate the absence of residues. There is currently one property under quarantine in the NT.

This program has four components:

1. National residue survey (NRS).
2. Beef organochlorines, organophosphates and synthetic pyrethroids residues.
3. Hormonal growth promotants (HGPs).
4. National antibacterial residue minimisation (NARM) program.

NRS

NRS is a random sample survey to monitor residues in Australia's agricultural food commodities, which has been operating to some extent since the 1960s.

Since 1996 the need for participation in the NRS for domestic consumption as well as for the export market has created an additional cost for small industries.

During 2001-02, DBIRD signed an agreement with NRS to follow-up trace backs greater than the residue action level, usually maximum residue limit (MRL) and take appropriate action.

Activities

During 2002-03, 47 samples were collected from NT stock, primarily through abattoirs and analysed. They included 27 cattle, 10 buffaloes, seven camels, 2 horses and one pig. There were no detections greater than the MRL/maximum permissible concentration (MPC) from an NT property. There were no violations of antimicrobials, organochlorines or organophosphates from NT stock.

An incident report was received from an abattoir in South Australia. A cow from an HGP-free consignment was found to have an implant in its left ear. After questioning the owner of the station (who does not use HGPs but acquired animals that were treated on other stations), it was decided that there was no reason to doubt his statement and query the validity of the trace-back. It was probably an identification problem at the abattoir. This matter was reported to South Australian authorities, who will address it so trace-back in future detections can be positively identified.

Beef organochlorines, organophosphates and synthetic pyrethroids

The main issue for the Northern Territory continues to be the interval between the last treatment for cattle tick and buffalo fly and slaughter, to satisfy the limit to MRL in both domestic and export markets.

Advice was provided to all producers in the cattle tick and buffalo fly area on the residue risk and control of cattle ticks and buffalo flies.

HGPs

Many domestic and export markets are sensitive to cattle products derived from animals implanted with HGPs.

A national program to comply with European Union (EU) import requirements was developed in 1993 which satisfied EU reviewers. This program comprised two components - controls on the use of HGPs in the cattle industry, and systems for the recognition of stock which have not been implanted with HGPs. Controls on HGP use are underpinned by the NT *Control of Hormonal Growth Promotants (Stock Act*). Two properties are audited for compliance each year. A register of HGP users is maintained in the NT as a requirement of the national HGP control system. Last year, 58 (compared with 76 the previous year) properties in the Northern Territory purchased 211,840 doses of HGPs for use. This is an increase of twenty-five percent compared with the number of doses purchased in the previous financial year.

On 1 December 1999, a new national system for declaration of HGP freedom began which was designed for accrediting properties wishing to specifically supply the EU market. Accredited properties are only to hold cattle not implanted with HGPs, hold appropriate documentation, and adopt the national livestock identification scheme (NLIS). Accredited properties may only purchase cattle from accredited properties and must notify the NLIS national database of the individual identification of any stock sold outside the system. This component is now covered under the Federal *Export Control Act*, but is administered by State authorities. Two properties are audited for compliance each year. Currently, there are four EU-accredited NT properties and there is interest from at least one more to become accredited.

NLIS describes use of permanent devices containing electronic transponders from which individual identification can be read electronically. Approved devices may be rumen pellets or ear tags applied at weaning which then will remain with that animal for life.

Two audits were completed during the year on two EU-accredited properties as required under the national HGPs audit program. No audits were carried out on HGP users this financial year. NRS reimburses the States for this activity at $380/audit.

During 2001, use of pink tags bearing the words "HGP Free" were allowed to be used as transaction devices to declare cattle HGP free, but were no longer accepted for the purposes of the EU market. Industry requested this system to remain for the purposes of other markets such as Saudi Arabia, Korea and Jordan. AQIS now uses the pink tags together with the appropriately endorsed national vendor declaration as the basis for the Non-EU HGP free certification system.

NARM

NARM is a national program to monitor antibiotic and antibacterial contaminants. The national program is now targeted to high-risk areas, which excludes the Northern Territory. Another initiative by AFFA is the targeted antibacterial residues minimisation program. This allows AQIS officers in abattoirs to select high-risk animals for sampling for antibiotic residues.

PROJECT: Crocodile Farming

Project Officers: V. Simlesa and D. Morton

Location: Darwin and Katherine Regions

Objective:

Provide a regulatory service to crocodile farms in the Northern Territory.

In order to carry out regulatory duties under the Territory's *Parks and Wildlife Conservation Act* on crocodile farms in the NT, two DBIRD officers are appointed as honorary conservation officers. In

addition, the veterinary officer is authorised to provide certification under the Commonwealth *Export Control Act.*

Regulatory duties include:

- The inspection and certification of export shipments.
- Collation of monthly reports from all NT crocodile farms to Environment Australia through the Department of Infrastructure, Planning and Environment.
- Regular full audits and/or inventories of all stock on NT crocodile farms to conform to the requirements of the Convention of International Trade in Endangered Species of Fauna and Flora (CITES).
- Issuing of export/import permits involving farmed crocodile products produced in/entering the NT.
- Regular inspection of NT crocodile abattoirs and the issuing of health certificates to accompany crocodile skins, as required by importing countries.

A disease investigation service is provided to all NT crocodile farms on request.

Activities

DBIRD is responsible for all regulatory duties associated with the crocodile industry in the NT.

A Rural Industries Research and Development Corporation and QDPI joint venture to manufacture pellets as a source of feed for crocodiles is under way. Experimental feeding trials with the pellets are now conducted on three NT farms.

The Technical Officer gave crocodile industry talks to a number of schools as part of school projects.

The Technical Officer, with Greg Crawford from AZRI completed stage one of a three-stage course for Restricted Area Movement and Security run by NSW Agriculture.

Fifty-six export and four import NT movement permits were issued, 29 of which were for export overseas. A total of 3,721 crocodile (*Crocodylus porosus*) belly skins were exported overseas. A total of 29 skin shipments were inspected and 10 health certificates were issued. A total of 70 C. *porosus* and 85 C. *johnstoni* belly skins were sold in the domestic market. A total of 4,873 crocodiles were processed yielding 14,165.3 kg of meat. A total of 4,101 live crocodiles were exported domestically.

PROJECT: Emergency Animal Disease Preparedness

Project Officers: K. de Witte and Pastoral Division Staff

Location: NT Wide

Objectives:

Participate in contingency planning and training for emergency animal disease preparedness.

Ensure that DBIRD staff, relevant organisations and pastoralists have a continuing high level of awareness in relation to emergency diseases and their role in a response.

The *Protect Australian Livestock Campaign* is a nationally coordinated awareness project for emergency animal diseases (EAD) that runs year round. The EAD hotline continues to receive a small number of important calls. One of these resulted in an investigation into the feral buffalo population on the Tiwi Islands. Fortunately, all results were negative for exotic vesicular diseases. Other EAD submissions have been made, mainly of maggots for screw-worm fly exclusion.

The NT operational response plan for foot and mouth disease (FMD) progressed. This plan details how the Territory will respond to a disease outbreak in the context of its limited resources. The plan is a derivative of AUSVETPLAN and contains a number of appendices with prepared documentation, staffing and siting information for a worst case scenario FMD response. The rapid response team is a concept designed to assist smaller jurisdictions in an EAD response. Various inputs were provided to support the concept including planning for an exercise in March 2004.

Staff obtained experience by assisting in *Exercise Minotaur* based on an FMD outbreak scenario in the eastern States. This was a major, senior government officer level training exercise and participation was extremely useful in gaining experience with the management of a response and also in the operation of local disease control centres. There has been ongoing promotion of FMD awareness through newsletters, media interviews and presentations at Northern Territory Cattlemen's Association meetings, DBIRD Primary Industry Group gatherings, and regional meetings and field days. One stock inspector has conducted numerous presentations, which were well received by the cattle industry. On this theme, property biosecurity has been a topical issue and a paper has been produced for inclusion in the NT operational response plan.

As part of the national emergency animal disease preparedness (EADP) training program, a veterinary officer attended a workshop for controllers and was assessed. Further local training took place at the Animal Health Conference in March 2003. The NT continues to send veterinary officers for exotic disease courses at the Australian Animal Health Laboratory. The EADP competency standards and assessment methods for the various tasks within an emergency animal disease response are on the DBIRD Primary Industry Group intranet site. A register of competencies is maintained and is the basis for targeting gaps in training.

Departmental officers contribute to the technical and policy management of the national program at several levels. The AUSVETPLAN manual revision includes revision of FMD, carcase disposal, valuation and control centre management under various arrangements. The Territory is coordinating a review of the destruction manual. The revised manuals for anthrax, surra, bovine brucellosis, Australian bat lyssavirus, bluetongue and Newcastle disease are due soon.

Contributions were made to the policy and action plans for a livestock standstill, zoning in a disease outbreak, FMD vaccination and free zone surveillance requirements. Australia has commissioned its own FMD vaccine bank arrangements, which has increased cost to the Territory. The commissioning of an Australian Veterinary Reserve is also an issue that has merit and is one of many that are being examined following the outbreak of FMD in the UK.

The EAD response agreement has been reviewed particularly in respect of financial matters. Consultations were held to seek changes to reinforce powers under the *Stock Diseases Act* to deal with an EAD.

Inspections of garbage disposal facilities in towns, remote communities and stations were conducted throughout the Territory by stock inspectors to determine the risk of inadvertent or deliberate swill feeding to pigs. Swill is garbage containing mammalian or poultry protein which is not allowed to be fed to pigs. The level of awareness was found to be high and few significant problems were encountered. Public vigilance and reporting is appreciated. One incident of swill feeding was investigated with a negative result.

PROJECT: Honeybee Industry

Project Officers: K. de Witte and V. Simlesa

Location: NT Wide

Objective:

Provide technical advice, disease investigation and regulatory services to the honeybee industry.

There is concern over the potential introduction of exotic bees and parasitic mites after recent experiences in Australia and New Zealand. The Asian honeybee *Apis cerana* was detected in Darwin in 1998 and subsequently eradicated.

The national sentinel hive program (NSHP) was established in 2000 to enhance surveillance for exotic bees and bee parasites. One of these parasites is the exotic *Varroa* mite, which is a natural ectoparasite of the Asian honeybee. The *Varroa* mite has switched to the European honeybee (*Apis mellifera*) as a host, and has become a serious pest in the bee world. There are three highly specialised species of *Varroa* mite, of which *V. jacobsoni* has the widest distribution and *V. destructor* poses the greatest threat. The *Varroa* mite established in New Zealand in 2000, but Australia remains free.

The NSHP includes both hives and log traps. The European honeybee hives are established at Darwin Port and East Arm Port. The hives were donated and are maintained by a local beekeeper. Monitoring is conducted every three months. A commercially produced pest strip (Bayvarol strips), specifically designed for the detection of the *Varroa* mite is placed within the hive for 24 hours. A sticky board is placed at the bottom of the hive to capture any *Varroa* mites detected by the Bayvarol strip. Sticky boards are submitted to the Entomology Section after 24 hours for identification of possible mites.

The log traps have been established to monitor the presence of the Asian honeybee. The traps no longer have a pheromone lure placed inside. The trap design has been tested and it was found that the hollow palm tree trunk was the most appealing to the Asian honeybee. The traps are designed with a small access hole on the side for bee entry. Each month the log traps are checked and the presence of any honeybees is recorded and if any are present, they are sampled. There are five traps established in the Darwin region, one at Darwin Airport, two in the East Arm area and two in the Darwin Port area. One log trap is also established at Gove and one at Groote Eylandt. Pheromone lures are not utilised in the log traps; detection of adult Asian honeybees is brought about by the Asian honeybees' preference for hollow palm logs.

The Apiary Officer enforced NT quarantine requirements that were imposed following the discovery of the small hive beetle (*Aethina tumida*) in Queensland and New South Wales. All queen bee shipments and live hives were inspected and had a health certificate issued before the shipment entered the NT. The Apiary Officer inspected queen bees and live shipments before release.

The Apiary Officer attended the Northern Territory Beekeepers' Association annual general meeting in Darwin and was appointed public officer.

The Apiary Officer also obtained statements of attainment and a certificate of competency through Animal Health Australia.

PROJECT: Legislation

Project Officers: B. Radunz, Project Leaders and Parliamentary Counsel

Location: NT wide

Objectives:

Amend stock and meat legislation as required.

Amalgamate the various stock legislation into a Stock Act.

Conduct a legislation and compliance program.

There are currently five Acts, with associated Regulations, relating to stock: *Stock Diseases Act, Stock and Travelling Stock Act, Brands Act, Exotic Disease Compensation Act,* and *Hormonal Growth Promotants {Stock} Act*. The goal is to amalgamate the legislation into a Stock Act and concurrently remove outdated and unnecessary legislation.

In response to national preparedness planning for foot and mouth disease and for bovine spongiform encephalopathy there is national agreement to ensure legislation exists in all jurisdictions to implement 16 critical success factors. The *Stock Diseases Act* is being amended.

To prevent the spread of disease, notices by the Minister or the Chief Inspector of Stock are prepared to provide the necessary legislative powers to enforce required stock movements within the Northern Territory or for importation of stock into the Territory.

There is a program to audit compliance with the more important regulatory controls. If non-compliance is detected the response may be to initiate a prosecution, issue an infringement notice, or provide education and a warning.

Activities

The new Government affirmed the urgent amendment of the *Stock Diseases Act* and the amalgamation of the stock legislation into a Stock Act. A draft Bill to amend the *Stock Diseases Act* was prepared and consultation completed. A national competition policy review has started with the objective of introducing the draft legislation in the Legislative Assembly in September 2003. A discussion draft of the Stock Bill was completed for consultation with the relevant stakeholders.

The following notices were gazetted:

1. Revocation of the TFAP program and declaration of the TFAP 2 program.

2. Movement restrictions relating to Parkhurst resistant ticks.

3. Importation of bees, bee products and equipment relating to the small hive beetle.

4. Compensation rates for cattle.

5. Revocation and declaration of standards and codes relating to the *Meat Industries Act*.

The Stock Diseases Regulations Schedule 1 was amended to include the small hive beetle as a prescribed disease.

Compliance program
Audits of health certificates and waybills were as follows:

Abattoir	3
Export depots	19
Properties	52
Ruminant feed ban – retailers	2
Saleyard	47
Tick conditions - horse events	3

No cases of non-compliance were detected during the audits.

PROJECT: Livestock Identification

Project Officers: K. Small and A. Kluth

Location: NT Wide

Objectives:

Ensure that a livestock identification and tracing scheme can provide a consistent trace-back system across Australia.

Ensure compliance with the Northern Territory Brands Act and Regulations and the Stock Diseases Act and Regulations.

Consumer demands for food safety have highlighted the importance of being able to trace meat products back to the property of origin. The Australian cattle industry aims to stay ahead of its competitors with this important trade issue.

National Livestock Identification Scheme (NLIS)
A system of permanent identification of cattle using radio frequency identification devices contained in a rumen bolus or an ear tag has been adopted by NLIS.

Devices are approved for use in the Northern Territory pursuant to Regulation 20 of the Stock Diseases Regulations. The conditions of use are also specified.

The European Union (EU) has accepted the NLIS system of permanent identification as the basis of a trace-back system to allow access to its beef market.

Meat and Livestock Australia has developed a national database which will keep records of all permanently identified stock.

All NT cattle herds have been issued with property identification codes. The updated pastoral database is fully operational. The database stores all cattle property details.

Implementation of NLIS
During 2002-03 the Primary Industries Ministerial Council identified a national approach to livestock identification and tracing as a priority for Australia.

The Northern Territory Cattlemen's Association and the Northern Territory Livestock Exporters Association do not support mandatory adoption of NLIS.

The Territory Government, with support from Meat and Livestock Australia, is establishing a number of NLIS demonstration sites across the NT. The sites will allow the NT cattle industry to assess the operational performance of electronic identification and full transaction recording.

Both herd-based and individual animal-based tracing systems will operate in the Northern Territory.

National vendor declarations (NVDs)

A national working group has been developing a proposed combined waybill and NVD. The form would have limited application in the NT.

Brands

Changes to the Brands Regulations have been implemented in relation to branding positions and cross branding. No changes to *the Brands Act* will be made until the new Stock Bill is produced.

PROJECT: Meat Industries

Project Officers: S. Sell and R. McFarlane

Location: NT Wide

Objective:

Ensure compliance with national standards, and foster export and domestic markets for all sectors of the NT meat industry.

The Department of Business, Industry and Resource Development (DBIRD) is responsible for regulating the meat industry in the Northern Territory, from slaughter through to processing and storage for wholesale.

The Department of Health and Community Services regulates meat retail outlets.

DBIRD licenses and regulates:

- Abattoirs that slaughter all types of animals, including poultry and crocodiles.
- Wholesale meat processing, including the manufacture of small goods.
- Slaughter of game animals.
- Game meat processing.
- Slaughter of pet meat animals.
- Pet meat processing.
- Slaughter/processing of bait meat animals.
- Cold stores (domestic meat storage).

The regulatory role of DBIRD in the meat industry in the NT is empowered by the *Meat Industries Act* 1996 (Northern Territory), the Meat Industries Regulations (Northern Territory) and the following national standards and codes of practice:

- The Australian standard for hygienic production of crocodile meat for human consumption.
- The Australian standard for hygienic production of natural casings meat for human consumption.
- The Australian standard for hygienic production of ratite (emu/ostrich) meat for human consumption.
- The Australian standard for construction of premises and hygienic production of poultry meat for human consumption (second edition).
- The Australian standard for hygienic rendering of animal products.

- The Australian standard for the hygienic production and transportation of meat and meat products for human consumption.

- The Australian standard for the hygienic production of game meat for human consumption.

- The Australian standard for the hygienic production of rabbit meat for human consumption.

- The livestock at slaughtering establishments model code of practice for the welfare of animals.

Standards are non-prescriptive (outcome based) and initiate change from the historical meat industry compliance method of online government inspection to a system of company self-regulation via government approved and audited hazard analysis and critical control point (HACCP) based quality assurance programs.

Meat industry sectors requiring meat inspectors need to employ their own.

The primary regulatory function of DBIRD is performed by audit, whose frequency varies with throughput and compliance history.

News
Because of a shortage of wild pigs in eastern States due to drought, there are currently three game meat processing companies operating five game meat field depots in the NT.

DBIRD conducted wild pig field-harvesting courses for 92 people during July and August 2003. The number of game meat slaughter licensees has increased from seven in 2002-03 to 39 in 2003-04.

The Australian Quarantine and Inspection Service (AQIS) exemptions to the *Export Control Act* allowing meat from NT domestic-licensed abattoirs and processors to be exported to East Timor, Indonesia and Brunei will cease early in 2004 when a new AQIS tiered export system will be introduced.

Progress report
- Twelve meat industry licences were issued to abattoirs:
  - Eight for red meat (one export and seven domestic).
  - Three for crocodile (two export and one domestic).
  - One poultry (domestic).
- Sixteen licences were issued to wholesale processors:
  - Thirteen independent processing and packing operations.
  - Three smallgoods manufacturers.
- Two licences were issued to pet meat processors.
- Twelve licences were issued for slaughter for pet meat
- Thirty-nine licences were issued for slaughter of game meat.

The Barkly Meats abattoir at Tennant Creek and Teys Brothers Katherine abattoir did not open for the 2003 season.

PROJECT: Monitoring and Eradication of Cattle Tick Strains Resistant to Chemicals

Project Officers: K. Small, D. Russell and I. Doddrell

Location: NT Wide

Objectives:

Locate chemically resistant strains of cattle ticks on NT properties and prevent their spread.

Advise industry on the chemical control of any detected resistant strains of cattle ticks.

Prior to April 1999 there were no known cattle tick strains resistant to synthetic pyrethroids or amitraz in the NT. Previously some resistant strains to organic phosphates were detected during the 1970s and 1980s. Organic phosphates as acaracides were banned in 1987.

There are strains of cattle ticks resistant to one or more acaracides in Queensland. All cattle from the tick-infected areas of Queensland require a clean inspection followed by plunge dip to enter the NT. Despite this control, there is a low level of activity to monitor for resistant ticks as there may be illegal movements or inspectors in Queensland may not detect ticks. Although there is little cattle tick control in the NT to improve production, the widespread establishment of resistant ticks would have a significant effect on achieving tick-free cattle for export overseas and interstate.

Fully engorged female cattle ticks are collected in the field and sent to the Animal Research Institute, QDPI, for processing and larval packet testing against a number of tickicides. Collectors and station owners/managers are given the results and appropriately advised. The program targets properties that report poor tick kill and properties on which pour-on synthetic pyrethroids are used for cattle tick or buffalo fly control.

Parkhurst strain resistant ticks (resistant to synthetic pyrethroids e.g. cypermethrin and flumethrin as in *Bayticol*®, *Barricade 'S'*® and *Blockade-S*®) were found on two properties in the Mary River area in April 1999.

Situation in 2002-03

Parkhurst strain cattle ticks have been eradicated from one property. There are nine properties infected with Parkhurst ticks. Movement controls are in place to reduce the threat of further spread of these ticks.

An active surveillance program commenced to determine the extent of spread of Parkhurst ticks in the Darwin area.

The establishment of plunge dips charged with amitraz at the Darwin export yard and the Noonamah export yard has facilitated the movement of cattle from infected properties to export under a permit system. Amitraz plunge dips are also available at Opium Creek and Twin Hills.

PROJECT: Stock Movements

Project Officers: Veterinary Officers and Stock Inspectors in the Regions

Location: NT Wide

Objectives:

Provide property and animal certification for export, interstate and intrastate movements.

Facilitate interstate and intrastate movements from the tick infected and tick protected areas by providing a service to inspect and/or treat cattle and horses for cattle ticks.

Prevent entry of cattle ticks from interstate, particularly acaricide resistant strains from Queensland.

Prevent the entry of Johne's disease and tuberculosis from interstate.

In consultation with industry and consumers, the Government prescribes controls to prevent the spread of animal disease. This was a response to cattle disease plagues common in the 18th and 19th centuries. In recent years there has been increasing industry self-regulation. While market and quality assurance programs have been developed and will continue, there are industry and consumer expectations for governments to protect consumers from health risks and animals from the spread of diseases. This applies within the NT (e.g. for cattle ticks) and for national and international markets (e.g. for bovine tuberculosis and other diseases).

A service is provided to NT producers to facilitate trade by the certification, inspection and treatment of stock, if required. Control programs (e.g. for cattle ticks) may also be implemented. Mobile spray plants and chemicals are provided for spraying horses for movement.

There is a continual review of stock movement controls and area declarations in consultation with State governments and industry associations.

Stock from the tick-infected area require a clean treatment (clean inspection and treatment) to pass into or through the NT tick-free areas or into the tick free-areas of other States. Treatment is by plunge dipping, except for led and tractable horses and show cattle, which may be sprayed in lieu of dipping. The tick free areas in the NT are designated as the Free Zone Protected Area, and the Central Control Zone Protected Area. The tick infected areas are designated the Infected Zone Protected Area, and the Northern Control Zone Protected Area. A map showing these areas can be accessed from the following DBIRD internet page: http://www.nt.gov.au/dbird/dpif/animals/cattle_ticks.shtml

Cattle moving to Western Australia also require inspection for burrs.

Cattle moving to all States except South Australia require a health certificate. Other stock moving interstate may also require a health certificate.

Certifications are provided to the Australian Quarantine and Inspection Service (AQIS) regarding the disease status of properties and animals to satisfy export protocols. The *Animal Health Information System* is an associated project for improving the reporting and retrieval of disease data. Planned active surveillance programs complement passive surveillance disease monitoring.

Some export protocols require treatment of animals prior to export. The Department provides this service where authorised private veterinarians are not available.

The Department issued 289 property of origin health certificates for the export of cattle from NT properties.

Table 1. Summary of activity for 2002-03

Cattle inspected and treated for cattle ticks from tick areas	
Number of visits	156
Number of animals	66,604
Cattle moved interstate from tick-free areas	
Number of certificates	350
Number of animals	129,217
Cattle inspected for movement to WA	
Number of visits	48
Number of animals	32,918
Horses inspected and treated for cattle ticks from tick areas	
Number of visits	221
Number of animals	1,178
Other stock inspected	
Number of visits	22
Number of animals	2,635
Total Property visits	*447*
Cattle inspected at saleyards	
Number of visits	47
Number. of animals	16,499

PROJECT: Surveillance

Project Officers: D. Pinch, Veterinary Officers and Stock Inspectors

Location: NT wide

Objectives:

Provide credible disease surveillance information to support the sale of livestock and livestock products.

Investigate the occurrence of diseases in the NT livestock industries.

Participate in national animal health surveillance programs.

Surveillance of the animal population in the NT means that health and disease data is collected, analysed and interpreted so that it adds to our knowledge of endemic diseases, identifies new diseases, elucidates risk factors for diseases, and allows planning and implementation of ways to control the disease. Surveillance encompasses:

1. The collection of animal health data during disease investigations initiated by the producer (passive/general surveillance).

2. Planned surveys to target a specific disease (active/targeted surveillance).

3. The provision of NT information as part of national programs to enhance Australia's trading status.

4. A secure and reliable computer system to store and retrieve the data and communication of results to relevant parties.

Departmental investment in surveillance activities described in this and other projects in this report is around $1.2m for 2002-03 (excluding external funding). The surveillance activities protect a livestock industry worth over $220m to the NT.

The activities described below are major components of this project. The diagnostic highlights are an interesting summary of passive surveillance investigations for the period, and as such do not cover all

investigations carried out. Surveillance activities are also covered in other reports (e.g. bluetongue survey).

National transmissible spongiform encephalopathy surveillance program (NTSESP)
Australia is free of the two major transmissible spongiform encephalopathies (TSEs), bovine spongiform encephalopathy (BSE), which affects cattle, and scrapie, which affects sheep. However the Office International des Epizooties (OIE) terrestrial animal health code (TAHC) requires that countries claiming to be free of TSEs have a surveillance system in place to detect BSE and scrapie should they occur. It is important that Australia meets this requirement to assure continued access to export markets. NTSESP was started in 1998 to address this issue. Animal Health Australia coordinates the program, with State/NT/AQIS coordinators organising activities in their region. There is also information about NTSESP on the Animal Health Australia website at: www.aahc.com.au/surveillance/ntsesp/index.htm .

OIE guidelines are used to determine necessary surveillance levels. Surveillance involves examining a large range of specimens from cattle (over two years of age) or sheep with signs of nervous system disease. The number of cases that each State/Territory need to examine has been calculated according to its cattle or sheep population. The calculation was revised in 2003, due to changes in the distribution of cattle and sheep populations in Australia. The NT examines 23 cattle cases annually and no sheep.

At the May 2003 OIE general session amendments to the TAHC relating to BSE and BSE surveillance were adopted. The NTSESP coordinators' meeting in August 2003 considered the impact of these changes on Australia's surveillance for BSE.

The program operates on the calendar year. The NT achieved 24 submissions from cattle that were negative for BSE in 2002. Government veterinary officers, stock inspectors and a private veterinary practitioners collected samples in the NT. Some of the diagnoses for the sampled animals indicated bovine ephemeral fever, septicaemia, zamia plant poisoning, transit tetany and pneumonia.

Johne's disease zoning
The veterinary committee (now animal health committee) introduced formal zoning for bovine and ovine Johne's disease (JD) in Australia on 1 August 1999. There are four zones for both bovine and ovine JD: Free, Protected, Control and Residual. The Northern Territory is a Protected Zone for bovine JD.

In order to maintain Protected Zone status, the Northern Territory is required to fulfil objectives set out in the standard definitions and rules for bovine JD. This involves surveillance activities and an annual report to the animal health committee. The Northern Territory's Protected Zone status was endorsed for another year at the veterinary committee 13 in December 2002.

The Northern Territory started an active surveillance program in 2001 on properties that had imported cattle from Control Zones, interstate. This surveillance involves performing a test for JD on blood collected from the imported cattle and up to 100 in-contact cattle. Three properties in the Alice Springs region were monitored as part of this surveillance during 2002-03 (six properties were monitored in 2001-02). Some identified properties are exempted if the herd of origin of the imported stock reaches a higher status for JD. There was no evidence of JD through this surveillance.

Surveillance for JD was demonstrated to be effective in the first half of 2002. Two house cows, on two different properties, that underwent testing as part of surveillance in a dairy herd that was being dispersed, were positive for JD infection. The dairy had imported animals from Control Zones, interstate. A trace forward and testing program from the index herd was implemented. Many properties were put in quarantine, and owners decided either to post-mortem the implicated animals to be removed from quarantine, or to test the animals over a five-year period. At the end of June 2003, seven properties (with a total of 14 cattle) still remained in quarantine, pending resolution of their situation.

National animal health information system (NAHIS)
NAHIS is a surveillance program coordinated by Animal Health Australia that has input from the State, NT and Commonwealth Governments. NAHIS provides timely and accurate summary information on Australia's animal health status to support trade in animal commodities and meet Australia's international reporting obligations. It also provides information on Australia's capabilities and activities in animal disease surveillance and control.

A quarterly report is provided to NAHIS on NT animal health status, specific testing carried out at Berrimah Veterinary Laboratories and significant animal disease events. Similar reports from all the Agriculture/Primary Industry Departments, AQIS, Northern Australia Quarantine Strategy, the National Arbovirus Monitoring Program, the National Residue Survey, the Commonwealth Department of Family Services and Health, and various national reference laboratories are collated.

A quarterly report, *Animal Health Surveillance Quarterly*, is produced and circulated within the NT to various clients, including livestock industry groups. There is also information about NAHIS on the Animal Health in Australia website at: www.aahc.com.au/nahis/index.htm .

Animal health newsletter

Animal Health News from the Northern Territory is a quarterly publication produced by veterinary laboratory and animal health staff. It started at the beginning of 1996. It is sent to all registered veterinarians in the NT (and bordering towns in WA and Queensland), stock inspectors, NT livestock industry organisations and other interested people both within and outside the department. The articles from laboratory and field staff in southern and northern regions cover topical animal disease events, animal health surveillance news, information from Berrimah Veterinary Laboratories and other items.

Issues 26 to 29 were produced during 2002-03, with about 190 copies distributed each quarter. The newsletter is also available from the DBIRD website:

www.nt.gov.au/dbird/dpif/pubcat/newsletters/ahnnt.shtml

Passive surveillance

The investigation of disease events in livestock reported by producers achieves two objectives. First, the provision of a diagnostic service by veterinary officers and stock inspectors for sick animals assists producers to treat, prevent and control diseases in their animals, and thereby enhances profitability and animal welfare. Second, providing this service also enables documenting passive surveillance for both exotic and endemic livestock diseases. Information from passive surveillance can be used for market health assurances in trade. The accumulation of knowledge over time regarding endemic disease conditions in livestock also enhances the advice and extension information that is provided to producers.

There is an active extension program on prevention of diseases such as botulism, tick fever and coccidiosis across the Northern Territory. Advice to property owners is provided on request or following a disease investigation.

Advice may be offered over the phone, or a property may be visited to investigate the history of a disease, conduct clinical examinations of stock, and/or to perform post mortems and collect samples. Following assessment of the visit to the property and the results of laboratory findings, producers are advised of the outcome, and control measures are discussed.

Endemic disease

Table 1 shows the number of submissions, by region, for the July 2002 to June 2003 period. Field veterinary officers and stock inspectors usually visit properties or provide advice over the phone. This is a crude estimate of activity because a submission can range from a phone call, to examining one animal, to examining and sampling many animals.

Table 1. Record of activities by staff to support industry during 2002-03

	Darwin			Katherine			Tennant Creek			Alice Springs			Total
	P	A	R	P	A	R	P	A	R	P	A	R	
Bee	-	2	-	-	-	-	-	-	-	-	-	-	
Bird	-	-	-	1	-	-	1	-	-	-	-	-	
Buffalo	-	8	-	-	-	-	-	-	-	-	-	-	
Cattle	**7**	**2**	**26**	**19**	**44**	**27**	**5**	**28**	**2**	**4**	**19**	-	
Crocodile	5	-	-	2	-	-	-	-	-	-	-	-	
Deer	1	-	-	-	-	-	-	-	-	-	-	-	
Goat	5	-	-	1	-	1	-	-	-	-	-	-	
Horse	2	-	1	31	6	1	4	-	-	1	-	-	
Insect	-	-	-	-	-	-	-	3	-	-	11	-	
Pig	3	-	-	-	-	1	-	-	-	-	-	-	
Poultry	6	-	-	3	14	-	-	9	-	-	18	-	
Rabbit	1	-	-	-	-	-	-	-	-	-	-	-	
Sheep	-	-	1	-	-	-	-	-	-	-	-	-	
Tick	-	15	-	2	-	-	1	-	-	-	-	-	
Total	**30**	**27**	**28**	**59**	**64**	**30**	**11**	**40**	**2**	**5**	**48**	**0**	

Source: ANDI
P => Passive (general) investigations
A => Active (targeted) surveillance activity (includes NTSESP, bluetongue survey, tuberculosis surveillance, tail rot survey, sentinel herd/flock/insect sampling, JD targeted surveillance, Elsey/Florina virus survey)
R => Regulatory/movement activity (includes trace-forward testing for JD, movement tests)

The 183 activities were done on almost 80 cattle properties. The figures in Table 1 include 27 submissions from sampling sentinel cattle herds, 41 submissions from sampling sentinel poultry flocks and 14 submissions from insect collections associated with sentinel herds. These categories of submissions have not previously been reported in the Technical Annual Report. It is therefore difficult to compare the figures with those of previous reports. Excluding sentinel herd samples, there were 262 submissions. There were 209 submissions in 2001-02, and 101 cattle investigations. Sampling of trace-forward animals from the JD cases in 2002 accounts for a significant number of the regulatory cattle submissions in Table 1.

Diagnostic highlights 2002-03

Alice Springs region

Over a three-day period in August, 10 of 67 bullocks died. The primary lesions were a fibrinous pneumonia, and evidence of septicaemia. A virus affecting the respiratory system has not been isolated, but is strongly suspected as the primary cause, compounded by stress and dusty yards. *Pasteurella multocida* was isolated from pleural fluid.

Six of 23 bulls died in October showing clinical signs of botulism. There was evidence of carcase chewing and the bulls had not been vaccinated. Botulism vaccination is not widely practised in the region. Algal intoxication was the main differential diagnosis. However, the algae invading the local turkey nest (water dam) were identified as green algae, and not the toxic blue-green algae.

The loss of 10 bullocks was investigated in November. Clinical signs and post-mortem evidence indicated poisoning by *Acacia georginae* (gidyea/gidgee poisoning). The toxin contained in this small tree/large shrub is fluoro-acetate. This station does not experience losses to gidyea often.

During March, a station had 21 cows and two weaners die overnight, out of a total of 150 animals due to caltrop (*Tribulus terrestris*)/button grass (*Dactyloctenium radulans*) poisoning in stockyards. Both plants accumulate nitrates when growing rapidly on nitrogen-rich soils. Caltrop also contains saponin poisons. The deaths occurred only after stock were not fed hay for the second day, which supports the view that poisoning generally occurs in hungry stock.

Tennant Creek region

During a two-week period in October, seven of 300 weaners died. Many more became sick and recumbent before recovering, raising suspicion of bovine ephemeral fever (BEF) virus infection. It is not unusual for BEF outbreaks to occur during October in the Tennant Creek region. Further investigations into stock deaths the following month led to a final diagnosis of botulism on the basis of

clinical signs, necropsy and high antibody levels to type D botulinum toxin. Only local cattle were dying, as introduced cattle had been vaccinated.

Cattle deaths at another station were investigated in November. A post-mortem was carried out on an emaciated cow, that had dehydrated and had very high field exposure levels of antibody to type D botulinum toxin. The introduced cattle had only been vaccinated against type C botulinum. Although botulism was implicated, the local cattle on the bore/dam were equally affected by lack of feed and stagnant fetid water in the dam.

Deaths of 18-month-old steers on a Barkly Tableland property were investigated during March. Many animals in the paddock were down and many showed clinical signs typical of BEF. Mortality was about 1%. Blood samples from two animals and polymerase chain reaction (PCR) results were positive for BEF virus. PCR results from a blood sample taken from a sick cow on a neighbouring property were also positive for the BEF virus.

Eleven old breeder cows died during mustering and drafting in April. They showed a stiff gait, paresis, and went down in sternal recumbency. They were drooling saliva and breathing heavily initially, then suffered progressive depression, lateral recumbency and death 24 to 36 hours later. Necropsy and laboratory tests showed a ketotic hepatopathy with secondary acute pneumonia. BEF virus is likely to be the cause, as at least 12 cows recovered when they were left alone as soon as these signs were seen. Steers from a neighbouring station were positive for the BEF virus the previous month, indicating the virus was active in the area.

Katherine region

Mortality in wild birds was reported near Katherine during August. At least 20 ducks and one pelican were found dead or dying around or in sewage ponds. Botulinum toxin type C was detected.

There was a classic case of post-transport Cook town ironwood (*Erythrophleum chlorostachys*) poisoning in breeder cattle during October. The cattle had been transported from an area where ironwood does not occur. About 5% mortality occurred within 12 to 48 hours of arrival. Affected animals developed diarrhoea without blood, severe colic, became dehydrated, recumbent and died suddenly. Presence of easily recognisable ironwood leaves in the rumen was the main indicator on post mortem.

In December maggots were removed from a station horse. They were identified as third stage larvae of the steel blue blow fly (*Chrysomya saffranea*). The investigation excluded the screw-worm fly, which causes significant production losses overseas.

An owner of a small farm applied endosulfan (with wetting agent) directly to his nine steers as a treatment for buffalo fly. All animals salivated and two died. Samples of brain and fat showed a very high level of endosulfan. Because of the likelihood of violative residues, the stock on the property was placed under quarantine and a residue management plan was formulated.

A private practitioner examined an 8½ month-old quarter horse foal. It showed weakness, frothing at the mouth and an altered mental state. Despite treatment, it progressed to lateral recumbency and became non-responsive over the next 24 hours. It was euthanased and a post-mortem was conducted. Histological examination of lesions in the lung was indicative of severe, acute suppurative bronchopneumonia. There was also marked dilation of the choroid plexus by proteinaceous fluid. Samples were sent to the Australian Animal Health Laboratory for exclusion of Hendra virus and Australian bat lyssavirus, which was particularly important in this case as the foal had bitten the arm of the owner. Results from a range of tests for these two viruses were negative.

Fourteen weaner steers were reported to have died over a period of two weeks in May following de-horning, castration, branding and vaccinating. One sick animal showed classical signs of tetanus: rigid legs and neck, sawhorse stance, raised tail, grinding teeth, locked jaw and salivation. The equipment used during the husbandry activities was not kept clean. The plan was to vaccinate two weeks prior to marking at the next round of mustering, and improve hygiene.

Maggots were removed from the wound of a calf that had been bitten by a dingo in June. They were identified as larvae of the steel blue blow fly, most closely resembling *Chrysomya saffranea*. This excluded the screw-worm fly.

The survey of horses for the DPP V5337 ('Florina') and DPP V4834 ('Elsey') viruses continued this year. Although no more clinical cases have been confirmed, blood tests have demonstrated the continuing presence of these viruses in the NT. In one case, a horse that succumbed to purpura haemorrhagica after a brief episode of respiratory disease was found to be seropositive to the Elsey virus although no virus could be isolated from the samples collected. This mare had a foal at foot that never showed any signs of malaise, neither did any of the other horses kept in close contact with the mare. In another case, a mare was euthanased after showing neurological signs (incoordination, ataxia, blindness) and mucopurulent nasal discharge. The post-mortem results indicated subacute/chronic pyogranulomatous pneumonia and meningitis of unknown aetiology. Haematology was suggestive of a viral infection but serology results were negative in this case for both the Florina and the Elsey virus.

Darwin region

The Department responded to a report on the Emergency Disease Hotline in July of lesions suspected of being an emergency disease. A field investigation was carried out to assess the possibility of an exotic vesicular disease occurring in feral pigs near Ramingining, about 390 km east of Darwin, on the north coast of Arnhem Land. Post-mortem examination of 45 pigs in the vicinity of the reported disease cases showed no pathology or clinical signs of illness consistent with vesicular diseases of pigs. Serology conducted at the Australian Animal Health Laboratory was negative for foot and mouth disease virus serotypes O, A and Asia 1. The investigation demonstrated the very high cost of disease investigation in feral animals in a remote locality. The local network of contacts developed by the Northern Australia Quarantine Strategy in Arnhem Land was valuable in facilitating the investigation.

Mortalities in weaner cattle were investigated in the Douglas Daly region during August. Sudden deaths were occurring in weaners in reasonable condition. Examination of one fresh carcase showed extensive petechial haemorrhages throughout the subcutaneous fat, in the mesentery, epicardium, lymph nodes of the head, larynx and inter-costal muscles. The liver was yellow, and on histopathology showed fibrosis, cholangiolar cell hyperplasia and biliary hyperplasia, and changes to the hepatocytes. This would suggest a liver toxin such as pyrrolizidine alkaloids. There are crotalaria plants (rattle-pods) in the area, which have been associated with toxicity throughout Australia.

Two jersey cattle kept near Darwin developed profuse, watery diarrhoea in November. One animal was recumbent, unable to stand and severely dehydrated. It was destroyed, and the post-mortem examination revealed a rumen full of mangoes and a large knot of plastic, rope and irrigation tubing. The rumen fluid had a pH of 4.1. There were 14 weaners and yearlings in the paddock, which had a small amount of green pick. Several days earlier a large field bin of mangoes was dropped in the paddock for the cattle. The two jerseys were the only horned animals in the group, and they dominated the other stock when feeding on the mangoes. The large consumption of mangoes led to acidosis.

Two young buffalo were reported to have died over a six-day period in November on a property near Batchelor and another two, both nine months old, had a staggering gait before becoming recumbent. Examination showed both had a fever, were in lateral recumbency and were slightly bloated with stiff legs. The upper legs were held clear of the ground by the rigid muscles. The third eyelids were slightly prolapsed. The jaws could not be opened and a slight stimulus would set off muscle spasms. The stock had been grazing a fairly bare paddock, supplemented with export cattle cubes. It is thought that under some conditions tetanus toxin might be absorbed from the gut resulting in outbreaks in young stock.

In response to concern about the small hive beetle, a beekeeper submitted dying bees to the Berrimah Veterinary Laboratories in November. However, investigations revealed poisoning from nearby rambutan spraying. Seven out of 13 hives were lost.

In late December there was over 75% mortality in a flock of about 60 Muscovy ducks near Darwin. Over a period of five days ducks of all ages were affected. They showed leg paralysis that progressed to profound weakness with flaccid wings and neck. Botulism (type C toxin) was confirmed by the mouse protection test.

Blood samples were submitted in February from three lame bulls at an export yard near Darwin. All had a neutrophilia and, although the BEF PCR result was negative, the BEF serum neutralisation test titre was high, indicating recent exposure to the BEF virus.

The Northern Australia Quarantine Strategy staff investigated a report of lame, weak and ataxic buffalo on Melville Island during February. Clinically affected buffalo were found to be staggering and dragging their hind legs. They were in an area with cycad plants/zamia palms (*Cycas* spp), and may have eaten some. Histological examination of spinal cord sections showed some evidence of an axonopathy. A diagnosis of zamia staggers was made.

An 18-month-old buffalo on a research farm was identified as a persistently infected carrier of bovine virus diarrhoea virus. It had not been doing well for several months, was in poor body condition and had pasty faeces. The cusps of the cheek teeth were irregular and sharp, and it had a generalised lymphadenopathy.

The *Leishmania* genus of parasites has been exotic to Australia. This changed early in 2003 when a parasite of the *Leishmania* genus was identified from skin lesions in captive red kangaroos in the Top End. Identification to species level is still under way. When the species has been identified, it will help answer the question of whether it is an exotic species, or whether it is an endemic species that had not previously been found. This finding has been reported to the OIE.

PROJECT: Tuberculosis Freedom Assurance Program

Project Officers: K. de Witte, Regional Veterinary Officers and Staff

Location: NT Wide

Objectives:

Maintain Australia's internationally recognised bovine tuberculosis free area status by:

a. continuing to implement a surveillance program that meets OIE standards; and
b. eliminating any cases of tuberculosis.

Identify post-2006 arrangements and manage their implementation

The tuberculosis (TB) impending free area declaration in November 1992 was a culmination of years of work by many pastoralists, private vets and departmental staff, at a cost of $192m. The Northern Territory was declared a free area for TB at the end of 1997 and so achieved the goals of the brucellosis and tuberculosis eradication campaign (BTEC). A further $39m was spent during the period from 1993 to 1997.

A five-year monitoring program, known as the TB Freedom Assurance Program (TFAP), was adopted and funded from 1998 to 2002 by State, NT and Commonwealth Governments, together with the cattle industry. The national forward estimate for TFAP was $33m, of which expected expenditure in the NT was $13m. The main focus was the turn-off of previously exposed cattle. Three TB cases were detected and investigation programs were conducted in cattle herds during 1998 and 1999. This resulted in de-stocking two smaller herds in the Darwin region and establishment of an eradication-testing program on a large herd in the Katherine region. In 2002, TB was detected in two buffalo herds, which were removed. A full report on TFAP 1 will be published.

TFAP 2 will run from 2003 to 2006 with the above objectives and a national budget of $20.1m. The program has a new deed with revised standard definitions and rules. Field TB testing will continue, particularly on properties with a TB case after 1988 and where there is little abattoir monitoring due to live export.

Activities

Eradication

There were no ongoing eradication programs.

TB detection

One TB case was detected in January 2002 in a small buffalo herd near Darwin. It was an old cow slaughtered at a local domestic abattoir. The cow was one of the original buffalo heifers retained from

a previously infected area in the mid-1980s. A total of 14 cases of TB were detected amongst approximately 1400 head removed from the index property and a neighbouring property. All isolates of TB have been shown by DNA typing to be the SP08 strain, a common isolate in buffalo. No stock has been retained, and stock removal activities will cease in 2003. All neighbouring properties have been checked.

National granuloma submission program (NGSP)

TB surveillance at abattoirs has dropped to very low levels in the northern third of the Northern Territory due to the dominance of the live export market.

During the period there were 5,559 cattle and 1,583 buffalo slaughtered at five NT abattoirs. Seven granulomas were detected, with three confirmed as TB from the buffalo TB incident.

TB testing July 2002 to June 2003

	Number tested	**Number of reactors**	**Number with TB**
Cattle	42,831	59	1

Testing was done on 47 properties. The single TB case was the buffalo.

TB monitoring programs

Cattle previously exposed to TB infected animals remain a very low, but possible, risk of undetected TB cases despite completion of the eradication program (at CF2 or CF3 status). Of the estimated 24 million cattle in Australia there were about 200,000 on 70 properties in this risk category in 1997. The national cattle industry decided that the owners of these properties should adopt risk management strategies to minimise the risk and the scope of a possible future TB case.

In 1997 there were 50 properties in the NT which records indicated may have had stock remaining that were previously exposed to TB infected animals. The owners of three properties decided not to adopt the voluntary monitor program. Twelve properties have conducted a program but had not yet completed it at the end of 2002, four of them had the majority of exposed cattle (34,000) related to TB cases in 1997 and 1998.

At the end of 2002 there was a decrease in category A cattle from 4,872 to 1,800 remaining on one property with financial problems. Category B cattle decreased from 49,660 to 44,100. Category A cattle are breeders that were 12 months of age or older when exposed to TB infected stock. Category B cattle are progeny of cattle de-stocked due to TB or progeny of category A breeders.

Voluntary monitoring programs have been replaced by ‘approved property TB surveillance agreements’, mainly for properties with a history of TB after 1988 who are committed to the live export trade. There are about 60 properties with TB surveillance agreements for TFAP2. It is expected to test 75,000 cattle in 2003 and then drop to about 25,000 annually.

TB testing contracts for private veterinarians have been revised. There are eight contracts and five active testers. Four new staff members were trained in testing and post mortem techniques. The TFAP record keeping system ‘ERIC’ is being redesigned as an Access database to reflect simplified needs.

Expenditure during 2002-03

Operations	$730,809.98
Compensation	$355,224
Mustering subsidy	$358,173.57
Interest subsidy	$0
Freight rebate	$27,586.75
Type G (TFAP1)	$7,363
Type H (TFAP1)	$16,753
TOTAL	**1,495,910.10**

PROGRAM: Berrimah Veterinary Laboratories

Objective:

Provide a quality assured veterinary laboratory service.

The Berrimah Veterinary Laboratories (BVL) provide an ongoing diagnostic service in the broad fields of veterinary pathology and veterinary virology. BVL also conducts research projects and participates in quality assurance programs to ensure that the quality of tests carried out at BVL meets national and international standards.

BVL is accredited by the National Association of Testing Authorities (NATA) in the field of veterinary testing in the disciplines of anatomical pathology (necropsy, histopathology and cytology), microbiology (bacteriology, mycology and virology), parasitology and serology of infection. The accreditation of BVL was renewed after NATA conducted the two-yearly assessment in March this year. The scope of accreditation was raised with the addition new services such as identification by molecular techniques, histological identification of prior disease lesions and tests for Johne's disease for bovine, camelid, caprine, cervine and ovine species.

A total of 1,770 submissions were received and processed during the year at BVL. Each submission may consist of one or more specimens and each specimen may undergo one or more tests in one or more of the 12 Sections of BVL.

The 1,770 submissions consisted of 28,020 specimens and generated some 50,495 individual tests in gross and microscopic pathology, bacteriology, clinical pathology, parasitology, serology and virology. The numbers of tests and reasons for investigation were:

- 6,127 tests for diagnosis of disease in production animals;
- 126 tests associated with monitoring for bovine tuberculosis;
- 6,397 tests for export and movement certification and regulatory purposes;
- 1, 543 tests on a service charge basis for companion and performance animals, aviary birds and native fauna;
- 25,194 tests for sentinel herd and flock monitoring;
- 4,124 tests for research programs;
- 6,522 tests for surveillance programs;
- 462 tests for quality assurance.

BVL participates in 24 laboratory tests in the Australian National Quality Assurance Program (ANQAP) for veterinary serology and virology. BVL also participates in quality assurance programs in bacteriology, haematology, parasitology and anatomical pathology.

The water microbiology laboratory, which is integrated into BVL's management structure but which has a non-veterinary client base, tested 5,453 water samples from various sources. The Alice Springs water laboratory tested 2,642 samples.

Table 1. Laboratory submissions by region and by species

	Darwin	Katherine	Tennant Creek	Alice Springs	Interstate/ overseas	Total
Banteng	13				2	15
Bat	14				2	16
Bee	2					2
Bird (cage & wild)	44	2	1			47
Buffalo	22	2				24
Camel				2		2
Cat	29					29
Cattle	237	158	50	25	12	482
Crab	14					14
Crocodile	13	2				15
Deer	1				1	2
Dog	336	4		1	7	348
Donkey		1				1
Elephant	1					1
Fish	88			3	1	92
Goat	21	2			2	25
Horse	31	48	8	2	7	96
Human	3				10	13
Insect	93	31	8	11	1	144
Lion	1					1
Monkey	4					4
Mouse	1					1
Mussel					3	3
Native fauna	69	3		1		73
Oyster	3				1	4
Pearl oyster	35				1	36
Pig	72	3			7	82
Poultry	80	17	10	18	6	131
Prawn	5			4	15	24
Rabbit	2					2
Rat	10					10
Sheep	12				4	16
Other	10	1			25	36
Total	1,266	274	77	67	107	*17 91

* This figure is based on date collected.

Table 2. Type and number of laboratory submissions

Diagnostic	338
TFAP**	63
Export	22
Movement	45
Regulatory	62
Sentinel	352
Research	227
Survey	137
Fee for service***	476
Quality assurance	44
Other	4
Total	****1770

** TFAP: tuberculosis freedom assurance program
*** Companion and performance animals, aviary birds and native fauna
**** This figure is based on date received at BVL

SUBPROGRAM: Diagnostic Pathology

PROJECT: Diagnostic Pathology

Project Officers: **A. Janmaat, J. Humphrey (50%), L. Melville (25%), C. Shilton, S. Benedict, L. Small, G. Paterson, L. Chambers, M. Mahoney, D. Cumberland, R. Wilson, N. Cox, C. Day, S. Auman, N. Elliott and M. Gayoso**

Location: BVL

Objective:

Provide a quality assured veterinary pathology service to support diagnostic, regulatory and research programs in livestock health and production.

The sub-program is divided into the sections of gross pathology, histopathology, cytology, bacteriology, parasitology, serology, clinical chemistry, haematology and urinalysis. The last three sections fall under the heading of clinical pathology. Water microbiology is also a section of the pathology area. It has a non-veterinary client base.

Gross pathology

Submissions 206

The activity of this section consists of post-mortem examinations of cadavers and gross examination of pieces of organs and tissues from a large range of species. Aquaculture submissions (44% of the total) included 53 finfish, six crustaceans, 28 pearl oysters and four other molluscs. There were 21 submissions from poultry, 13 from crocodiles, 10 from bats, eight from cattle and seven from goats – accounting for 29% of the total.

- Aquaculture diseases included nodavirus infection in juvenile barramundi, possible algal toxicity in pearl oysters and likely jellyfish stings in sea cage barramundi.

- Melioidosis is a common disease in the Darwin area caused by the bacterium *Burkholderia pseudomallei*. It was diagnosed in a goat, a feral pig, a cat and in monkeys.

- Botulism in birds is an ongoing problem. The diagnosis is based on clinical signs and lack of post-mortem abnormalities. Confirmation is by the mouse toxin protection test. The disease was diagnosed in backyard chickens, ducks, turkeys and in pea fowl.

- Septicaemia in juvenile crocodiles is often associated with the isolation of *Providencia rettgeri. Salmonella* sp was isolated from juvenile crocodiles showing head tilt and spinning movements.

Histopathology

Submissions 543

Of the total submissions, 11 were from buffalo and seven from cattle under the Tuberculosis Freedom Assurance Program either as lesions from reactors or as lesions collected at abattoirs under the national granuloma submission program (NGSP). The brains of 22 cattle were examined as an ongoing NT contribution to the national transmissible spongiform encephalopathy surveillance program (NTSESP). This program is designed to demonstrate freedom from BSE and scrapie, and to provide early detection should these diseases occur. Due to the Johne's disease quarantine, 39 submissions were received for Johne's disease exclusion.

- In a herd of buffalo, seven out of 60 reacted to the intradermal caudal fold test. All were histologically positive for tuberculosis including the demonstration of acid-fast bacilli. Another animal from the same herd was detected with tuberculosis in an NGSP submission

- All submissions for TSE and Johne's disease were free from histological evidence of these diseases

- Histological examination of spinal cords form buffalo from Melville island confirmed the clinical diagnosis of zamia (*Cycad* sp) staggers

- The kidneys from two Brahman cows from the same property in the Katherine area, submitted under NTSESP, showed characteristic vacuolation of the renal tubules possibly due to a low dose of an algal toxin

- Interesting lesions in dogs were granulomatous inflammation due to *Pythium* sp (a cause of swamp cancer in horses) infection in two animals and a rarely seen transmissible venereal tumour in another

- Leishmaniasis was diagnosed elsewhere in a skin lesion from a captive (in the NT) red kangaroo.

This Section participates in the QDPI and the national registry of domestic animal pathology and histology quality assurance programs.

Cytology

Submissions 86

Submissions from private practitioners on a fee for service basis accounted for 67% and submissions for diagnostic purposes from production animals accounted for 33% of the total.

Bacteriology

Submissions 438

Tuberculosis submissions accounted for 14% of the total, diagnostic submissions for 26%, fee for service submissions for 47% and research, surveillance and QA submissions for 13%.

Interesting or common isolations included:

- *Providencia rettgeri* which continues to be a common isolate from septicaemic juvenile crocodiles and *Burkholderia pseudomallei* (the cause of melioidosis); continues to be isolated in a range of species in the Darwin area

- A bacterium isolated from necrotic barramundi gills was confirmed as *Tenacibaculum maritinum* by a reference laboratory

- Psittacosis in a monk parakeet which was confirmed with the chlamydia antigen detection test kit. Eye swabs from two cockatiels from the same aviary were also positive in the test kit

- *Pythium* sp (a cause of swamp cancer in horses) was isolated from granulomatous lesions in two dogs and a fast growing environmental *Mycobacterium* sp was isolated from a pyogranulomatous cellulitis in a cat.

For QA purposes, the section participates in the IFM proficiency testing program for veterinary microbiology and the three Leptospira MATs and culture of *Mycobacterium bovis* (the cause of bovine tuberculosis) are part of ANQAP proficiency testing.

Parasitology

Submissions 206

- Identification of parasites in aquaculture species continues to be an important part of the work in the Section as is the movement testing for liver fluke in horses and cattle.

- There were a number of submissions of maggots for screw-worm fly exclusions. None of the maggots were identified as larvae of the screw-worm *Chrysomya bezziana.*

- A number of ticks found on cattle and horses were the ornate kangaroo tick *Amblyomma triguttatum ornatissimum.*

- Fixed blood smears submitted as part of NAQS surveillance activities in East Timor showed *Trypanosoma evansi* parasites, the cause of Surra, in cattle and a dog.

The Section participates in a faecal egg count proficiency testing program run by Agriculture WA.

Serology

Submissions 276

Submissions from sentinel cattle for bluetongue ELISA testing were the biggest group at 50%, followed by Johne's disease quarantine submissions (20%), diagnostic submissions (8%) and export submissions (3%). Export submissions usually consist of serum samples from many animals requiring more than one test. The eight export submissions to this Section generated 3463 tests.

- A bovine calf and a young buffalo reacted to the pestivirus antigen detection ELISA presumably confirming their status as persistent virus carriers. Such carriers can cause significant reproductive losses when they infect non-immune animals in the early stages of pregnancy.

Eight tests were conducted in the Section as part of ANQAP proficiency testing.

Clinical pathology

Clinical chemistry

Submissions 115

Diagnostic submissions comprised 73% of the total followed by surveillance submissions 24%.

Haematology

Submissions 162

Diagnostic submissions comprised 54% of the total followed by surveillance submissions 26%.

The Section participates in the Royal College of Pathologists of Australia haematology quality assurance program.

Urinalysis

Submissions 42

Submissions from private practitioners on a fee for service basis were 83% and submissions for diagnostic purposes from production animals were 17% of the total.

Water microbiology

Samples Darwin 5453 Alice Springs 2624

Most samples come from drinking water supplies and are subjected to three individual tests to determine whether or not the water is potable.

SUBPROGRAM: Virology

PROJECT: Diagnostic Virology

Project Officers: **L. Melville, N. Hunt, R. Weir, M. Harmsen, S. Walsh, S. Davis and D. Flanagan**

Location: A.L. Rose Virology Laboratory, Berrimah Farm

Objective:

Provide of an accurate, efficient and reliable veterinary virology service to support diagnostic, regulatory and research programs in livestock health and production.

Background:

The diagnostic virology service comprises both virus isolation and identification and serology. An increasing number of virus detection tests based on polymerase chain reaction (PCR) have been introduced to supplement conventional isolation techniques.

Results:

During the year 147 submissions were received for diagnostic virus isolation, electron microscopy or PCR. Bovine ephemeral fever (BEF) virus was isolated from cattle. A flavivirus was isolated from a kangaroo. A total of 240 submissions were received for diagnostic serology, including 19 for export testing. A further 60 submissions were received from NAQS and other surveys with 79 submissions from research projects.

An increasing number of samples associated with aquatic animals were received during the year including 227 fish samples for nodavirus PCR and 607 prawns and 50 crabs for white spot PCR.

Export testing consisted of 1,702 cattle sera for enzootic bovine leucosis (EBL), 59 horse sera for equine infectious anaemia (EIA), 4 horse sera for Hendra virus and two sheep and 24 cattle sera for bluetongue serotypes.

The Australian national quality assurance program provided quality assurance tests for agar gel imunodiffusion tests for EBL, BVD, EIA, BEF, epizootic haemorrhagic disease, bluetongue and Aino. Serum neutralisation tests were performed for IBR, bluetongue, BEF, Akabane and Aino. Haemagglutation inhibition tests were performed for Newcastle disease virus.

A total of 24,951 serological tests were performed during the year.

PROJECT: National Arbovirus Monitoring Program (NAMP)

Project Officers: **L. Melville, N. Hunt, M. Harmsen, R. Weir, S. Walsh, D. Flanagan, G. Bellis and S. Davis**

Location: BHF, BARC, DDRF, KRS, VRRS, AZRI, Rockhampton Downs, Mt Sanford, Inverway, Helen Springs, Hayfield

Objectives:

Support trade by providing information to meet Australian Quarantine and Inspection Service (AQIS) requirements for export protocol negotiation and certification.

Provide dynamic surveillance for bluetongue early warning in the northern bluetongue endemic area to detect any new viruses or vectors entering Australia and monitoring any southern spread.

Control important insect-borne endemic disease by monitoring for endemic virus activity and the insect vectors which transmit them.

Background:

NAMP is an integrated national program jointly funded by industry and governments to monitor the spread of economically important insect borne viruses of livestock and their insect vectors.

Method:

Monitoring is achieved by using sentinel herds at various sites around the Northern Territory, which are bled at regular intervals and tested for antibodies to a number of viruses. At BHF, weekly blood collections are taken and virus isolations performed. Monthly light trap collections of insects are also made at each site.

Results:

1. Sentinel herd serology and virus isolation

Beatrice Hill Farm
A total of 265 viruses were isolated from the following groups:

Bluetongue	type 1	Sept - May	79
Palyam		Nov - March	11
EHD	type 5	Sept - May	43
EHD	type 7	Sept - May	19
EHD	type 8	Oct – May	10
Ungrouped/untyped			103

Monthly serology also indicated Akabane activity from August – November and May. BEF activity was recorded in October, November and February – April. EHD activity occurred from September to May and Palyam from November - March.

Berrimah
Monthly serology indicated the following activity:

Bluetongue	All months except September and December
Akabane	September - November, January
BEF	August – September, March - May
Palyam	November – January, April
EHD	October – January, March - April

14 bluetongue type 1 isolates were made.

DDRF
Monthly serology indicated the following activity:

Bluetongue	All months except August, September, February and April
Akabane	July, October, November and January.
BEF	July, January – May
EHD	October - December
Palyam	October – February

Four bluetongue type 1 and 2 EHD type 2 isolates were made.

KRS
Monthly serology indicated the following activity:

Akabane	July, August, November - February, May
BEF	February, April
Bluetongue	September, January - April
EHD	March, April
Palyam	November – April

Six bluetongue type 1 and 1 EHD type 5 isolates were made

VRRS
Monthly serology indicated the following activity:

Akabane	July – November, January, April
BEF	March, April
Bluetongue	April – June
EHD	April - June
Palyam	December, March, April

Two EHD type 5 isolates were made

Mt.Sanford
Serology indicated activity of Akabane in October, BEF in May, bluetongue in January and Palyam in March – May.

Inverway
Serology indicated activity of Akabane in April – May, BEF in May and Palyam in May.

Rockhampton Downs
Serology indicated activity of Akabane, BEF and Palyam in March.

Helen Springs
Serology indicated activity of Akabane, BEF and Palyam in April and June.

Hayfield
Arbovirus activity detected included Akabane in October, December and April, BEF in April, bluetongue in October and April and Palyam in October and April.

AZRI
The only arbovirus activity detected was BEF in April.

2. Entomology

C.brevitarsis was found at all the northern sites and a single insect was collected at Rockhampton Downs in October, the first time it has been found at this site. A single insect was again collected at Mt Sanford in February. *C.actoni* was limited to BHF, BARC, DDRF, KRS and VRRS and *C.fulvus* to BHF, BARC and DDRF. Small numbers of *C.wadai* were found on one occasion at BHF and BARC.

A single isolation of *C.actoni* was made at Hudson Creek, the Darwin port monitoring site.

PROJECT: Monitoring for Murray Valley Encephalitis (MVE) and Kunjin Viruses for Territory Health Services

Project Officers: **L. Melville, N. Hunt, S. Aumann and N. Cox**

Location: Darwin, Katherine, Tennant Creek, Alice Springs, Gove

Objective:

Detect flavivirus (MVE and Kunjin) activity through poultry sentinel flocks which are bled monthly and tested for antibodies to these viruses.

Background:

Sentinel chickens are used to monitor flavivirus activity in Australia. Currently 26 flocks are maintained in the north of Western Australia, eight in the Northern Territory, nine in New South Wales and 10 in Victoria. The aim is to provide early warning for the potentially fatal disease in humans caused by the viruses MVE and Kunjin.

Results:

Sentinel flocks were located at Leanyer, Howard Springs, Beatrice Hill Farm, Katherine, Tennant Creek, Alice Springs, Ilparpa swamp and Gove. Seroconversions to MVE were widespread in the north occurring at:

Gove in April
Howard Springs in June
Katherine in May

Seroconversions to Kunjin occurred at Gove in April and May and at Katherine in May.

PROJECT: The Duration of Viraemia in Cattle Following Natural Infection with Bovine Ephemeral Fever (BEF) Virus

Project Officers: **L. Melville, N. Hunt, S. Davis and S. Walsh**

Location: BHF, BARC, DDRF, and A.L. Rose Virology Laboratory, Berrimah Farm

Objectives:

Monitor natural BEF infections of cattle to provide additional data on the duration of viraemia as detected by virus isolation and Polymerase Chain Reaction (PCR).

Investigate whether a carrier state is established following natural BEF virus infection by re-testing cattle with a known history of previous infection.

Background:

Bovine ephemeral fever is an inflammatory disease of short duration (“three day sickness”) caused by a rhabdovirus – the BEF virus. Previous work has shown that the duration of viraemia is short. In 1996 PCR for the detection of BEF virus was developed at the A. L. Rose Virology Laboratory. This proved to be a more sensitive method for detection of the BEF virus. This project enabled more extensive testing of naturally infected animals to both confirm the limited period of viraemia and to validate the BEF PCR under field conditions. Biosecurity Australia provided funding for the work.

Method:

Between October 2001 and May 2002, 133 cattle at three different locations, (Berrimah Farm, Beatrice Hill Farm and Douglas Daly Research Farm) were monitored for infection with BEF virus. Weekly blood samples were collected from each animal during the time when BEF virus was active. Serum neutralisation tests (SNT) for BEF were performed on these samples to determine when infection of an individual animal occurred. Virus detection tests, both isolation and PCR, were carried out on sequential weekly blood samples collected around the time of seroconversion.

The presence of a carrier state following natural infection with BEF virus was investigated by re-testing animals with a known history of previous infection. Virus detection tests, both isolation and PCR, were carried out on 83 animals infected between two and eight months earlier.

Results:

During the observation period, 57 animals were initially identified as sero-converting and having samples suitable for viraemia testing. From these animals, BEF virus was isolated from six blood samples. BEF virus was identified by PCR in 35 blood samples. Virus was only identified in one sample from any individual animal, indicating that the period of viraemia was less than 13 days. Virus could not be identified in weekly blood samples from 22 animals, indicating that the period of viraemia in these animals was less than seven days. Subsequent titration of the neutralising titre showed that only 54 animals had confirmed sero-conversions. When this group of animals was considered the relative sensitivity of the BEF PCR and BEF isolation was 65% and 11%, respectively.

Thirty of the animals in which BEF virus was identified were sero-negative at the time the virus was present. In five animals, low levels of neutralising antibody were present at the time virus was detected.

Virus detection tests carried out on 83 cattle previously infected with the BEF virus were negative, confirming that a carrier state does not exist.

PROJECT: Bluetongue Survey

Project Officers: L. Melville and D. Pinch

Location: Tennant Creek and Katherine regions

Objective:

Provide scientifically defensible evidence for the location of the bluetongue surveillance zone in the Northern Territory, Queensland and WA.

The 2003 bluetongue surveillance zone for the Northern Territory was to be proposed by 31/12/2002.

The 2004 bluetongue surveillance zone for the Northern Territory will be proposed by 31/12/2003.

The 2005 bluetongue surveillance zone for the Northern Territory will be proposed by 31/12/2004.

Background:

NAMP sentinel herds are sparsely distributed in northern Australia and limited serological samples are collected for other purposes. Defining the limits of the free zone is therefore difficult and often based on historical data that may not accurately reflect the two-year monitoring program required by the OIE.

This strategic annual seroprevalence survey for antibodies to bluetongue virus (BTV) in cattle in the Northern Territory, Queensland and the Pilbara region of Western Australia is being carried out with the support of Meat and Livestock Australia. It is a three-year project, and began in mid-2002.

Results:

2002 Survey
Cattle on three properties in the bluetongue surveillance zone (February 2002 version) and on six properties within 100 km of the northern border of the bluetongue surveillance zone were sampled (northern Barkly Tableland and southern Katherine regions). Evidence of bluetongue virus infection was found on eight of the nine properties, including all three properties in the bluetongue surveillance zone (February 2002 version). This is further south than initial expectations.

There are eight types of BTV that may be found in the Northern Territory. Testing initially involved a broad-spectrum test for evidence of any BTVs, then more specific tests for the type of BTV if the sample was positive to the broad-spectrum test. Most of the positive samples were due to BTV type 1.

Property	BTV Zone (Feb. 2002 map)	No. tested	No. positive to both test types	Prevalence range (95% CI*)
1	Surveillance	81	4	1.4 - 12.2
2	Surveillance	87	14	9.2 - 25.8
3	Surveillance	80	7	3.6 - 17.2
4	Possible transmission	60	18	18.8 - 43.2
5	Possible transmission	67	10	7.4 - 25.7
6	Possible transmission	60	1	0.04 - 8.9
7	Possible transmission	60	5	2.8 - 18.4
8	Possible transmission	83	1	0.03 - 6.5
9	Possible transmission	66	0	0.00 - 5.4
Total		**644**	**60**	**7.2 - 11.8**

* 95% confidence interval

A teleconference of the national arbovirus monitoring program technical group was held in mid-December 2002. Results from this survey were discussed, and new zone boundaries were proposed for Biosecurity Australia to endorse. These boundaries take into account the results of the survey in Queensland and Western Australia. The current bluetongue surveillance zone map is available at: www.namp.com.au .

Survey plan - 2003
This year the properties to be surveyed are located on six north south transects. This will provide better information on the southern limit of bluetongue virus infection. At the end of June 2003, six properties had been sampled. Results will be collated at the end of 2003.

PROJECT: Investigating Bluetongue Virus Persistence in Cattle

Project Officers: L. Melville, N. Hunt, S. Davis and R. Weir

Location: Beatrice Hill Farm and A.L.Rose Virology Laboratory, Berrimah Farm

Objective:

Determine if bluetongue virus (BTV) is present in skin biopsies taken at various times during and after natural infection with the strain of virus circulating in the 2002-2003 wet season.

Background:

In 2003 a paper was published claiming that infectious BTV could be recovered from ovine skin biopsies more than nine weeks post infection. The finding of BTV in the skin of sheep infected nine weeks previously recalls the regulatory problems that were caused by previous reports (ultimately retracted) describing persistence of virus in a “persistently infected” bull. Such reports cause concern because acceptance by regulatory agencies may lead to reintroduction of international regulations banning movement of sheep and cattle with antibodies to BTV.

Method:

Cattle skin biopsies and blood samples were collected weekly from 16 animals naturally infected with BTV1. The blood samples were processed for virus isolation by embyronated chicken egg (ECE) inoculation and for serology by BTV cELISA and BTV1 virus neutralisation. A total of 171 skin biopsy samples were collected and cultured in the presence of IL2 and epidermal growth factor (EGF). Sampling commenced either during viraemia or up to seven days after the last isolation of BTV1. Weekly sampling continued until 42-90 days and monthly sampling to 102-150 days after the last isolation. Skin biopsy cultures were harvested 7-10 days after processing and held at –80^{o}C prior to virus isolation by ECE inoculation.

In five of these infected cattle lymphocytes were harvested from blood samples collected during viraemia to 28 days after the last isolation of BTV1. Lymphocytes were isolated through Nyco-Prep and co-cultured in the presence of IL2 and EGF with a primary bovine skin fibroblast cell line. The skin fibroblast cells were previously shown to support BTV1 growth. Co-cultures were harvested at seven days and processed for virus isolation by ECE inoculation.

Results:

BTV1 was isolated from all animals and serology confirmed infection with BTV1. BTV1 virus was not isolated from the skin biopsy cultures or from the lymphocyte/skin fibroblast co-cultures. These results show that there is no evidence of persistent BTV infection of lymphocytes in naturally infected cattle and BTV cannot be isolated from cultured skin biopsies from these animals.

HORTICULTURE

PROGRAM: The Vegetable Industry

PROJECT: Bamboo Research 2002-03

Project Officer: **M. Traynor**

Location: CPHRF and two grower sites

Objectives:

Trial irrigation and fertiliser inputs and scheduling for optimum shoot production for D. asper and D. latiflorus conducted on established planting at CPHRF and two grower sites.

Investigate thinning rates on grower sites with D. asper and D. latiflorus in relation to shoot size and yield.

Correlate leaf nitrogen levels with shoot sap nitrate levels to develop a simple nutrient monitoring system for growers.

Background:

The Horticulture Division of DBIRD together with the Central Queensland University is participating in a three year ACIAR (Australian Centre for International Agricultural Research) funded project titled "Improving and maintaining productivity of bamboo for quality timber and shoots in Australia and the Philippines". Although this project includes research on timber production, the Division will concentrate its involvement on the production of quality vegetable shoots.

Method:

Research is being conducted on the two species identified as having strong potential as vegetable shoot producers. These are *Dendrocalamus asper* and *Dendrocalamus latiflorus*. Along with the established trial planting at CPHRF, the farms of the two largest commercial producers of these two species were selected as additional trial sites. The producers are Mr. Richard Kingsley of Bamboo Planet Earth Pty Ltd (D.asper) and Mr Phil Vivian of Pal Enterprises (D.latiflorus). All experiments on the three trial sites are fully randomised with three replicates. Treatments combine irrigation, fertiliser and thinning trials for the purpose of defining management practices for optimum shoot yield and quality. For details on these experiments refer to the 2001-02 Technical Annual Report.

Progress of Research Work:

This report covers the progress of the second year of the project. All experiments were established on the three trial sites before the start of the 2002 dry season. Irrigation systems to satisfy the requirement of the experiments were established and monitoring sites were installed in March 2002. After sprinkler flow tests were completed, the irrigation treatments commenced in May 2002. Fertiliser treatments commenced after initial leaf and soil nutrient testing of all sites in October 2001.

The initial thinning of all treatments was done in late 2001 and the diameters of all remaining culms were recorded to test uniformity. Shoot selection to satisfy all thinning treatments was conducted during the 2001-02 wet season. The first thinning operation to maintain the specified standing culm densities was done in July 2002. Shoot selection was again conducted during the 2002-03 wet season. Fertiliser and irrigation response data was collected during 2002. The first shoot yield data was recorded during the 2002-03 wet season.

Fertiliser Use

The CPHRF and Vivian sites used a mineral NPK blend of 15:4:11. An organic product with NPK of 5:3:1.5 was used at the Kingsley site. Fertiliser treatments commenced after initial leaf and soil nutrient testing of all sites in October 2001. Fertiliser was applied to the 20^2 m irrigated area around each clump. In other words, the "per hectare" rate was applied on a per clump basis.

Monitoring

The fertiliser experiments are based on leaf nutrient analysis. The first fully expanded leaves were collected from branch terminals of one-year old culms. All monitoring was conducted on designated sample clumps from each replicate of each treatment and standardised on the 100% irrigation treatment. The following sampling strategy was followed before, during and at the end of the shooting season:

- Sample to determine nitrogen (N) content.
- Application of required rate of N per hectare.
- Sample after three weeks to measure the response.

Progress

Fertiliser treatments commenced after initial leaf and soil nutrient testing of all sites in October 2001. Where the leaf testing of the 100% treatment showed that 3% leaf N had been reached then no fertiliser was applied at that site. Although not presented in this report, the other major elements and trace elements were tested with each leaf sample. The planned testing of shoot sap nitrate to correlate with leaf nitrogen levels was not conducted during the 2002-03 shoot season, but is set as a priority for next season.

Nitrogen application and response for the CPHRF site showed the 100% N inputs over the past year had kept the leaf N level fairly constant until a pronounced drop in November. The leaf test in early October showed 3% N had been reached and therefore no N was applied, but with the onset of shooting the leaf N content dropped rapidly. It needs to be noted that the CPHRF site has by far the better soil structure of the three trial sites and also has a history of fertiliser application during a previous trial. Despite this the response to the two rates of nitrogen applied is expressed in the treatment yields.

At the Vivian site the N application and response data showed that leaf N levels were increasing dramatically from 25% through to 200% which is consistent with the yield increases across those treatments.

For the Kingsley site, the increasing rates of applied organic fertiliser had little effect on leaf N levels over the past year. The N in organic fertiliser must be decomposed by microbes (mineralised) before it can be taken up by plants. This process releases ammonium ions into the soil. If the roots or rhizome of the bamboo require N then the ammonium form of N will move to those parts of the clump. In contrast, when the nitrate form of N used on the other sites enters the plant it is immediately translocated to the leaves. This could help explain why the leaf N shows minimal response at this site while the response within the treatment yields is strong.

Irrigation

All irrigation treatments are based on mean monthly daily evaporation replacement. The irrigated area was 20 m^2 around each clump.

Monitoring

All treatments were monitored twice weekly with tensiometers at 20, 40 and 80-cm depths and once a week with the Diviner Moisture Probe to 1 metre depth. All water inputs were metered and recorded. Tensiometers measure the soil water potential or the energy required for roots to remove water from the soil. Maintaining the tensiometers within their working range of 0 to 80 cb has been difficult in poorer quality soils with low water holding capacity. The Diviner measures volumetric soil water content (VSWC) at 10-cm increments and monitoring sites require no maintenance.

Progress

Irrigation treatments commenced in May 2002 and interpretation of the data for the Diviner Moisture Probe is discussed for each trial site. Data is the average of three replicates and depths of 10, 20, 30, 60, and 100 cm of the soil profile were selected for close examination. Total profile water to 60-cm depth for all sites was also examined.

For the CPHRF site the drought and the 50% treatments show very similar VSWC throughout the dry season and all depths remained below wilting point for CPHRF soil. Only when 100% water was started on the drought treatment at the start of October did the shallow depths climb above wilting point. The 50% treatment did not reach those levels until the onset of heavy rain in February. For the 100% treatment it is clear where the watering began in early May after the dry down following the wet season. The shallow depths remained above their wilting points and fairly constant until late September when plant water use increased significantly. This reduction in water content continued until late October when rainfall events began to influence the monitoring. This water use is also noted in the 50% treatment to a much lesser extent. An interesting observation from this data is that there appears to be little or no water use by irrigated clumps over most of the dry season. This supports the belief that the clumps are essentially dormant during that period.

For the Vivian site there appears to be little difference in VSWC between the 50% and 100% inputs and the total profile water of both treatments remained much the same throughout the year. A small increase in water use can be seen around the end of September.

At the Kingsley site the 50% treatment was very dry at 10, 20, 30 and 60-cm depths throughout the dry season and the 100% treatment held considerably more water at the shallow depths during this period. Water use can be noted on both treatments around mid to late September. Although the difference is not great, the 100% profile consistently held more water.

Thinning

The first thinning operation to maintain the specified standing culm densities was done in July 2002. During the shoot harvest of 2002-03 the designated number of shoots were left in each clump to grow into culms. There is now two generations of experimental culms in each thinning treatment with their own colour identification marking.

Shoot Yields

When assessing yield data from the 2002-03 shoot season, a couple of points need to be noted. Plants on all three trial sites are only around four years old and may take several more years to reach their managed yield potential. Of the two species being researched only *D. latiflorus* produced shoot quantity of a marketable size. Experiments have been running for only one year and require a minimum of three years to be effective. The data is yet to be fully statistically analysed, but the results show some interesting trends.

Shoot harvest commenced in early October 2002 and finished in late March 2003. Harvests were conducted twice a week to ensure that shoots were within the accepted height to base diameter ratios of 2:1 and 3:1. Shoots were then trimmed ready for market before each shoot was weighed, measured and recorded. Data from the three sites is discussed separately.

CPHRF Site (*D. latiflorus*)

At this site the 100% fertiliser rate produced more shoots than the 25% rate throughout most of the harvest period and the higher rate produced more shoots early in the season. With the irrigation treatments the total yield appears similar between the 50% and 100% inputs, although the higher rate resulted in earlier shooting compared with the other treatments. The droughting treatment has run for only one dry season and will require at least another year to confirm these results. While total yield seems comparable, it appears that dry season droughting delayed the start of shooting by several weeks compared with irrigated clumps. Planned measurements of dry season transpiration and photosynthesis of treatment clumps at CPHRF in 2003 will help explain these results.

Vivian Site (*D. latiflorus*)

This site includes a 200% fertiliser treatment, which clearly produced many more early shoots and easily surpassed the total yields of the other treatments. In the same areas the 100% rate out performed the 25% rate. With the irrigation experiments no earlier shooting of the 100% treatment was evident at this site. Yields over the shoot season appear similar for both treatments. In the first year of trials it was not expected that the thinning treatments would have any significant effect on yield. The higher early yields of the 222 treatment could be attributed to the fact that only two shoots need to be left to grow into culms. The longer-term effects of thinning are of most interest.

Kingsley Site (*D. asper*)

For the fertiliser experiments the increase in yield from the 25% treatment through to the 200% treatment is evident mainly in the second half of the shoot season. Early shooting associated with the 200% rate at the other sites has not occurred at this site. With irrigation at this site the higher yield of the 100% watering is clear and earlier shooting is very evident compared to the 50% treatment. As with the Vivian site, the 222 thinning treatment has yielded more shoots than the higher culm density treatments. Only the continuation of these treatments over several dry season thinning operations will fully test their effects on shoot yield.

General Comments on Experiments

The 100% irrigation treatment failed to provide the VSWC that was expected. This could be a result of unusually high evaporation in 2002 or the bamboo water requirement was underestimated in evaporation replacement calculations.

The yields from the 25% fertiliser treatment are obviously low and not likely to increase with continuation of that rate.

High rates of pre – shooting fertiliser seems to promote earlier shooting, a higher percentage of larger shoots and higher shoot number. Application as early as September could be worthwhile.

Studies of bamboo root distribution and seasonal activity would help with irrigation and fertiliser management.

Acknowledgements:

This research is partially funded by ACIAR and commissioned by the Plant Sciences Group at Central Queensland University. Thanks to commercial collaborators Richard Kingsley, (Bamboo Planet Earth) and Phil Vivian, (PAL Enterprises), the DBIRD Chemistry Laboratory for leaf nutrient analyses and the DBIRD biometrician, Mark Hearnden.

PROJECT: Asian Vegetables – Industry Development

Project Officers: **G. Walduck, M. Traynor, J. Thomas, G. Owens, K. Bui (Industry based IDO) and Dr. B. Thistelton (Entomology)**

Location: CPHRF

Objective:

Support the Asian vegetable industry and its organisation.

Introduction:

This industry is centred near Darwin with 50+ small growers producing a range of Asian vegetables for local and capital city markets. The main thrust of work in this area this year has been in supporting the grower organisation and the Industry Development Officer (IDO) and supplying information on better practice farming techniques through growers meetings, field days and printed material.

Major Activities and Outcomes

Assist industry and NTHA with preparation of a funding application for HAL/industry funded IDO. The application was successful and Kim Bui was appointed as vegetable IDO and is operating very effectively. DBIRD Horticulture staff are on the Management Committee together with industry representatives.

Prepare, print and distribute an English/Vietnamese publication of all current DBIRD printed information on Asian vegetables. This was a joint DBIRD/IDO project and has been distributed to NT growers and interstate vegetable IDOs. Feedback indicates that it has been well received by growers and interstate recipients as well.

Prepare colour posters of pest and diseases of Asian vegetables in Northern Australia. This project involved Horticulture and Resource Protection staff and the results will be released in October.

Prepare and present current information sets on agricultural pesticides for use in the NT, at a series of evening meetings in conjunction with the Asian Vegetable Growers Association. This was supported by best-practice information and spray technology field days on growers' properties. Current feedback indicates a raised awareness of pesticide issues, especially IPM and residues. There has even been a request for the information from the Victorian Asian vegetable producers for the information.

Conduct a *Fertigation Field Day* at CPHRF supported by evening sessions at the Asian Vegetable Growers Association monthly meetings. This ongoing program appears to have improved understanding of basic fertiliser practices and reduced reports of nutrition related problems.

Distribution of planting material of Japanese taro (small corm taro) to interested growers to test under commercial conditions. Small-scale trials conducted at CPHRF as part of a national project on Japanese taro indicated the best quality was produced in the NT. As a result, small quantities have been released to interested commercial growers for commercial testing.

Organise meeting of researchers on Asian vegetables at Gosford NSW. This is a RIRDC sponsored project and brings together all workers currently working on RIRDC funded projects once a year to improve communication and exchange ideas and results. Horticulture NT organised the 2002-03 meeting which was held at Gosford NSW and was attended by workers from most States and Territories. Proceedings of the meeting will be distributed soon.

Conduct pilot business skills workshop to improve bookkeeping skills of Asian vegetable growers. This was organised and run in conjunction with Horticulture DBIRD, the vegetable IDO and a private bookkeeper. It was funded by BU$LINK. Participation was below expectation due in part to other unexpected commitments of members at that time of the year. There is still interest and another school may be conducted at a different time and in a different format.

PROGRAM: The Mango Industry

PROJECT: Crop Forecast Evaluation – 2002 Mango Season

Project Officer: **G. Owens**

Location: Top End

Objective:

Provide the mango industry with a crop forecast to enable better planning of logistics and marketing.

2002 Forecast

The mango season crop forecast was generated using the same method as in 2001. The response to the flowering surveys increased and more trees were represented in the final forecast. It was one of the coldest dry seasons on record with Darwin recording 84 days where the minimum temperatures were less than 20°C. The build-up was intensely hot with maximum temperatures averaging over 40°C during the later period of fruit maturing.

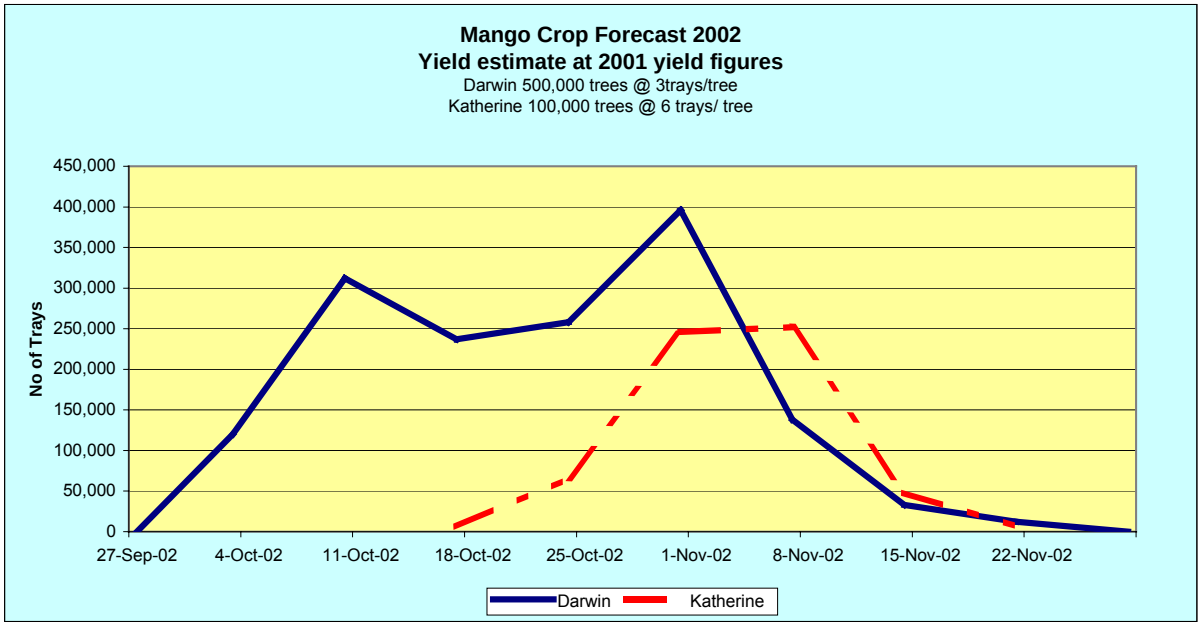


Figure 1. Mango crop forecast 2002

The forecast generated in August 2002 indicated an extended harvest period for Darwin mangoes as a result of two main flowering peaks. It predicted the harvest starting in late September and going into November. Katherine would begin as Darwin production went through a second peak and then last into mid November.

An attempt was made to estimate gross volumes by generating a forecast for the amount of fruit that may be produced if the trees on average yielded as much fruit as the year before. This prediction is shown in Figure 1.

The following messages from the forecast were given to growers pre-season:

- Substantial production starting from the first week of October.
- Potentially large volumes for five weeks.
- Highlighted the overlap of late Darwin and early Katherine fruit.
- Have the crop logistics ready for the first week in October.

2002 Mango Crop Flow

The harvest period in Darwin was shortened by the unusual weather conditions and the earlier fruit did not display the characteristic external maturity indicators.

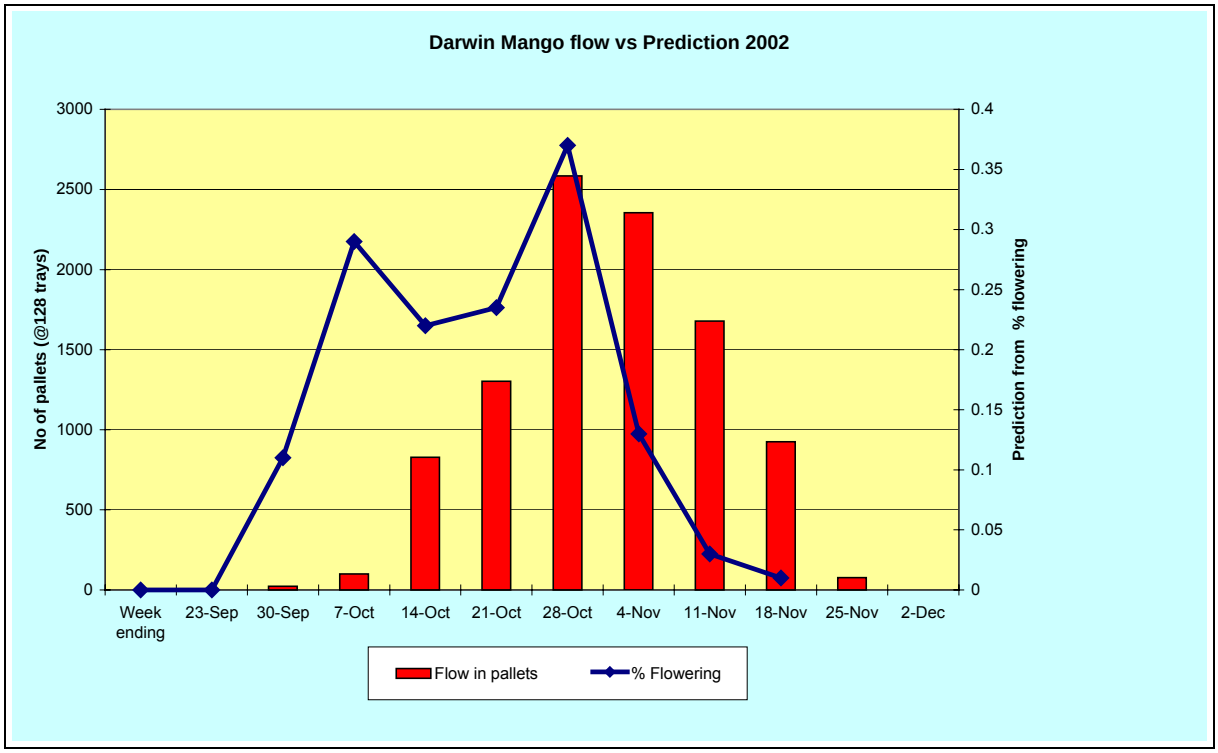


Figure 2. Katherine outcomes

The prediction for Katherine was very close to the actual outcome. The one-week delay between fruit being ready for picking and being dispatched is about normal. A much larger sample of the total trees from Katherine was included in the flowering survey. Katherine normally has colder dry seasons. Anything under 12^{o}C is considered 0 in heat units; therefore it was not as greatly affected by the cold. There was more concentrated flowering in Katherine. Labour was an issue at peak demand.

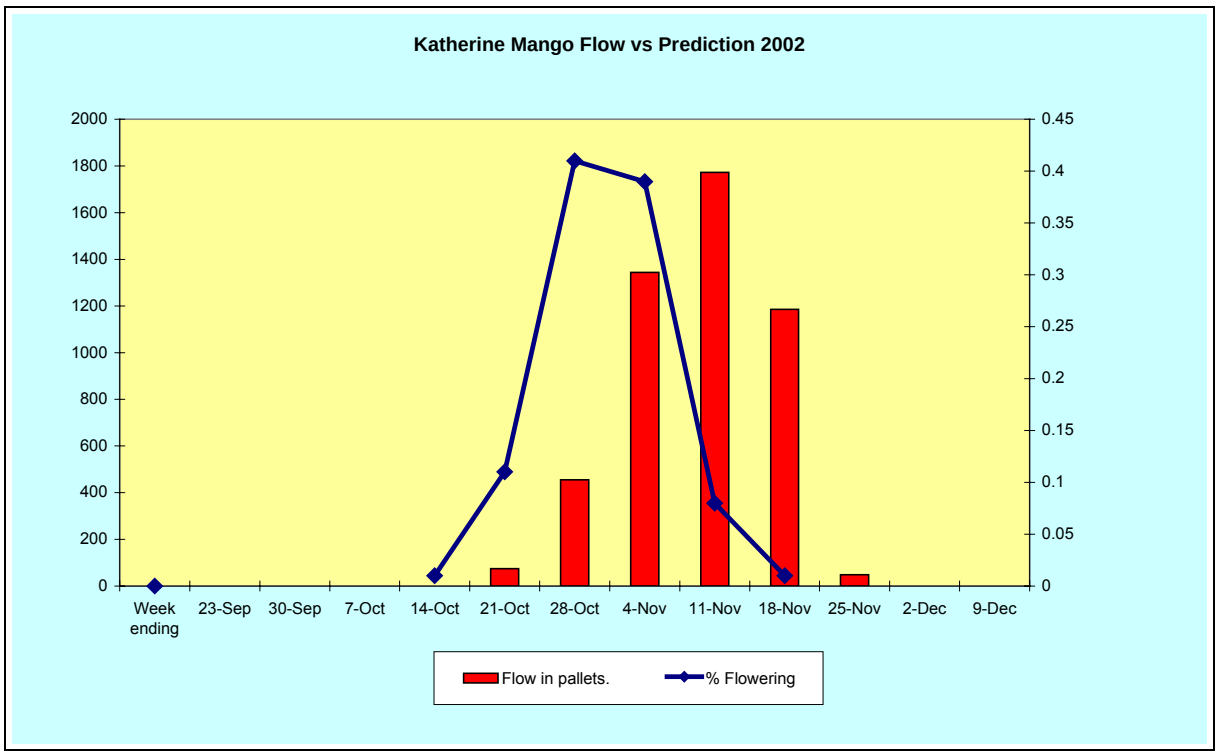


Figure 3. Katherine mango flow compared with prediction - 2002

Darwin Outcomes

The Darwin prediction was approximately seven to 10 days too early. The Darwin harvest was more concentrated than predicted. Cold weather pushed the fruit from the early flowering back into late October. External maturity indicators were unreliable, as the fruit was narrow and beaky, but it was recording an adequate dry matter for harvest when cut. The intense heat of September and October caused earlier ripening of fruit from the later flowering and pushed it back into early November. The transport system held up well. The cool chain system was still under intense pressure during peak periods. Availability and retention of field and shed labour was a major issue during the peak demand period.

Lessons from 2002

Rework the forecast in late August / early September to take into account the key fruit maturing period, especially when weather conditions vary greatly from seasonal averages.

Keep all transport and labour hire representatives in the information loop. A number of pickers arrived early and could not afford to stay until the fruit was ready to harvest.

PROJECT: The Australian Mango Breeding Program

Project Officers: V. Kulkarni[1], I. Bally[2], S. Blaikie[3] and P. Johnson[4]

Location: CPHRF, Darwin, Southedge Qld and ARS Kununurra WA

[1] NT Department of Business, Industry and Resource Development
[2] Queensland Department of Primary Industries
[3] CSIRO
[4] WA Department of Agriculture

Objective:

Develop improved mango cultivars for the domestic and export markets through a hand-pollinated hybridisation program. It was recognised that each region may have some differences in objectives but many objectives would be common to all regions.

The specific aims of the project were initially to:

- Develop hybrid cultivars with superior fruit quality and production characteristics that are suited to the various mango-growing regions in Australia.
- Generate a minimum of 50 individual hybrids for each parental combination over three years.
- Generate some quantifiable data on the inheritance of characters and the combining ability of specific mango cultivars.

The broad objectives of the program have been to develop cultivars with the following characteristics:

Dwarfness – Reduced tree vigour and size is desirable, as Kensington Pride is over-vigorous at the expense of cropping in the hotter growing districts.

High productivity – Mangoes are generally low producers when compared with other species such as avocado or stone fruit, and among mangoes, Kensington Pride is a low producer, on average producing between 5 to 10 tons per hectare.

Fruit size (400 g)– The current domestic market has a preference for fruit in the range of 325 to 400 grams, making up trays of 18 to 20 fruit.

Fruit colour (good blush) – Both Australian and export markets prefer fruit with high blush.

Retention of the KP flavour – The Australian market and many export markets recognise the unique flavour of Kensington Pride as the cultivar's greatest asset.

Reduced sap burn and post-harvest problems – One of the greatest post-harvest fruit quality problems with Kensington Pride is skin browning and sap related injuries. Any reduction in this problem will significantly increase fruit quality.

Longer shelf-life – The shelf-life of Kensington Pride is relatively short; prolonging storage time will improve access to export markets.

Reduced physiological disorders in the fruit – Physiological disorders in the current varieties pose a major fruit quality problem that is hard to control using management techniques. Susceptibility to specific forms of disorder is cultivar related.

Early maturing – Cultivars that produce fruit earlier than Kensington Pride have a distinct market advantage, especially in the Northern Territory.

Reduced susceptibility to disease – In certain mango growing districts pre-harvest diseases such as bacterial black spot seriously limit the production of late cultivars. A reduction in susceptibility to this and other diseases will improve productivity and fruit quality.

Program of Activities:

The Australian National Mango Breeding Program is a long-term project that has been divided into four phases of development.

Phase 1, Hybridisation

The hybridisation phase was completed in 1997. A total of 1800 hybrids were generated.

Phase 2, Initial selection and characterisation

The second phase of the program involves the initial screening of hybrids for desirable types and collecting data on the specific characteristics for inheritance analysis. This screening is being done using the progeny planted at the two sites, Southedge and Coastal Plains. Southedge was chosen because of its cooler night temperatures and elevation, which stimulated the hybrids to flower at a younger age than in warmer areas. Detailed evaluation commenced in the 1999-2000 season and will continue until 2006. However, most trees will have been evaluated by 2003.

Phase 3, Detailed regional testing

The third phase of the program involves the planting of replicated trials in several agro-climatic regions to compare and evaluate the most desirable selections from the initial screening (Phase 2). Data obtained from these trials will be used to evaluate the commercial suitability of selections for the different growing regions in Australia and to prepare applications for Plant Breeder Rights.

The future of the Program was discussed in Darwin in November 2000, with all participating agencies. An agreement was reached in April 2001 on a set of core principles in respect of a pathway to commercialisation of potential new varieties coming out of the Program. These principles are set down in the following section.

Australian Fresh Mangoes (AFM) were selected as the commercial partner for the project.

Phase 4, Market testing

The fourth phase of the Program consists of market testing and commercialisation of potential hybrids. This will involve testing in domestic and export markets of commercial quantities of fruit produced in grower-cooperator orchards. It is expected that contracting with grower cooperators for this purpose will commence in the second half of 2003. A possible first release of a commercial cultivar could happen as early as 2006.

Results During 2002-03:

Commercial Agreement with AFM

Negotiations with AFM have been protracted and have resulted in the delay or postponement of some project activities due to financial constraints. The main effect was a delay of 12 months in establishing trees on grower cooperator's farm. A conditional agreement with AFM was signed in late May 2003, with the expectation of the full agreement to be signed by 30 September 2003. The full agreement is conditional on the success of an HAL project to manage the further testing and commercialisation of the hybrids. The proposed project will run for six years with a budget of $100,000 a year. This will free up resources to commence a program of in-depth data analysis and post harvest evaluations and market evaluations/commercialisation of the best hybrids.

HAL Project Proposal

Since the signing of the conditional agreement with AFM in May the technical committee members have been in regular contact with each other and with AFM to discuss the future progress of the project and the development the HAL project proposal.

Future milestones for the project will be incorporated in the HAL project proposal. They will include activities such as establishment of hybrids on grower-cooperator farms, establishing a data recording system and market testing of the selected hybrids.

Replicated trials of the best hybrids will be established on agency Research Stations where management of the hybrids can be fully controlled. Data from these trials will be used for detailed genetic analysis of the new hybrids, for registration with Plant Breeders' Rights and to develop information packages on the performance and management of any hybrid for commercial release.

Hybrid Evaluation and Selection

The most promising hybrids have been selected on the basis of a combination of characteristics, from observations made at the three sites where the material has been planted. The selection has an initial bias towards fruit attributes for which the most information has been gathered, and the elite hybrids have been placed in two groups (A and B+) according to their inferred potential.

"A" group hybrids have potential for commercial release and are included in replicated trials currently planted at Southedge and Coastal Plains, with additional trials to be planted at Kununurra and Coastal Plains. There are currently six trees in the "A" group and they will be offered to growers-cooperators for regional evaluation.

"B+" group hybrids have been selected as having a highly desirable combination of fruit characteristics, however they require further evaluation to confirm their commercial potential. Trees in this group will be retained for further evaluation as single tree selections.

Heritability Evaluation of Mango Characteristics

Continue the evaluation of fruit and tree characteristics of hybrids planted on Southedge and Coastal Plains Research Stations. The data will be added to the heritability analysis of these characteristics.

Of the 1800 hybrids generated in the project, 400 remain to be assessed at Southedge Research Station. The remaining 218 of the hybrids assessed in 2002-03, were re-assessments of the "A" and "B" groups and a subset of hybrids in a range of families assessed to examine the consistency of performance between years.

At Coastal Plains Horticulture Research Farm, 634 hybrids were assessed in the 2002 season taking the total number to 1,063. Analyses of these data will give valuable information about the genetic effects of each family and the reliability of performance between seasons.

Initial estimates of heritability were calculated for some of the fruit characters in a subset of the families and were presented at the international conference in Brazil in September (see attached abstract). Conclusions from the analyses were that fruit weight, width, shape, ground skin colour and pulp depth have high heritabilities – all above 0.60. These characters are likely to be reflected in progeny. Also, there were indications that if red or burgundy blush was a feature of either parent then this character was also likely to be shared by the progeny. Similarly, the Kensington Pride flavour of the male parent was regularly detected in the progeny. Further, more comprehensive analysis of the existing data, including all families, will be required to confirm these initial findings and to expand the application of the study.

"A" group replicated trials - The two new "A" group hybrids selected in the 2001-02 season will be added to the replicated trial blocks at Southedge and Coastal Plains Research Stations. An additional replicated trial of the "A" group hybrids will be planted at the Frank Wise Research Farm in Kununurra.

During the 2002-03 season's evaluations, one "A" group hybrid was demoted to "B^+" because of its large fruit size, pitted lenticel appearance and sunken stem end. One "B^+" group hybrid was promoted to group "A" because of its flavour and high yield.

The replicated trial at Southedge Research Station now contains all the current "A" group trees, a few "B+" group and parents of the "A" group. There is no room for the addition of more trees in this trial plot.

Four of the "A" group trees fruited in the Southedge replicated experiment for the first time in the 2003.

Replicated “A” group trials have been planned for Darwin and Kununurra. Propagation of hybrids for inclusion in these trials is currently under way.

Budwood supply scheme - A clean budwood scheme is being developed to initially establish a germplasm repository, supply the replicated trials and provide grower-cooperators with “A” group hybrids for regional evaluation. This scheme will then be expanded to ensure sufficient high quality certified disease free budwood is available of all varieties released to ensure the rapid uptake of the new variety by industry.

Propagation and multiplication of the “A” group hybrids has primarily been undertaken in Kununurra where a clean budwood orchard has been established. Some additional multiplication of budwood has also been carried out in Mareeba. Propagation of selected hybrids has also been undertaken at Katherine Research Station, which is a clean site for the NT. The protracted negotiations with AFM which prevented the distribution of hybrid budwood to grower-cooperators, have allowed the accelerated establishment of the clean budwood block at Kununurra, which now has 50 trees planted in the field of each “A” group hybrid. We are now able to supply adequate quantities of clean budwood to all grower-cooperators from this point forward. Extension of propagation in the NT will further accelerate generation of sufficient number of selected hybrids.

Post-harvest disease evaluation - Some preliminary disease screening of the “A” and “B” group hybrids and their parents will be carried out in the 2002-03 fruit season. Fruit rot will be the initial focus of this screening to determine if any significant disease resistance is present in the hybrids.

This activity was not carried out over the 2001-02 season due to budget restrictions.

Shelf-life evaluations - Preliminary shelf-life testing of the “A” group hybrids will be carried out in the coming season to identify hybrids with longer shelf life than the currently grown commercial varieties.

Shelf-life evaluations were not undertaken at Mareeba during the 2002 season due to restrictions on labour availability.

Market testing - If funding is available some sensory evaluation of the “A” group hybrids will be carried out in the major domestic and export markets. This information will highlight the particular requirements of various markets and give the breeding team some guidance in selecting hybrids for commercial release.

No formal market testing of the hybrids was undertaken over the 2002-03 season. However, Mr P. Johnson showed a few fruit of a couple of the “A” group hybrids from Coastal Plains to an English importing company during a visit to London in December 2002. The fruit was well received and the company wished to be kept informed of future evaluation of the varieties in the European market.

Security - Security recommendations and protocols will be drawn up for the breeding project to protect intellectual property and preserve commercial confidentiality. These will include recommendations for security on research stations and information release from the project

Progress has been delayed due to the protracted negotiations with AFM. Research station security is to be based on the Western Australian model.

Dr Vinod Kulkarni presented a paper titled *Inheritance of fruit characters in hybrid mangoes produced through controlled pollination* at the VII International Mango Symposium Recife, Brazil, in September 2002. An abstract is presented below.

Abstract:

Richard I.S. Brettell - CSIRO Peter R. Johnson - AgWA
Vinod J. Kulkarni - NTDBIRD Warren Müller - CSIRO
Ian S. E. Bally - QDPI

Mango fruit quality attributes have been evaluated in hybrids produced by the Australian National Mango Breeding Program. Since its inception in 1994 the program has generated more than 1800 hybrids from 33 parental combinations using controlled pollination methods. Characterisation of the fruit was carried out by assessing 24 internal and external attributes, and an estimate was made of the heritabilities of characters for which the data were either quantitative or were scored on an evenly

ordered hedonic scale. Analysis of the data indicated that many important fruit quality aspects such as fruit weight, fruit shape, ground skin colour, fruit width and pulp depth have high heritabilities, and can therefore be readily selected in a breeding program. For non-ordered traits scored in discrete categories (blush colour, bloom, lenticel colour, embryo type and flavour), an estimate was made of data consistency from multiple scores for individual hybrids at different times and locations. A relatively high consistency value was recorded for fruit flavour and in combinations involving Kensington Pride, between 24% and 47% of hybrids were scored as having Kensington Pride flavour. The embryo type of hybrids was also recorded and the data are discussed in the context of polyembrony being controlled by a single dominant gene.

The full paper is available from Dr Vinod Kulkarni.

PROJECT: Improvement of Mango Productivity

Project Officer: V. Kulkarni

Location: Various

Objective:

Improve productivity in mango by understanding the key factors that affect it and by addressing limitations imposed by these factors.

Program of Activities:

1. Advise on improvement of flowering, fruit-set and other factors that impact upon production in the NT.

2. Conduct collaborative research with other organisations in several areas including flowering, which impact upon productivity.

3. Present research results at the VII International Symposium.

4. Present a keynote paper at the VII International Mango Symposium, Recife Brazil 2002.

Mango Flowering – Theories and Practices

Abstract:

While identity of the flowering factor(s) continues to be a mystery, erratic flowering also continues to be a serious limitation in mango production. Concepts have been developed to attribute flowering to environmental, genetic, hormonal and nutritional factors. The three factor hormonal theory of flower promoter, flower inhibitor and bud activity in the floral cycle has however drawn significant support. What does this theory mean? What information do we have on the flower promoter and inhibitor? Can we explain the normal observations with the help of this hypothesis? Taking the hormonal theory as a central theme, is it possible to link the theories together? A wide range of natural and imposed stress conditions and horticultural practices are reported to induce flowering. Some treatments are reliable in some situations but not in others. Can we explain these practices, the anomalies associated with them and other orchard situations with a holistic approach? How can this knowledge be used in developing strategies for various climatic regions? The review addresses some of the practical issues in the light of the theoretical background of the 'Tri-factor hypothesis'.

The full paper is available from Dr Kulkarni.

PROJECT: Collaborative Research Project with the University of Florida

Project Officers: V. Kulkarni and T. L. Davenport*

Location:

*Tropical Research and Education Centre, University of Florida, USA

Objective:

Characterise the floral stimulus in mango

Introduction:

Dr Vinod Kulkarni was invited by the University of Florida to participate in a collaborative project at the Homestead Campus.

Flowering is a very important event in the life of higher plants because it is the first step towards sexual reproduction of the species. The subject is of obvious importance from commercial and scientific points of view. In spite of over a century of research in the area, it is not clear what actually causes the change of the meristem from vegetative to reproductive. The idea of a unique flower hormone, floral stimulus or flower promoter ('Florigen') has been postulated in herbaceous annual plant species in which flowering can be induced by subjecting them to a specific environment such as day length. It has been shown that flowering in these species is regulated by a flower promoter synthesised in leaves in specific day length conditions. The role of light in these cases is independent of their photosynthetic role. The flowering promoter can be transmitted from an induced donor to a receptor in non-inductive day length. In some cases, grafting a single leaf or a part thereof can induce flowering in receptors in non-inductive conditions. For a long time, similar evidence was lacking in tree fruits. It was believed that flowering in trees is controlled by a wider array of situations and therefore, may not be following the pathway of a hormonal flower promoter. Most tree crops follow an erratic flowering habit leading to 'on' and 'off' years. Precise reasons for this erratic behaviour are not known. It is ironic that for work on flowering, physiologists have preferred annual species to trees in spite of the fact that the problem is more serious in trees. The reasons for this are more of convenience and short flowering cycles. It is more convenient to work with small annual plants on benches than large trees in the field.

Some of the strongest support for the hormonal concept in trees came from the graft transmission studies in mango by Kulkarni (1986, 1988 and 1991). Using the multi flowering off season cultivars as donors of the floral stimulus, the off season flowering habit could be readily transmitted within a few days to the receptor shoots of single flowering cultivars grafted onto the off season cultivars. Using this approach Kulkarni clearly demonstrated the crucial hormonal role of mature leaves in the floral cycle and their inhibitory role in the vegetative cycle. He also demonstrated the need for an active meristem in the floral cycle for flowering to occur. Dr Kulkarni proposed in 1989 the hormonal concept of flower promoter, flower inhibitor and bud activity as three crucial factors influencing flowering in mango. This concept was later supported by some work at the University of Florida by Dr Davenport in 1995.

Although there is now adequate circumstantial evidence to support the hormonal nature of the flowering promoter, it has not been possible to extract it and establish its identity. Its identity is however no panacea. It will be of equal importance to understand some characteristics of the promoter such as its longevity, how far it can travel from the source and impact of environmental conditions, especially temperature, on its persistence. This information will be of considerable interest not only from a scientific point of view but also from the commercial aspect. It will be useful in developing management techniques to manipulate flowering and tree canopy. I was invited by Dr Davenport to participate in a project on physiology of flowering in mango and characterisation of the flower promoter. That visit and study was mainly aimed at understanding the nature of the flower promoter and quantitative requirement for flowering including:

- Longevity of the promoter in the leaf.
- Extraction of the promoter.
- Development of an in-vitro bioassay technique for the promoter.
- Identification of differences in leaf extracts in an induced state and in a vegetative state.

Method:

Material and techniques varied with each experiment. Only general issues are discussed here. Details of methodology are separately discussed in each experiment.

The experiments were divided into three categories based on the experimental material and environmental conditions.

Field experiments: These were carried out in Krome and Acosta Orchard nearly 25 km from the TREC Homestead. Two prominent Florida cultivars were used in these experiments, Keitt and Tommy Atkins. All trees used were grafted trees on a uniform rootstock of bearing age (10 years in the Acosta and 15 years in the Krome Orchard).

Growth chamber experiments: Experiments in a controlled environment were carried out in growth chambers. Temperature and humidity could be controlled in these chambers with a computerised system.

Laboratory experiments: These were conducted in Dr Davenport's laboratory at TREC Homestead.

Results and Discussion:

Experiment 1. Number of leaves required for flowering

Earlier work by Kulkarni (unpublished) had shown that there was variation among cultivars with regard to number of leaves required for flowering. With the final objective of developing a bioassay to test flower-inducing property of leaf extracts, it was necessary to know this requirement for the two cultivars used for the present investigations (Keitt and Tommy Atkins). In other words, having established that leaves are the origin of the florigenic promoter, varying the number of leaves on the shoot (from six to 0) may reveal threshold level required for flowering. Further, this requirement may also be influenced by the flowering condition of the shoot just prior to the treatment. This experiment was conducted on two sets of plant material in cultivars Keitt and Tommy Atkins. In the first set shoots were selected before flowering had occurred on the shoots (‘resting' shoots). Any shoot showing bud activity at the terminal was debudded so as to prevent any buds, which had already differentiated before commencement of the experiment. In the second set, flowering shoots were deblossomed before applying the treatments. These were designated as 'flowering'.

The treatments were applied between mid January to early February 2001. The actual date for each set was:

- Tommy Atkins resting: 12 January - 14 January 2001 (Acosta Grove)
- Tommy Atkins flowering 1 February - 2 February 2001 (Krome Grove)
- Keitt resting: 11 January 2001 (Krome Grove)
- Keitt flowering: 16 January 2001(Krome Grove).

Minimum temperatures (typically occurring at night) were inductive during this time period (Figure 1).

Branches with large number of terminal shoots were selected (generally 20 but in some cases, more than 20). The selected branches were girdled to isolate and prevent flow of flower promoter from the rest of the tree. Each shoot tip was then debudded or deblossomed as the case may be by pinching or cutting off the new growth. At the same time, all shoots on a replicate branch were defoliated to retain 0, 1, 2, 4 or 6 leaves. Ten replicates were used for each treatment so that there were four sets in the end (Tommy Atkins resting and flowering and Keitt resting and flowering) with five leaf number treatments in each. Each branch was tagged and labelled with codes L (for leaf number experiment, T or K for the cultivars Tommy Atkins or Keitt), F for flowering shoots used for deblossoming. Resting buds were not marked but were identifiable by the absence of "F" and 0, 1, 2, 4 and 6 to denote the number of leaves left on each shoot on the branch. Roman numerals were used for the replicates (I to X).

Results: Data was collected after the new growth appeared on the shoots and was clearly distinguishable. These were categorised as Generative (shoot bearing only flowers and no leaf), Vegetative (only leaves), Mixed (bearing both flowers and leaves) and Transitional (shoot starts as one type and changes at some definite point to the other type). Rare occurrence of chimeric shoots (a mixed shoot with leaves on one side and flowers on the opposite side), was also noted.

Data on proportion of generative, mixed, vegetative and transitional growth from different treatments is summarised below.

Table 1. Flowering and vegetative response to number of leaves/ receptor shoot in the floral cycle in Keitt and Tommy Atkins mangoes

1. Keitt resting

	0 leaf	1 leaf	2 leaves	4 leaves	6 leaves
% Generative	5.9	93.5	99.1	99.9	100
% Mixed	0.9	0.7	0.4	0.1	0
% Vegetative	93.2	5.8	0.5	0	0
% Transitional	0	0	0	0	0

2. Keitt flowering and deblossomed

	0 leaf	1 leaf	2 leaves	4 leaves	6 leaves
% Generative	27.4	99.5	99.6	99.7	100
% Mixed	2.8	0	0.1	0	0
% Vegetative	69.8	0.5	0.3	0.3	0
% Transitional	0	0	0	0	0

3. Tommy Atkins resting

	0 leaf	1 leaf	2 leaves	4 leaves	6 leaves
% Generative	8.3	99.3	99.6	100	100
% Mixed	0.5	0	0	0	0
% Vegetative	91.2	0.7	0.4	0	0
% Transitional	0	0	0	0	0

Tommy Atkins flowering and deblossomed

	0 leaf	1 leaf	2 leaves	4 leaves	6 leaves
% Generative	14.1	97.3	98.8	99.8	100
% Mixed	1.5	0.5	0.3	0.2	0
% Vegetative	84.4	2.2	0.9	0.	0
% Transitional	0	0	0	0	0

Discussion:

In both cultivars, total defoliation resulted in significant reduction of flowering response. There was however, some flowering in both cultivars when the total defoliation treatment was applied at the peak of the flowering cycle when shoots were deblossomed. This could be attributed to the small quantity of the promoter that could be persisting in the phloem at the time of defoliation. In resting shoots, comparatively fewer numbers of shoots in 0-leaf treatment flowered. Interestingly, only one leaf was adequate to induce over 90% flowering in all cases and there was no significant difference in one, two, four or six leaf treatments. It must be noted that these experiments were conducted just at the time of flowering or during the flowering cycle and it would be a good idea to repeat the experiments in future by applying the treatments much earlier – at least two months before the first onset of flowering. Unpublished work by Kulkarni (1984) had shown significant variation in the Indian mango cultivars in respect of number of leaves required for flowering when shoots were cinctured and defoliated approximately two months before flowering. Regular bearing cultivars such as Banganpalli and Neelum flowered readily with just one pair of leaves whereas erratic and alternate bearing cultivars such as Dashehari and Langra required at least five pairs. This experiment supported the regular bearing habit of both cultivars Keitt and Tommy Atkins.

Experiment 2. Longevity of the flower promoter

Earlier studies had shown that the floral stimulus in mango is synthesised in mature leaves. It travels in the phloem and on reaching an active meristem, induces flowering. Graft transmission studies by Kulkarni in 1987 have also shown clearly that the promoter is labile. Thus if a meristem (apical bud) is not active during the duration of supply, it escapes the stimulus and fails to flower. Later, on resuming activity after the floral cycle, such dormant buds will eventually produce only vegetative flush.

This experiment aimed at establishing the time of persistence of the stimulus in the meristem. Detached shoots from the tree were used as experimental material for this experiment. The longevity of the promoter could be examined by allowing the receptor apical meristem to activate at different times before harvesting from the mother tree. Bud activity in the apical meristem could be induced by defoliation of the receptors in the floral cycle. By leaving the defoliated shoots on the tree for varying number of days before harvesting, a significant variation could be achieved in time taken for bud burst after detachment. Thus, defoliated shoots left longer on the tree had a significantly accelerated bud activity than shoots defoliated on the day of harvest. The detached shoots were then allowed to grow in cool or warm growth chambers.

Details of the experiment are given below.

- Cultivars: Keitt and Tommy Atkins
- Growth chamber temperatures: warm (25^0C at night and 30^0C during the day) or cool (10^0C at night and 25^0C during the day).
- Pre-treatment of the shoots before harvest: Negative day number of initial deblossoming and defoliation: -14, -12, -10, -8, -6, -4, -2, 0.
- Day of bud break: Positive day number on which pinhead size active buds were first observed on the shoots.

The actual steps involved were as follows:

Flowering shoots on Tommy Atkins trees were selected and deblossomed and defoliated at two days interval for 14 days after commencement of the first treatment. The day 14 treatment was on January 22, 2001 and day 0 was on February 5, 2001. At least 30 shoots were to be made available in each treatment on the final day at the time of harvest. All shoots were harvested on day 0 (February 5) and brought to the growth chamber facility at TREC. Shoots were then inserted in perlite in plastic containers. The containers were then left in a large plastic trough with water. The shoots received a constant supply of water absorbed by the perlite through the holes in the plastic containers. The treatment shoots were grown in two temperature conditions described above in two growth chambers. Observations were recorded on each shoot on the date of bud break and then subsequent growth (vegetative, mixed or flowering). The experimental number of days is summarised in the calendar chart.

The results of the experiments are summarised below.

Number of days of defoliation and bud activity: As seen from the chart below, the number of the shoot was left on the tree after defoliation had a significant impact on the time taken for bud break. The longer the shoot was left on the tree, the earlier was the bud break. In fact several shoots in D -14 treatment were already breaking on D 0 on which all shoots were harvested. As expected, there was a gradual reduction in bud activity, least being recorded in D 0.

Relationship between time taken for bud break and flowering: It was clear that those buds which broke early after separation flowered readily whereas delay in break resulted in weakening of the generative process with fewer panicles from each shoot and eventually production of only vegetative shoots from the buds.

Temperature conditions after separation and flowering: Temperature conditions to which the shoots were exposed after separation had impacted both on rate of bud break and persistence of the response. Bud break was much faster in the warm chamber as compared to the cool chamber. As a result of this, shoots in the warm chamber flowered earlier but the process was completed much earlier than in the cool chamber.

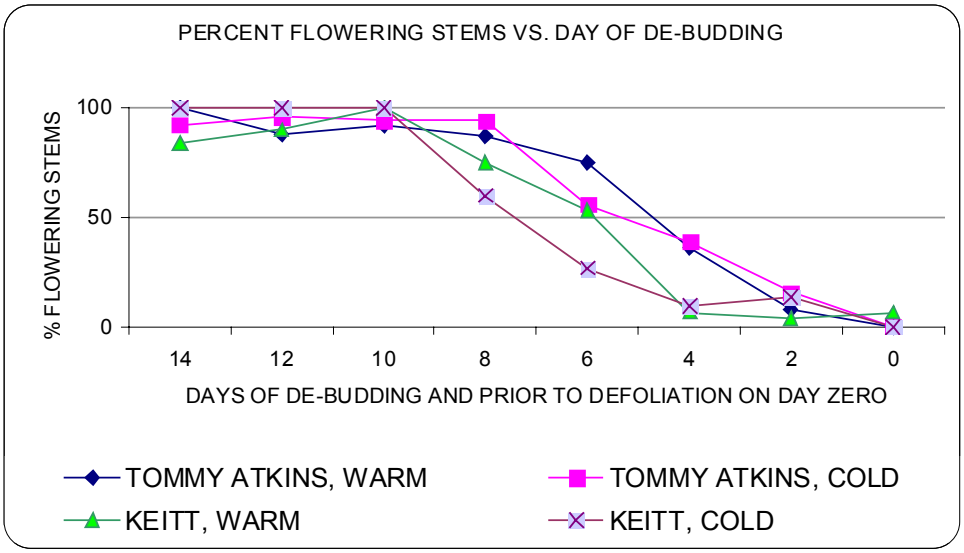


Figure 1. Final summary of flowering activity in relation to number of days for bud activity

Experiment 3. Movement of the floral promoter over distances

This experiment was designed to investigate distances travelled by the flower promoter. The cultivars used were Keitt and Tommy Atkins. Trees in flower were selected. Branches were selected so that there were at least six shoots, one leafy donor and the others defoliated receptors. Three types of branches were selected. (1) Forked with donor (leafy) shoot at the apex of one of the branches, (2) Linear, with the donor shoot at the apex of the branch, (3) Linear, with the donor shoot at the base of the branch. All branches were girdled below the lowest shoot or below the fork to isolate from the rest of the tree for the phloem supply. All shoots except the donor were simultaneously defoliated. In order to vary the quantity of supply of flower promoter two leaf number treatments were used on the donor shoot, one with five leaves and the other with 10 leaves. Thus, the layout was:

Cultivars: Keitt and Tommy Atkins

Leaf numbers: 5, 10

Treatment dates: For Keitt: 17-19 January, 2001; For Tommy Atkins: 24 –25 January 2001

Number of replicate branches /treatment: 10

Example of labelling pattern for each replicate DK10 IV (Distance experiment, Keitt cultivar, 10 leaves on the donor, replicate number 4). All distances were measured from the source shoot.

Forked and linear branches were used in the distance experiment

Results: All receptors with leafy donor flowered readily irrespective of the location of the donor shoot or the number of leaves on each donor. It was clear in this experiment that five leaves were adequate to induce flowering in all receptor shoots irrespective of distance. Thus there was an optimum supply of the flower promoter to induce flowering over the distances and receptors targeted in the experiment. Although the 10 leaf treatment recorded more flowering shoots than the five leaf treatment, the difference was not significant and certainly not a case of dramatic decline in the number of flowering receptors. The impact of distance therefore could not be examined. It must be noted that this experiment was commenced around the same time as Experiment 1 on number of leaves required for flowering. It would be ideal to repeat the experiment with only one leaf on the donor.

Experiment 4. Bioassay for the flower promoter

Bioassay experiments aimed at extracting the flower promoter from the phloem exudate and testing its flower-inducing property on a receptor in non-inductive conditions (higher temperature). They also aimed at developing an effective delivery system for the exudate (or any test solution) to the target site (apical meristem). All bioassay experiments were conducted in cv Tommy Atkins.

Number of leaves required for extraction of the exudate to be applied to a single receptor: It was clear from experiment 1 on the number of leaves required for flowering that only one leaf was sufficient as a source of the floral promoter for a shoot. It would then be adequate to put into the target receptor one leaf equivalent exudate (preferable two) every day until termination of the experiment. The assumption was that an adequate quantity of the promoter would be retained during extraction, application and uptake by the receptor after the daily application. In the final experiment, two-leaf equivalent exudate was applied daily.

Receptors: Two types of material were considered. (1) Detached shoots from field or from marcots in growth chambers. (2) Intact on potted marcots in growth chambers.

Detached shoots: These needed to be prepared in such a way as to ensure absence of any promoter. Two sources were used namely shoots from marcots in a non-inductive warm growth chamber and shoots from the field which were simultaneously girdled and defoliated. Receptors from the growth chamber were used for preliminary experiments whereas shoots from the field were used for the final run. For shoots from marcots, mature terminal shoots were defoliated to activate the buds and shoots were harvested with the first signs of bud activity. The protocol for shoots from trees in the field was:

Day one - Branches on trees from Krome grove were girdled and shoots were simultaneously deblossomed and defoliated. The apex was given a clean cut to remove any undeveloped but differentiated buds.

Day five or six - When buds were showing signs of activity, they were harvested in plastic bags and brought to TREC. They were immediately inserted in 6 " containers in 50/50 perlite: vermiculite mixture and kept wet in water in a plastic tub.

Day six or seven - The day following harvest: Commencement of application of test extracts/exudates was commenced and was continued until visual identification of the apical meristem

Intact shoots on trees: Mature shoots on marcots from the warm (25/30°C) growth chamber were used. Marcots were completely defoliated to prevent the possibility of the flower inhibitor from the leaves in non-inductive conditions.

Donor leaves as a source of the flower promoter: Mature leaves from the cold chamber plants were harvested in the afternoon (around 4 p.m.). Leaves were immediately plunged in 1 mL distilled water in 1.5 mL cuvettes (two leaves /cuvette) through a hole made in the lid of the cuvette large enough to pass the two petioles of the leaves (one at a time) so that the base of the petiole rested in water. These cuvettes were then lowered to rest on the rim of 1-cm glass test tubes, which in turn were placed in a plexi-glass container with a lid. The walls of the container were lined with wet paper

and approximately 2 " water was maintained in the plexi-glass container to create high humidity which would prevent excessive loss of water from the cuvettes.

Technique of Application of the Exudate to Receptors

Preliminary attempts to apply 1 mL of the exudate to the receptor through the scar cavity left after pruning the terminal bud or through xylem by dipping the shoots in the exudate in a test tube were unsuccessful. A negligible quantity was taken through the dip technique in a small number. Application to the terminal bud through an extension trough at the tip of the shoots was the most successful technique. A small paraffin trough (approximately 2-cm high) was prepared over the shoot apex so as to accommodate the quantity of the exudate (1 mL). The base of the paraffin was wrapped tightly on the stem so that exudate applied in the trough did not leak through. Test solution could be left overnight for gradual uptake by the apex. This technique was tested in detached shoots as well as on shoots on intact plants. Uptake by intact shoots was more rapid and predictable than in the detached shoots. In some cases, more than 75% of the exudate was left in the trough in detached shoots even after 24 hours. It was therefore decided to use shoots on intact marcots as the receptor material.

Concentrating the exudate in a speed vacuum drier: In order to further expedite the process of uptake of the exudate, concentrating the exudate was achieved in a speed vacuum drier, Speed Vac Plus SC 110 A (Savant USA) for approximately 45 minutes on low heat. Volume of the exudate could be substantially reduced to 0.5 mL with this method without affecting the temperature of the exudate.

Etiolation was tried as a technique to prevent any loss of flower promoting activity as a result of exposure to light. This was achieved by applying aluminium foil 'hats' over the troughs and leaving the shoots covered except for diffused light at the time of application in the evening.

A Typical Protocol for Bioassay with Detached Shoots

9 February 2001: Prepared several shoots on cv Tommy Atkins in Krome Grove. Branches were girdled and shoots deblossomed and completely defoliated above the girdle.

16 February 2001: Harvested shoots and transferred to plastic bags, brought to TREC and inserted in 6" containers in vermiculite: Perlite mixture (50:50) in greenhouse. Buds were active at the time of transfer.

17 February 2001: Application of exudate commenced using the para film trough receptor. Exudate was from cold chamber leaves and was concentrated in a 'Speedvac'.

Application of Leaf Extracts to Test Receptors

18-27 February: Application of the exudate to the receptors.

Only part of the exudate was taken up. Application was however continued until 27 February in spite of the problem in uptake. Left over exudate was discarded every day. Application was discontinued after 27 February. None of the receptors had shown signs of flowering and turned out to be vegetative.

Bioassay with Attached Shoots

Material:

Receptors - Tommy Atkins marcots from the warm chamber had receptors with several shoots. Preliminary tests were conducted on uptake of distilled water using the para-film trough technique and were found to be satisfactory.

Treatments and number of receptor shoots: All receptors were defoliated and receptor shoots de budded before commencement of application of exudates.

Control in warm chamber – six shoots.
Exudate from donor and in warm chamber – eight shoots.
Exudate from donor in cold chamber – eight shoots.
Exudate from cold chamber in warm chamber receptor etiolated – six shoots.
Etiolation alone in warm chamber – five shoots.

Application commenced on 27 February 2001. The standard protocol of extraction, concentration in vacuum and application late in the evening in diffused light was followed every day until 14 March.

Results: No flowering was observed in any receptor.

Discussion:

Although it was disappointing that we did not succeed in extracting the flower promoter, the technique of para-film trough seems to hold promise for the future. There is perhaps a need to look at the timing of extraction and application. One more suggestion would be to use the technique on species, which need fewer inductive cycles such as day length sensitive species requiring only one or two cycles of short days. It may also be worthwhile to develop techniques to take phloem sap from intact trees in floral cycles as a source of the flower promoter. Clearly, a lack of an effective transfer is a limitation in plants.

Experiment 5. Chromatographic assessment of differences in leaf extracts in inductive and non-inductive temperature conditions

This experiment was the last one to be initiated and could only be started before my scheduled departure from the USA. The main objective was to explore the possibility of finding any differences in chemical composition of the leaf extracts from the cold chamber (flowering) marcots and those in vegetative condition from the warm chamber.

Method: HPLC was used for chromatographic assessments. Leaf extracts were taken following the same technique as used for the previous experiment (Experiment No 4).

The basic protocol was extraction of phloem exudate, bulking up sample from 12 leaves, concentrating it and running a measured quantity to establish leaf equivalents. The sample prepared for injection onto the C18 column was filtered through a 0.2 μ syringe filter, diluted 1:10 in milli Q water and injected into an equilibrated milli Q water or TEA buffer (4 mM adjusted to pH 3.39) phase at two minutes on the chromatograph.

At minute 15, a 60-minute ramp to 100% methanol was begun. Peaks and retention times were plotted on the graph.

Results: As mentioned earlier only a couple of runs could be made with the warm chamber and cold chamber leaf phloem exudates. There were no significant differences between the two except that on one occasion, one peak was broader in warm than in the cold chamber source. It should be noted that these were very preliminary attempts and there is a need to standardise techniques including extraction techniques. This line of approach will be continued by TREC for further investigations.

References:

Kulkarni, V.J. (1986). Graft-induced flowering and fruiting in the mango (*Mangifera indica* L). *Journal of Horticultural Science,* 61: 141-145.

Kulkarni, V.J. (1988). Further studies in graft-induced off-season flowering and fruiting in mango (*Mangifera indica* L). *Journal of Horticultural Science*, 63: 361-367.

Kulkarni, V.J. (1991). Physiology of flowering in mango studied by grafting. *Acta Horticulturae*, 291: 95-104.

PROJECT: Secondment of a Horticulture Officer to the NT Mango Industry Association (NTMIA) 2002-2003

Project Officer: **D. Hamilton**

Location: NTHA Office

Objective:

David Hamilton was seconded to the NTMIA (NTHA office) for 12 months commencing on the 28 May 2002. The NTMIA agreed to supply office support, operating expenses and transport while David remained employed by the NT Government. The main objective of the secondment, as an Industry Development Officer (IDO), was to gain professional development while assisting members of the NTMIA in organising and coordinating programmed activities.

Programmed activities were developed and monitored by a management committee. The committee consisted of the seconded IDO, a Senior Extension Officer (DBIRD), two NTMIA representatives, (Darwin/Katherine) and the NTHA Administration Officer. Meetings were held on a monthly basis before the mango season started and then from time to time after the harvest.

Table 1. Summary of projects achieved with outputs and outcomes.

Project	Activities	Outputs and outcomes
Data base management	Phone survey	Members' details are up to date. Increased levy payments.
Technology transfer	IPM guide. Nutrition workshop. Soil and leaf sampling. Orchard spraying demo.	Publication -*Pests, Diseases & Disorders of Mangoes in the NT- An Illustrated Field Guide.* Skills base of growers improved.
Grower liaison	Addressing industry enquires.	Supporting information provided through local media, fax outs. Growers satisfied with outcome of query.
Best practice - harvest	On farm and packing shed participation and observation.	Report to NTMIA AGM. Information developed will be used to support a skill development program.
Endorsed wholesaler program	Application to wholesalers. Market visit and presentation to wholesalers.	Wholesalers are more aware of seasonal issues that growers face. Wholesalers are more aware of services provided by NTMIA & NTDBIRD. List of endorsed wholesalers provided to growers/packers. Grower/wholesaler relationships improved.
Quality out turn reports	Collect, distribute and address problem reports.	Most NTMIA members received at least 2-3 reports free. Effective monitoring tool for growers and packers. Report to NTMIA AGM
Market visit	Interview key people in Brisbane, Sydney and Melbourne markets	Report to NTMIA AGM Growers have greater awareness of supply chain issues. Growers have greater network of contacts.
Harvest office – address labour supply	Liase with stakeholders to address labour shortages.	Greater awareness between stakeholders of issues facing labour supply and its management. Labour shortage forum held with stakeholders Meeting minutes.
Code of Practice – commercial relationships between supply chain partners	Organise summit between stakeholders. Develop draft document.	Improved relationships between supply chain partners. Greater awareness of issues facing supply chain members. Consultative draft document for public comment completed.

Evaluation

A formal evaluation was carried out at the end of the secondment. Both the Board and the general membership considered the role of the IDO vitally important for the industry association. It needs to maintain a focus on key projects and continue its accessibility to the membership. The Association stated the need for continuing government support until such a time that it was capable of funding the position itself. At the end of the secondment the officer returned to DBIRD Berrimah but continues in the same role for the whole of the NT mango industry.

PROGRAM: The Banana Industry

PROJECT: Banana Tropical Race 4 Panama Disease Management

Project Officers: **M. Darcey, G. Walduck, C. Kelly and A. Daly (Plant Pathology)**

Location: CPHRF

Objective:

Discover and develop a commercially acceptable banana variety resistant or tolerant to Panama tropical race 4 disease for the NT banana industry and simultaneously develop field management methods to reduce the spread of the disease.

Specifically to:

- commission and operate a world class quarantine facility capable of undertaking secure research on *Fusarium oxysporum. cubense* - Tropical Race 4 [Foc4];
- locate and screen banana varieties for resistance or tolerance to Foc4 within the secure quarantine facility while ensuring no spread of Foc4 from the facility;
- test the commercial acceptability of any variety found resistant or tolerant to Foc4;
- develop and commercialise any resistant or tolerant variety found to be commercially acceptable;
- develop field management techniques aimed at reducing the spread of the disease;
- attempt to develop field techniques aimed at disinfesting currently infested areas.

Progress:

Construction of the Coastal Plains Banana Quarantine Station [CPBQS] was completed and officially opened on 2 July 2001.

During June and July the Coastal Plains Banana Quarantine Area (CPBQA) was planted with sacrificial plants and 14 test varieties introduced from overseas and the Queensland Department of Primary Industries.

Quarantine protocols for CPBQS and CPBQA were implemented on 22 August and officially proclaimed on 29 October 2002.

The CPBQA sacrificial plants were inoculated on 1 November 2001. They subsequently developed infection and successfully and evenly infected the site and subsequently the susceptible test plants were planted between them.

The operating protocols were externally audited on 7 November 2001 and have been internally audited twice. The system passed its second external audit in November 2002.

On 18 December 2001, the first external symptoms of FOCTR4 were observed on the Pissang berungan (Lakatan) sacrificial plants. The onset of symptoms in the sacrificial plants was rapid. First symptoms were visible within six weeks of inoculation and another six weeks from first symptoms to death. Within 26 weeks 95% of inoculated sacrificial plants died.

The causal organism was confirmed as FOCTR4 (VCG 2013012/16) by isolating it from plants showing Panama disease and conducting VCG and PCR tests at the Plant Pathology Laboratory, BARC.

Results from the first crop cycle confirmed the following:

Lakatan is much more susceptible than other varieties tested.

- Tissue cultured Cavendish (Williams) plants succumb to the disease much more quickly than plants planted as bits or suckers. This confirms earlier observations on Panama Temperate Race 4 in SE Qld.

- Cavendish is highly susceptible. FHIA25 is highly resistant and high yielding but is not acceptable as a dessert banana. Goldfinger is showing a degree of resistance. The seeded Malaccensis types have populations of both resistant and susceptible types and offer potential for breeding and genetic engineering in the future. Crossing of these types to produce seed for further use is under way. The results are summarised in Table 1.

Agronomic data on test plants has been recorded and reported previously.

The agronomic data on FHIA 25 is shown in Table 2.

Studies on rates of spread:

- Uncontrolled spread from a high inoculum source is being studied at CPBQA and preliminary results indicate a rapid spread with approximately 90% of test plants in immediately adjacent rows showing symptoms within 18 months of first symptoms. Surveys on a commercial property with an early detection and destruction program are showing very much reduced rates of spread over the same period at this stage. The data is not yet complete.

- Surveys of an infected commercial plantation with an early detection and destruction program indicate a strong seasonal trend with high incidence during the build-up and wet season. This confirms earlier observations.

A trial to test a range of biological agents potentially capable of slowing or suppressing FOCTR4 infection on Cavendish (Williams) is nearing completion and current indications are that none of the treatments have been effective.

Figure 1. FOCTR4 resistant variety FHIA 25 first ratoon bunch ready to harvest at CPHRF trial site

A project to assess host status of certain common weeds growing in the infected area at CPBQA has been undertaken as an honours project by Chelsea Hennessy of NTU in collaboration with CSIRO.

A second batch of eight new varieties has been established at CPBQA and is being tested. Two of these are promising in early assessments. Data from the first cycle will be available during late 2003.

New methods of treating initial infection sites are being tested now and results will be available in late 2003.

Changes in legislation based on current research and survey results are being prepared.

Table 1. Development of bananas with resistance to Fusarium wilt (Tropical Race 4) Proj. No. FR00043

Number of datum plants confirmed as severely infected by FOCTR4 at completion of plant crop cycle
[As per INIBAP guidelines and confirmed from lab test at harvest or by October 2002].

		Number of plants confirmed as severely FOC infected						Total ratable plants
Variety number	**Variety name**	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Replicate 5	Total	
1	Cavendish [Williams1017]	6	5	6	6	5	28	28
2	Cavendish [GCTCV119]	0	1	0	1	1	3	28
3	Goldfinger [FHIA 01]	2	2	3	2	2	11	29
4	FHIA 17 [944]	6	6	6	6	6	30	30
5	FHIA 18 [1033]	2	3	1	2	4	12	30
6	FHIA 25 [944]	0	0	0	0	0	0	30
7	High noon [SH3460.10	6	6	6	5	6	29	29
8	FOC susc.malaccensis 845	5	6	6	6	6	29	29
9	FOC susc.malaccensis 846	6	5	6	6	6	29	29
10	FOC susc.malaccensis 848	6	6	6	6	6	30	30
11	FOC resist.malaccensis 850	0	0	0	0	0	0	30
12	FOC resist.malaccensis 851	0	0	0	0	0	0	30
13	FOC resist.malaccensis 852	0	0	0	0	0	0	30
15	Pissang Berangan	6	6	6	5	6	29	29
	Rep. totals	45	46	46	45	48		

Notes

Treatments 2, 3, 5 contain some plants that are still free of FOC infection. Plant crop bunches have been harvested in all cases.
Treatments 8-13 [both resistant and susceptible Malaccensis types] cycle quickly and have produced two crop cycles to date.
1 October is 47 weeks after inoculation with FOCTR4 and is 69 weeks after planting.

Indications of susceptibilty from current data

Extremely susceptible [most died before bunch emergence] - variety 15
Very susceptible [most develop severe symptoms before bunch emergence, some died before bunch harvest] - varieties 1, 4 and 7 plus T/C Cavendish [Williams].
Susceptible [few plants showing symptoms at bunch emergence and most by bunch harvest] - varieties 8, 9 and 10
Slowly susceptible [not all plants showing symptoms at harvest] - varieties 2, 3 and 5
Potentially resistant [no symptoms to date] - varieties 6,11,12 and 13

Table 2. Agronomic characteristics of resistant variety FHIA25

Agronomic characters	**Plant crop cycle**	**Ratoon 1 cycle**	**Ratoon cycles 2-5**
Ave days from planting to shooting	348.3	n/a	
Days from bunch emergence to harvest	112	133	
Crop cycle (days)	459	349*	
Plant height at harvest (cm)	272	300	
Pseudostem girth at harvest (cm)	79.3	88.7	
Bunch weight (kg)	28.16	38	
Number of hands	10.83	16	
Number of fingers per bunch	204.16	310	
Av. finger weight (g)	119.67	103	
Indicative yield (tonnes fruit/ha/year)	27	43	40*
Resistant to yellow sigatoka	yes	yes	
Banana weevil borer feeding	yes	yes	
Potentially resistant to FOCTR4	yes	yes	
Market acceptability			
Acceptable as dessert banana	no	no	
Acceptable as cooking banana	yes	yes	
Acceptable as dried banana	possible	possible	
Skin appearance green/ripe	good	good	
Flesh appearance green	white	white	
Flesh appearance ripe	cream	cream	
Flesh texture ripe	firm/slimy	firm/slimy	
Taste as ripe dessert banana	soapy/bland	soapy/bland	
Taste and texture as dried banana	slightly chalky	slightly chalky	
Green life	as for Cavendish	as for Cavendish	

Hand and individual finger size and shape similar to average sized Cavendish * Estimate only

PROGRAM: The Citrus Industry

PROJECT: Evaluation of Navel Orange, Lemon and Mandarin Cultivars

Project Officers: I. Broad, the late N. Isgro, D. Salter and D. King

Location: Alice Springs Region

Objective:

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

Introduction:

The supply of navel oranges, lemons and mandarins to domestic markets is very limited during different periods of the year. For navel oranges, supplies are low between March and June; for lemons, between December and April; and for mandarins between January and March. The Queensland citrus industry is the first to supply early navel oranges for domestic consumption to replace Californian imports. Demand for lemons and mandarins is also strong while supplies are limited and prices are high from December to April. Studies on these fruits in the Alice Springs region have indicated that it may be possible to produce high quality, early maturing navel oranges. The potential for commercial production of high quality lemon and mandarin cultivars needs further evaluation.

Method:

Arid Zone Research Institute (AZRI) plantings

A trial plot of navel oranges and lemons was planted in 1997. The plot of navel oranges consists of three cultivars including Leng navel on Swingle, Washington navel on Citrange and Washington navel on Troyer Citrange. Two late maturing varieties have also been included. They consist of Barnfeild Summer navel on Trifoliata and Toc Summer navel on Citrange.

Lemon varieties consist of Fino, Verna, and Lisbon, all grown on Citrange rootstock.

Two years of data has already been collected from these trials. However, to make a complete assessment, research on these varieties will need to continue for a further two years. By 2005, enough yield information will have been gathered to accurately map the performance of individual cultivars.

A selection of mandarin cultivars was also planted in early 2000. These cultivars consisted of Ellendale on the rootstock Swingle, Ellendale on Troyer Citrange, Imperial on Sweet Orange and Imperial on Cleopatra. However, many of these were either damaged or destroyed by abnormally severe frosts during the 2002 winter period. Consequently half of the 20 mandarin trial trees at AZRI were removed. Replacements have been selected and will be planted out in the spring of 2003.

Varieties are assessed to determine which cultivars have the most potential for commercial production in Central Australia. Assessments will also be conducted to determine if fruit harvest times coincide with market demands and whether it would be possible to supply quality fruit when market supplies are limited.

Ti-Tree Research Farm (TTRF) plantings

A citrus evaluation trial was also established in 1999 at TTRF approximately 200 km north of Alice Springs. The varieties and rootstock combinations being assessed are Washington and Leng navel both grown on Troyer Cirtange and Rough lemon.

Lemon varieties include Eureka and Verna both on Benton Citrange and Fino on Troyer Citrange. Mandarin varieties include Imperial on rootstocks Cleopatra, Troyer Citrange, Swingle and Rough Lemon and Ellendale on Swingle. A tangelo variety, Minneola on rootstock Troyer Citrange, is also being trialled.

Method of Assessment

Each cultivar and rootstock combination is assessed on two levels. The first assessment is made on overall fruit quality. Five sample fruit from each tree are selected. The fruit is weighed; the diameter and rind are measured followed by a seed count. The fruit is then juiced and juice percentage is calculated. Finally, the juice is measured for Brix and acid levels. Results are then compared with the national standards to determine overall maturity. This process may be repeated up to three times to determine optimum maturity times for each cultivar.

The second level of assessment takes place during harvest. Fruit counts and weights are recorded and overall yields are calculated for each cultivar and rootstock combination.

Results and Discussion:

Maturity and yield data was not collected this season from any of the citrus varieties currently being assessed at AZRI. This decision was made after it became evident that both fruit numbers and overall fruit quality had been greatly affected by the frosts of 2002, and any data would have been inaccurate and would not fairly represent actual potential.

Soon after the frost damage had occurred a management strategy was set in place to try and prevent any slump in production lasting more than one season. The strategy was to remove all dead or damaged wood from trees, which in most cases meant reducing the size of the trees by almost half. This was primarily to promote new growth and to restructure the trees for production and management purposes. A fertiliser program was also implemented to ensure sufficient nutrients were being provided to trees during re-generation. This management strategy proved to be very effective in restoring trees to full health and it is expected that all affected trees will start a normal period of production this coming season.

The citrus plantings at TTRF are still in the early stages of development and require at least one more season of growth before any meaningful results can be obtained.

Pests and Diseases:

It became evident during last season that the Queensland fruit fly (*Bactrocera tryoni)*, if not appropriately managed, could have a serious effect on fruit quality and overall productivity. Since the discovery of the fruit fly appropriate methods of control such as bait sprays have implemented to prevent any damage this season.

The citrus leaf miner (*Phyllocnistis citrella)* was first detected at AZRI and TTRF last season at which time it was not considered to be a threat to either fruit quality or overall net productivity. Appropriate methods of control have been implemented to prevent an increase in citrus leaf miner numbers.

Evidence of fruit piercing moth (*Othreis* spp.) damage was found on some fruit from TTRF this season. However the moth is not considered a serious threat at this stage.

PROJECT: Industry Development Strategies for the Northern Territory Citrus Industry

Project Officers: M. Connelly, M. Hoult and C. Wicks

Location: Various

Objective:

Assist the Northern Territory citrus industry to develop and implement industry development strategies.

The Northern Territory Citrus Growers' Association's (NTCGA) Industry Development Plan

A working group of members of the NTCGA and DBIRD staff met for a strategic planning session on 16 October 2001. Dave Mundy and Liz Easton facilitated the meeting. The purpose of the plan is to identify the direction the NTCGA will take in the next five years by defining a vision statement and goals.

From this meeting, Version 1 of the NTCGA Industry Development Plan was developed and completed in June 2002 and was then circulated. In addition to the plan, which contained the industry goals, two background documents were prepared summarising a range of industry issues.

The vision statement developed at this meeting is "the Northern Territory citrus industry will have a cohesive and viable group producing volumes of quality fruit under our brand/logo for niche markets domestically and overseas".

This strategic plan was revised in June 2003. The following issues will be addressed:

- The updated plan identified areas requiring further work.
- Identifying new citrus scions and improved rootstocks for the Top End.
- Better agronomy for Top End citrus.
- Food safety requirements.
- Marketing of NT citrus.
- Industry development strategies.
- Cittgroup activities for NT citrus growers.

PROJECT: Management Strategies for Citrus in the Northern Territory

Project Officers: M. Connolly, A. Maddern and C. Wicks

Location: Various

Objectives:

Determine a range of management strategies for various regions.

Encourage adoption of management strategies by industry.

Assist in insect monitoring and encourage adoption of integrated pest management (IPM)

Several workshops were conducted to assist train citrus growers in insect monitoring and control. In May 2003, Megan Connolly conducted workshops on IPM in citrus in Darwin and Katherine. The Katherine workshop was significant in that a number of Kununurra growers attended.

Tree Management

In June 2003 a seminar and workshop on citrus management was conducted in Kununurra. A number of Katherine growers as well as two DBIRD representatives attended. The seminar was conducted by Dr. Andrew Krajewski and was entitled *Best management practices for production of high quality citrus.*

PROJECT: Improved Citrus Products for the Northern Territory

Project Officers: C. Wicks, R. Renfree and A. Maddern

Location: KRS

Objectives:

Identify cultivar/rootstock combinations suitable for both existing and potential markets when grown in various regions of the NT.

Optimise grower returns by producing fruit of the required cultivar and quality for the intended market.

Evaluate Mandarin Cultivars in the Top End – Katherine

Twenty-six mandarin cultivars grafted onto Swingle rootstock were planted at the Katherine Research Station (KRS) in 2001/2002. Treatments are single tree plots replicated four times. These trees have not been growing well. A decision will be made in 2003-04 about rejuvenating or replacing this trial. They have not yielded this season and do not look like doing so in the near future.

Evaluate Grapefruit Cultivars in the Top End

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

Results and Discussion:

In the 2003 season only some fruit was collected due to time constraints. The average yield (per tree) of the scion/rootstock combinations ranged between 52 and 187 kg (Table 1). The average fruit weight of the scion/rootstock combinations ranged between 336 and 774 g (Table 1). However the single tree (Ray Ruby) on a C35 rootstock had a yield of 194.6 kg with an average fruit weight of 422 g. Interpretation of the results needs to be treated with some caution due to the very small number of replications of some combinations. This is especially important, as many combinations have failed. Also note that the data was from trees which were planted in different years although they all were over seven years old and all had been severely pruned a few years ago.

Table 1. Average yield per tree with standard error and average fruit weight with standard error for grapefruit (rootstock x cultivar) planting at KRS in 2003

Cultivar	Rootstocks					
	Carriso		Swingle		Trifoliata	
	Yield (kg)	Average weight (g)	Yield (kg)	Average weight (g)	Yield (kg)	Average weight (g)
Flame	64.5+/-43.8	336+/-198	151.7	540		
Henderson	169.5+/-30.5	479+/-81	137.4+/-23.2	396+/-41	76.6+/-12.2	448+/-102
Marsh	103.6+/-102.1	472+/-14	175.3+/-10.2	508+/-23		
Oroblanco	78.9+/-69.1	774+/-119	93.9+/-16.9	702+/-7		
Ray Ruby	187+/-3.2	516+/-56	136.9+/-19.2	459+/-26	100.7+/-40.4	499+/-80
Rio Red	52.7+/-39.5	450+/-48	116.4+/-5.1	414+/-12		
Ruby	89.5+/-8.2	483+/-45	77.1+/-26.4	487+/-25		
Star Ruby	99.4+/-91.9	483+/-49	94.4+/-39.7	534+/-2		

Evaluate Lemon Cultivars in the Top End

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

Method:

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

Results and Discussion:

The yields ranged between 90.6 and 321.4 kg per tree (Table 2). There are no significant differences between the trees; however the variation (within and between varieties) is so high and replication is so small that meaningful statistical analysis cannot be conducted. In 2003 the Verna trees did not have very much flowering or fruit. This is interesting to see as the other cultivars yielded very well.

Table 2. Total yield and average fruit weight (both with standard errors where possible) for lemon cultivars on Benton rootstock at KRS in 2003

Cultivar	Yield (kg)	Average weight (g)
Eureka	168.1+/-65.9	143+/-8
Fino	125.0	148
Lisbon	321.4	160
Meyer	135.2	207
Villa Franca	105.5+/-14.9	142+/-4

Evaluate Pummelo Cultivars in the Top End

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

Results:

In Planting 1, all but three of the trees have died from termite damage and other causes. The three remaining trees became unthrifty and were skeletonised in 2001 in an endeavour to increase their vigour.

The trees in Planting 2 are yet to start producing fruit. They have been set back in previous years by sunburn and termite damage. However, they are now starting to increase in canopy size.

Discussion:

The 2002-03 season produced some high yields as discussed in these reports. However some of the yields were still low and some were extremely variable between trees within varieties. This problem can only be overcome by improving replication within the projects.

These projects however, have shown that citrus crops can be produced in the Katherine region. Hopefully the rootstock trials will help improve yields for the benefit of the NT citrus industry.

PROGRAM: The Table Grape Industry

PROJECT Develop Nutrition/Salt Management Guidelines for Table Grapes – Potassium Nutrition

Project Officer: A. Nesbitt

Location: Alice Springs

Objective:

Determine the response of grapevines to potassium fertiliser.

Introduction:

Potassium is an essential nutrient for grapevines. As large amounts of potassium are used during berry maturation, the uptake of potassium by vines is far greater than any other nutrient. Potassium deficiency generally affects the sugaring and colouring of berries. Furthermore, it can affect bunches, making them small and tight, and berries may ripen unevenly. In order to prevent potassium deficiency, fertilisers are sometimes used in vineyards. However, it is not known whether these fertilisers have any beneficial effect. Some of the benefits would be an increased potassium level in the petiole and soil and improved quality of berries. The question of benefit is being raised because of the following three reasons:

- Bore water supplies large amounts of potassium to the vine (about 260 kg/ha/annum). It is not known whether bore water can supply all the potassium requirements of vines.
- Vines do not absorb excess potassium when they already have adequate levels of the nutrient.
- High sodium levels in the vine can inhibit the uptake of potassium.

The trial was carried out to determine whether using potassium fertiliser had any beneficial effect on the vines at Ti Tree.

Method:

The trial was carried out in three separate vineyards using mature vines. Two vineyards had Menindee, Sultana and Flame. The third vineyard had only Menindee/Schwarzmann. The rates of potassium applied to the vines were 0, 20, 40 and 60 kg/ha of actual potassium, using potassium sulphate as the fertiliser. Each fertiliser treatment was applied to a group of five vines and each treatment was replicated four times along the vine row. Potassium fertiliser was applied to the vines on 8 August 2000 and again on 7 August 2001. A final sampling was done on 16 August 2002 without the reapplication of fertiliser to assess whether there was any long-term, or delayed, effect from the previous two applications.

Assessments made in the trial and the dates on which they were carried out are shown below:

- Potassium levels in the petioles in all the cultivars in the three vineyards (20/10/00, 6/12/00, 3/10/01, and again on the 15/8/02).
- Potassium level in the soil in Menindee/Schwarzmann (20/9/00, 4/9/01 and 7/11/01) and once in Flame (5/9/02).
- Sugar, acid and pH levels in the berry juice in Flame (1/11/01), in Menindee and Menindee/Schwarzmann (1/11/00 and 22/11/01) and Sultana (5/12/01).
- Potassium levels in the berry juice in Menindee and Menindee/Schwarzmann (1/11/00 and 22/11/01), and Sultana (5/12/01).

Results:

Only the results for the 2002 season are presented. Previous results can be seen in earlier Technical Annual Reports.

Petiole potassium
Petiole potassium levels in the three cultivars from one vineyard are shown in Table 1.

Table 1. The effect of potassium fertiliser on the potassium level (%) in the petioles collected on 16/10/02

K, kg/ha	Menindee	Sultana	Flame
0	4.12	2.94	3.09
20	4.25	3.10	3.23
40	4.21	3.16	3.06
60	4.18	3.08	3.04

As illustrated in Table 1, Potassium fertiliser did not increase the potassium level in the petiole one year after the final application of fertiliser. Similar results were obtained in the previous two seasons for all vineyards, even when fertiliser was applied.

Soil potassium
Soil potassium data is shown in Table 2.

Table 2. The effect of four levels of potassium fertiliser on the exchangeable potassium in the soil (cmol(+)/kg)

K, kg/ha	Soil potassium, cmol(+)/kg			
	20/9/00	4/9/01	7/11/01	5/9/02
0	0.43	0.42	0.46	0.51
20	0.47	0.64	0.62	0.61
40	0.51	0.87	0.81	0.54
60	0.55	1.11	1.15	0.6
	LSD = 0.1	LSD = 0.42	LSD = 0.3	LSD=0.07

Fertiliser did not increase the potassium level in the soil in 2000, but on both sampling dates in 2001, soil potassium levels were raised significantly only after a repeated application of potassium greater than, or equal to, 40 kg/ha. In 2002, the levels of potassium in the soil showed no correlation with the amount of fertiliser applied. The results show that the effects due to the addition of large quantities of potassium sulphate are negligible after one year under normal irrigation practices.

As mentioned earlier, potassium fertiliser can potentially raise the potassium level in the soil, at least in the short term, but does not necessarily result in any difference in the potassium levels in the petioles.

Discussion:

The absence of any vine response to potassium fertiliser may be due to the vines already having adequate potassium levels, as they will not take up additional potassium than is required. Another possibility is that high sodium in the vines inhibited potassium uptake. However, petiole sodium was below the toxic level in most trial sites at the time of sampling. Therefore, sodium would have played only a minor role in inhibiting the uptake of potassium

Although soil exchangeable potassium levels were also measured in the three vineyards, petiole potassium level is a better indicator of potassium deficiency than the soil test. This is because potassium deficiency can occur in vines due to other factors even when the soil contains adequate potassium levels. These factors include inadequate irrigation and high sodium or nitrogen levels in the vines.

Future Work

As the trial has shown, the addition of potassium to the soil in the form of potassium fertilisers (potassium sulphate) has had negligible effects on the vine and the soil. Therefore, as the trial has continued for three years without any evidence of potassium fertiliser providing a benefit to the vine, it is unlikely that this trial will continue in the future.

PROJECT: Develop Nutrition/Salt Management Guidelines for Table Grapes – Nutrient Standards Development

Project Officer: A. Nesbitt

Location: Alice Springs

Objective:

Validate or modify tentative petiole nutrient standards and identify nutrient problems.

Introduction:

Grapevines require adequate amounts of nutrients for growth and fruiting. Both nutrient deficiencies and excessive supplies of nutrients are harmful to vines. Measuring nutrient levels in petioles is a common diagnostic method used to establish whether vines are affected by any nutrient problems. The results are then compared with a set of nutrient standards. The reliability of this method depends on whether an accurate set of nutrient standards has been used. The standards that are widely used in Australia are those published by Robinson et al. (1997). These standards have three limitations:

- They were established for own-rooted Sultana vines.
- They are valid only at flowering time and not for the whole season.
- The nitrogen standard is only for nitrate nitrogen and no standard is suggested for total nitrogen.

The nitrogen standard is important because nitrogen has a very strong influence on the productivity of vines, including fruit maturity and quality. Both nitrate-nitrogen and total nitrogen measurements have had drawbacks as diagnostic tools. Nitrate nitrogen is affected by other factors such as soil moisture levels and salinity. Total nitrogen is slow to respond to changes in soil nitrogen levels. Therefore, because of these drawbacks, care must be exercised in interpreting nitrogen analysis data (e.g. observations of vine vigour).

A nutrient-monitoring program was carried out in Mildura, Victoria to correct these limitations in own-rooted and Ramsey rootstock Sultana vines (Nagarajah 2000). This work:

- Established that the potassium and phosphorus standards for own-rooted and Ramsey Sultana vines were different.
- Established standards for the whole season.
- Established total nitrogen standards.

A similar nutrient monitoring program was carried out at Ti Tree over the past four seasons (1999-2002). The goal was to validate or modify Robinson et al. (1997) and Nagarajah (2000) nutrient standards for the cultivars grown at Ti Tree. The results were also used to identify nutrient problems in vineyards, as well as to continue work with the evaluation of scion/rootstock combinations grown at Ti Tree.

Method:

The monitoring program was carried out using mature vines from all vineyards at Ti Tree. The cultivars and the number of vineyard sites from which petioles were collected for each cultivar are shown in Table 1.

Table 1. Cultivars and number of vineyard sites from which petioles were collected

Cultivar	Number of vineyard sites
Thompson	3
Thompson/Schwarzmann	1
Thompson/Ramsey	1
Thompson/Paulson	1
Flame Seedless	3
Flame/Freedom	1
Flame/Paulson	1
Menindee Seedless	3
Menindee/Sultana	3
Menindee/Schwarzmann	3
Menindee/Harmony	1
Menindee/Freedom	1
Menindee/Paulson	1
Red Globe/Ramsey	2
Crimson/Ramsey	1
Crimson/Paulson	1
Total	**27**

Additional cultivars have been included for the first time this year as part of a scion/rootstock evaluation study. However, many of the vines are still young and only one year's worth of useable data has been collected to date from these cultivars. This particular project may continue for another five years with nutrition as a major component.

The petioles were collected from opposite the cluster at monthly intervals from September until January. Samples were not collected after January because of degradation to the canopy due to grasshoppers and natural leaf senescence. Each petiole sample consisted of about 100 petioles, which were collected at random along a vine row. All the nutrients in the petiole samples were measured.

Results:

Nutrient standards
Tentative nutrient standards for the whole season for grapevine cultivars grown at Ti Tree are presented in Appendix 1. These are standards developed for the current list of cultivars that have been sampled over the past four years. Additions or alterations to these standards may occur as information is obtained on the new scion/rootstock combinations.

Nutrient problems
Nutrient analysis results were compared with the tentative nutrient standards and nutrient problems were identified. Individual reports were prepared from the sampling done at flowering and delivered to the relevant properties. Seasonal variations of the major nutrients and problems are highlighted below.

Macronutrients
Nitrogen – Nitrogen levels were only high in Ramsey rootstock vines and Crimson Seedless cultivars particularly at flowering time. This was confirmed by the increased vigour seen in those vines. High levels of nitrogen and excessive vigour would have delayed maturity. All other cultivars exhibited good nitrogen levels throughout the season. However, checks on vine vigour should be made regularly.

Phosphorus – Phosphorus was adequate at flowering in most cultivars. The exception being Menindee/Harmony which had lower than average phosphorus levels throughout the season. However, cultivars like Menindee/Sultana, Redglobe/Ramsey, Flame and vines with Paulson rootstock all showed marginal to deficient levels of phosphorus later in the season.

Potassium – Potassium was adequate for most cultivars both at flowering and during the rest of the season except for vines on Paulson rootstock, which had deficient levels at flowering but maintained those levels throughout the season. However, as there were no obvious deficiency symptoms, the standard for Paulson vines for potassium levels at flowering may need to be altered. More work is needed on this.

Calcium – The only cultivar that showed adequate, or near adequate levels of calcium throughout the season was Menindee/Sultana. Although calcium did rise steadily throughout the season, levels did not meet the increasing needs that showed adequate, or near adequate, levels of calcium throughout the season was Menindee/Sultana. of the vine.

Sodium – Sodium toxicity was a problem in the latter part of the season in all own-rooted cultivars. Grafted vines generally displayed good sodium exclusion capacities, consistent with the characteristics of their respective rootstocks.

Chloride – Chloride toxicity was a problem in all own-rooted cultivars and Menindee/Sultana. Vines grafted to traditional rootstock varieties showed good chloride exclusion.

Micronutrients
Data on micronutrient problems at flowering is presented in Table 2.

Table 2. Percentage of petiole samples that had adequate, high or marginal/deficient levels of micronutrients at flowering

Nutrient	Adequate (%)	High (%)	Marginal/deficient (%)
Copper	89	Nil	11
Manganese	7.5	92.5	Nil
Zinc	48	48	4

Although there were a few problems with micronutrients, such as marginal levels of copper in some samples and high levels of manganese in most samples, the results of nutrition studies this year have shown some improvements compared with previous years.

Iron was not included in Table 2 as the petiole iron level is not a reliable indicator of iron status. The best indicators of iron deficiency are symptoms in young leaves. In affected leaves, the blade is chlorotic, but the veins remain green. Iron deficiency symptoms were rare at Ti Tree.

Most of the relative micronutrient problems did not change later in the season. However, copper levels fell considerably to very low in all vineyards. This may have been due to the lack of copper sprays. Evidence of this was seen as a sharp incline in copper levels on one property between the last two sampling dates (December-January).

Discussion:

High nitrate levels in bore water and excessive irrigation of vines during the spring months can cause high nitrogen levels in vines. The problem is often worsened in Red Globe/Ramsey and Crimson varieties because of extensive root systems, which can absorb large amounts of nitrogen.

Vine nitrogen levels should be monitored monthly. Accurate scheduling of irrigation to ensure that the vine's water requirements are met without applying excessive amounts of water will reduce excess nitrogen and its harmful effects. In addition to petiole nitrogen levels, vine vigour is another indicator of vine nitrogen status - excessive vigour is an indicator of high nitrogen.

Phosphorus is the only macronutrient not supplied by bore water. Therefore, phosphorus fertiliser should be applied to vines once every few years. A recent trial indicated that significant reductions in soil (Olsen) phosphorus occurred following the application of phosphorus fertiliser. This problem is discussed in an accompanying report on a phosphorus response trial. High chloride levels in vines, caused by excess irrigation, reduce phosphorus uptake (Prior et al. 1992b). The harmful effects of phosphorus deficiency include a reduction in the fruiting capacity of vines (Skinner and Matthews 1989).

According to the petiole results, potassium deficiency was not a problem at Ti Tree. However, vines at Ti Tree sometimes show potassium deficiency symptoms, such as the upward cupping of basal leaves. Two factors, which can induce potassium deficiency, are high sodium levels in the vine and/or a heavy crop load. High sodium levels in vines caused by poor irrigation management reduce potassium uptake (Makirhara et al. 1999). A large crop load induces potassium deficiency because berries use large amounts of potassium during berry maturation. One of the harmful effects of potassium deficiency is delayed berry maturation.

Calcium deficiency is a problem at Ti Tree because of low calcium levels in the soil. The problem is probably aggravated by excess vine vigour, which results in a dilution of the calcium content. It is not known whether high sodium levels in the vine can reduce calcium uptake. Calcium deficiency cannot be easily corrected by applying foliar sprays or calcium fertilisers. A study carried out at Ti Tree showed that calcium sprays did not have a beneficial effect on the berries. The trial recorded the rate of water loss from grape clusters and berry sugar and acid levels. Some control measures that can be used to reduce calcium deficiency are:

- Controlling vine vigour by careful irrigation management and limiting nitrogen uptake.
- Not over-loading the vine with fruit by regular pruning and bunch thinning.
- Using scion/rootstock combinations such as Menindee/Sultana, which have a good capacity to absorb calcium.

Calcium deficiency can reduce the shelf life of table grapes. Adequate calcium levels are required to reduce the rate of water loss and maintain bunch quality, including the prevention of stem browning.

Sodium and chloride can be present in toxic levels in vines because bore water contains high levels of salt. Poor irrigation management aggravates the problem. Salt toxicity can affect vine health even before the appearance of salt toxicity symptoms in leaves (i.e. marginal leaf burn). Salt toxicity decreases growth, reduces yield and affects the quality of berries (Prior et al. 1992a and b, Walker 1994, Walker et al. 1997, and Stevens et al. 1999). The long-term solution to the problem may be to plant vines on salt-excluding rootstocks such as Ramsey, Schwarzmann, Harmony, Teleki, Rugeri and Paulson.

Micronutrient deficiencies, such as zinc and copper, can occur at Ti Tree because the soil is alkaline with a pH of about 8. Zinc deficiency can reduce fruit-set and decrease the crop load (Cook 1966, Christensen and Jensen 1978). It can be corrected by applying zinc sprays about two weeks prior to flowering. Zinc fertilisers applied to the soil are unlikely to be effective because the high soil pH would fix zinc in the soil. In addition to alkaline pH, high rates of phosphorus fertiliser can induce zinc deficiency (Alexander and Woodham 1964). Copper deficiency can be corrected by using copper fungicides at least once early in the season. High manganese levels occur in vines at Ti Tree even without applying any foliar sprays. The reason for this is not known, but vines did not show any symptoms of manganese toxicity such as necrotic spots on older leaves, and chlorotic mottling near leaf tips and along leaf margins.

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Appendix 1

Tentative petiole nutrient standards for grapevines

Tentative nutrient standards both at flowering (September) and for the October to January period are presented below. The tentative nutrient standards at flowering are those of Robinson et al. (1997), except for the standards used for nitrogen, phosphorus and potassium. These standards were established using the results of the nutrient monitoring program carried out over the past four seasons. The tentative standards will be revised, as more information becomes available, and other scion/rootstock combinations are included.

At flowering time (September)

Nutrient	**Adequate range**
Nitrate nitrogen, mg/kg	500 - 1200
Total nitrogen, %	0.8 – 1.0
Phosphorus, %	0.2 - 0.3
Potassium, %	2.4 – 3.0
Calcium, %	1.2
Magnesium, %	>0.4
Sodium, %	>0.5 Toxic
Chloride, %	>1 – 1.5 Toxic
Iron, mg/kg	>30
Copper, mg/kg	6 – 11
Zinc, mg/kg	>26
Manganese, mg/kg	30 – 60
Boron, , mg/kg	35 - 70

Exceptions to the above standards are indicated below:

- Ramsey or Schwarzmann rootstock vines – phosphorus 0.3 - 0.5%, potassium 3.6 - 4.5%.
- Menindee Seedless on own roots – potassium - 3.5 - 4.5 %.

October to January

Nutrient	Own roots	Rootstocks*
Nitrogen %	0.5	0.5
Phosphorus %	0.2	0.3
Potassium** %	1.5 – 2.0	2.5 – 3

The rootstock standards are for vines on Ramsey or Schwarzmann vines and not for Menindee/Sultana. For Menindee/Sultana, the standards are the same as for Sultana vines.

The exception to the above is the potassium standard for Menindee Seedless which is 3 – 4%.

	October	November	January
Calcium, %	>1.5	>2.0	>2.5
Magnesium, %	>0.5	>0.8	>1.2

*The standards for sodium and chloride at flowering are valid for the rest of the season.

PROJECT Develop Nutrition/Salt Management Guidelines for Table Grapes – Phosphorus Nutrition

Project Officer: A. Nesbitt

Location: Alice Springs

Objective:

Study the response of grapevines to phosphorus fertiliser.

Introduction:

Phosphorus performs a number of functions in the plant as a major component of energy-carrying phosphate compounds, nucleic acids and several essential co-enzymes. Therefore, phosphorus is extremely important and plays an indispensable role in energy metabolism. Hence, phosphorus deficiencies should be avoided. Phosphorus deficiency can occur in vines at Ti Tree due to inadequate supply of phosphorus fertiliser and high chloride levels. High chloride reduces the phosphorus levels in vines even when the soil contains adequate phosphorus levels. Excess phosphorus must not be applied because it can lead to zinc deficiency. Foliar sprays of phosphorus are generally ineffective.

A trial was carried out over the last three years to study the response of grapevines to different levels of phosphorus fertiliser. The third-year results of the phosphorus response trial are presented. It is a long-term trial and may continue for one more year.

Method:

Mature Menindee/Sultana and Menindee vines were used in the trial in two separate vineyards. Three rates of super phosphate fertiliser were used: 0, 20 and 40 kg phosphorus/ha. These rates of fertiliser were applied to groups of five vines and each treatment was replicated four times along the vine row. The fertiliser was first applied to the vines on 29/08/00. The same rates of fertiliser were reapplied to the same vines a year later on 07/08/01. Petiole phosphorus levels were measured in petioles from samples collected on 03/10/01, 22/11/01 and 13/02/02 in both vineyards after reapplication. Soil phosphorus levels were measured in both vineyards on 4/7/01 before reapplication and subsequently on 28/08/01, 07/11/01, and 13/02/02 after re-application.

Although petiole and soil sampling was continued in the 2002 season, no additional fertiliser was applied as soil levels were still quite high from previous applications. Petiole sampling took place on the 19/9/02 and 26/11/02, while one soil sampling was done on the 21/8/02 at both vineyard sites.

Results:

Petiole
Only the 2002 season results are presented (Table 1). Previous results can be seen in earlier Technical Annual Reports.

Table 1. The effect of phosphorus fertiliser on petiole phosphorus levels (%)

Phosphorus, kg/ha	Menindee/Sultana		Menindee	
	19/9/02	26/11/02	19/9/02	26/11/02
0	0.50	0.28	0.43	0.15
20	0.50	0.31	0.47	0.24
40	0.48	0.29	0.48	0.18

In 2000 and 2001, phosphorus fertiliser did not increase the phosphorus levels in the petioles. Likewise in 2002, there was no significant relationship between petiole levels of phosphorus and the amount of fertiliser applied. Although there seemed to be signs that petiole levels of phosphorus were starting to show a relationship to phosphorus additions in Menindee on the 19/9/02, this was not sustained in later sampling. However, given the nature of phosphorus uptake by vines and the characteristics of Central Australian soil, vegetative responses to the addition of phosphorus may take up to five years to occur.

Soil
An average of the soil (Olsen) phosphorus data for both sites is presented in Figure 1.

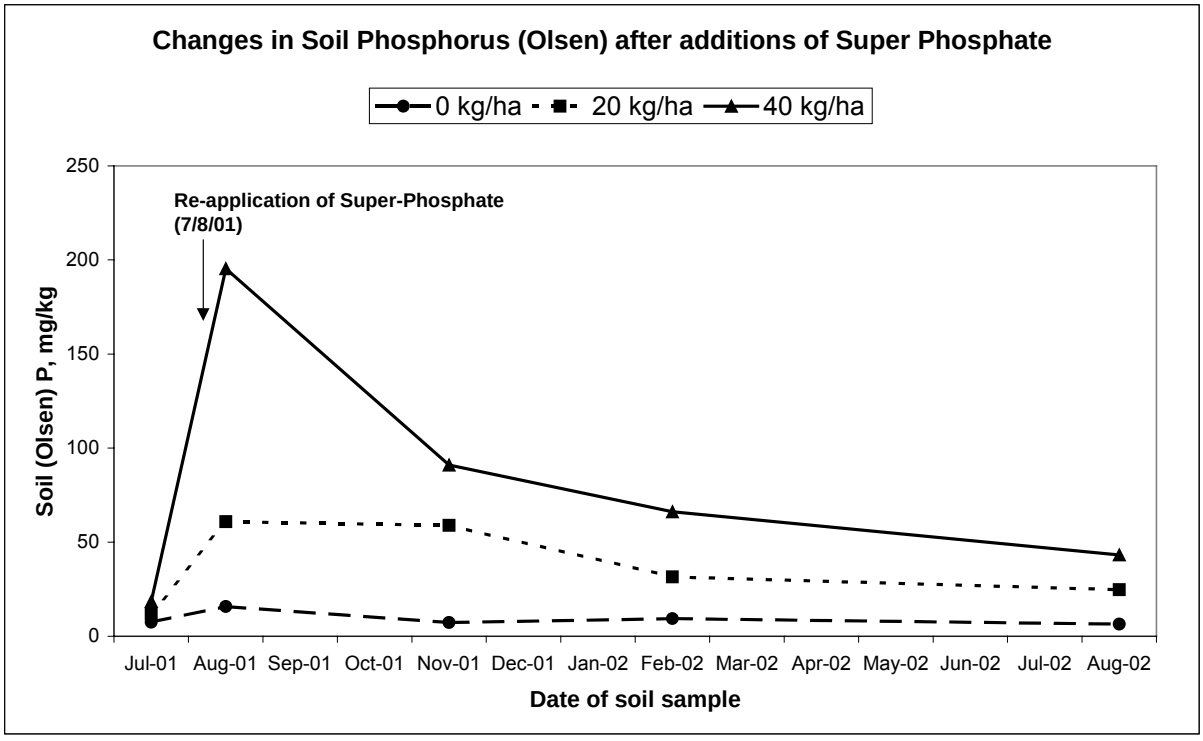

Figure 1. The effect of phosphorus fertiliser on soil (Olsen) phosphorus

There was a significant increase in the (Olsen) phosphorus level in soil samples collected on 28/8/01 following the re-application of super phosphate. This was followed by a rapid decline over the next three-month period, particularly for the high phosphorus (40kg P/ha) treatment. A similar process was observed the previous season, where this rapid decline occurred over a two-month period. However, it should be noted that the figures presented indicate an extremely high amount of phosphorus in the soil. This represents values much greater than what is normally needed for plant growth. The high readings are indicative of raw fertiliser possibly being present in the soil samples. Therefore, later

results give a much more accurate representation of the respective phosphorus levels, as there are still significant levels of phosphorus in the soil over one year after the final application.

Discussion:

Although there is a start of a trend for phosphorus to increase the petiole P level, this difference was not significant. This was not surprising as it takes about three to five years before vines show a response to phosphorus fertiliser.

The most significant observation made in the trial was a marked reduction in soil (Olsen) phosphorus between November and January. Similar results were observed last season. A number of factors can be responsible for this observation. These include uptake by the vines, fixation in the soil and leaching losses. In the alkaline soils at Ti Tree, iron oxides can play a significant role in the fixation of phosphorus (Holford 1977). In addition, excess irrigation and high soil temperatures at Ti Tree can accelerate the fixation of phosphorus (Burrow 1974). Two methods can be used to reduce the loss of phosphorus by fixation and leaching:

- Applying fertiliser only during the two periods when vines absorb phosphorus. The first ranging from after bud burst until veraison, and the second, less important, from about five weeks after harvest into the leaf fall period (Conradie 1981).

- Splitting the annual rate of phosphorus fertiliser application into smaller amounts.

It is not known if there are any differences in the loss of phosphorus from the types of phosphorus fertiliser used at Ti Tree (super phosphate, mono-ammonium phosphate and mono-potassium phosphate). A study has been carried out over the last two years to obtain information on the fixation rates of four different forms of phosphorus fertiliser.

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PROJECT Develop Nutrition/Salt Management Guidelines for Table Grapes – Soil Phosphorus Levels

Project Officer: A. Nesbitt

Location: Alice Springs

Objective:

Quantify the decline of soil (Olsen) phosphorus.

Introduction:

A grapevine fertiliser response trial using super phosphate has been carried out over the last two years. While this trial may need to continue for at least one more season, an important finding so far has been the rapid decline of phosphorus in the soil following its application. The decline of phosphorus in the soil may be due to a number of factors including pH of the soil, soil temperature, rainfall and leaching, iron and calcium contents and the form in which the phosphorus is applied. While most of these characteristics remain consistent across the grape growing region, it is not known which, if any, of the forms of phosphorus fertilisers is more likely to be lost or fixed more readily than any

other. Therefore a new trial was carried for one season to assess the rate of decline of four different forms of phosphorus fertiliser in a vineyard environment.

Method:

Four types of phosphorus fertiliser were applied in a replicated trial on Menindee/Sultana in one vineyard. The fertilisers included super phosphate, triple super, mono-ammonium phosphate (MAP), and mono-potassium phosphate (MKP). All forms of fertiliser were applied at a rate of 40 kg P/ha on 28/8/01. Soil samples were collected to only a depth of 30 cm on a monthly basis for the first three months and then twice more every second month. A final sampling was done one year after application. Samples were analysed for phosphorus content using both Colwell and Olsen methods. The last three samples were also analysed to estimate the level of soil solution P using a calcium chloride extract.

Results and Discussion:

Results from the six sampling dates are presented in Figure 1. There appears to be a difference in initial levels of phosphorus. However, this is most likely due to a residual effect from raw fertiliser entering the sample. As the first sampling was done soon after fertiliser application, it is highly possible that undissolved fertiliser was still present. In fact, even towards the end of the trial, six months after the application of fertiliser, both super phosphate and triple super could still be seen in granulated form.

From the results gathered, it is inconclusive as to which fertiliser is more readily fixed in the soil. However, there does seem to be a trend for super phosphate to maintain higher levels for longer periods, possibly due to its lower solubility (Figure 1).

Both the Colwell and Olsen method results showed similar trends. A relationship between these two tests is being established for Ti Tree soils.

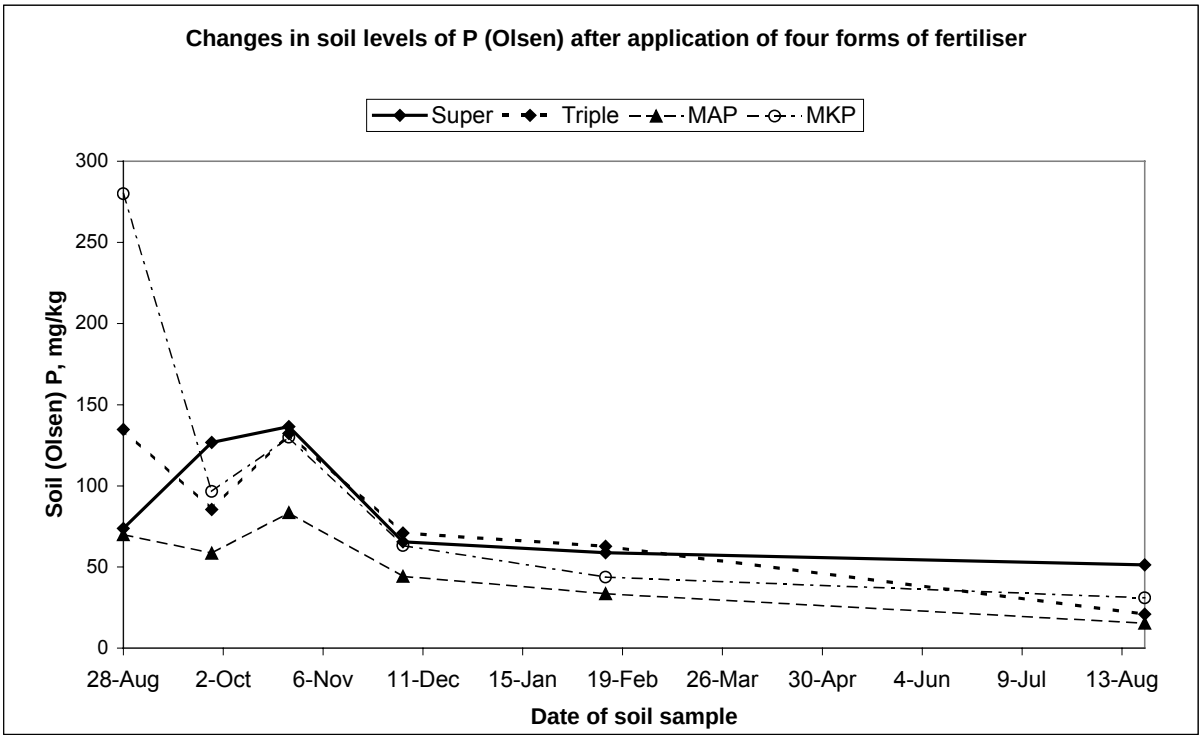

Figure 1. Changes in soil (Olsen) phosphorus following application of four forms of phosphorus fertiliser

Major problems exist for determining phosphorus levels in soils in relation to what is actually available for the plant, what is adsorbed, and what is fixed. Both the Olsen and Colwell methods estimate soil solution phosphorus (i.e. what is available for the plant), and a varying proportion of the adsorbed P.

As the Colwell method uses a longer extraction period, it estimates a higher proportion of this adsorbed amount. The ability for the soil to store P by adsorption (as a reservoir) and re-release it into solution is known as its buffer capacity (Moody and Bolland 1999). Using a test developed by Burkitt et al. (2000) it was found that Ti Tree soils have a low to very low buffer capacity (average P_{si} index <25). Therefore, a soil with a low buffer capacity will have a much lower critical value for Colwell P than a soil with a high buffer capacity.

One way to address the issue of estimating soil solution P is by using calcium chloride to extract soluble phosphorus only (Moody et al. 1983). While only limited work has been done on this to date, estimates show that super phosphate, and to lesser extent triple super phosphate, sustain higher concentrates of P in soil solution over time (Table 1). This means that more P is readily available for plant growth.

Table 1. Changes in CaCl2 extractable P (mg/kg) for four forms of fertiliser

	04/12/01	**13/2/02**	**21/8/02**
Super	14.1	8.1	5.2
Triple	16.3	10.3	2.4
MAP	9.8	4.9	1.5
MKP	11.8	4.8	2.5

Future work:

In partnership with the phosphorus response trial, this study may continue for one more year. Further results may indicate that estimating concentrations of soil solution P may be better for determining phosphorus levels particularly for soils with low buffering capacity.

References:

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PROJECT: Evaluation of Dormancy Breaking Agents for Early Table Grape Production in the 2002 NT Season

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

Location: Ti Tree/Territory Grapes/Ti Tree Farm

Objective:

Improve the productivity, quality and profitability of table grapes in the NT.

Introduction:

The table grape industry in Central Australia is based on the production of early maturing, high quality fruit for the domestic market. Table grapes grown in the Ti Tree/Pine Hill area, 200 km north of Alice Springs, begin to mature fruit in early November with the bulk of the harvest completed by Christmas.

The amount of “winter chill” grapevines receive in this area varies considerably from year to year. Often budburst is slow or erratic due to a number of factors including maximum and minimum

temperatures and rainfall throughout the dormancy period. This has implications for the management of the crop such as the timing for gibberellic acid sprays and the timing for harvest.

The application to vines of the dormancy breaking agent Dormex® (hydrogen cyanamide) to promote an early and more even budburst has become an essential management practice in the vine growing areas of Central Australia.

The chemical is usually applied to grapevines at the maximum recommended rate of 5% v/v of the product (2.5% active ingredient hydrogen cyanamide). A non-ionic wetter is also added to the spray mix at the rate of 50 mL/100 L of solution.

Past research has indicated that many factors determine the effectiveness of Dormex spray applications from year to year. Research conducted in the past has attempted to address a number of these variables in an effort to make the spray application more effective in terms of promoting an early and more uniform budburst.

Dormex Research Project – 1999

Research involved assessing the effectiveness of applications of Dormex at various rates when combined with a range of surfactants mixed with Dormex at various rates. The rates of budburst in these treatments were compared with the budburst rate in vines treated with the standard Dormex/surfactant spray mix.

Dormex Research Project – 2000

Research conducted in 2000 reassessed the effectiveness of a number of Dormex/surfactant spray mixes used the previous season as well as a number of other Dormex/surfactant spray combinations.

Dormex Research Project – 2001

Work comprised of further evaluating the effectiveness of one of the more promising Dormex/surfactant spray mixtures from the previous season against the recommended standard spray mix.

“Waiken” is another product that is claimed to have dormancy breaking properties. It was compared with two Dormex sprays at Territory Grapes.

Trials were conducted on Flame Seedless and Sultana vines. Flame Seedless were spur-pruned and the Sultana vines were cane-pruned. Results were variable in terms of the budburst rate between treatments in each variety.

The most effective spray that achieved the best budburst rate and total budburst in Flame Seedless was the standard Dormex surfactant combination (Dormex 5% Chemwet 0.06%) as recommended by the manufacturer. Dormex 2% and Chemwet 3% also achieved a satisfactory budburst.

Budburst in the sultana plots was very poor. Vines in all treatments did not achieve a budburst rate higher than 50%. Other factors such as climate, timing of spray applications, the ability of the spray to penetrate the bud scales and be absorbed by the bud could have affected the vine response to the dormancy-breaking sprays. It was decided that future work should include modifying the environment prior to the application of the dormancy-breaking spray in an attempt to improve spray absorption and budburst response.

Dormex Research Project - 2002

After consultation with industry it was decided to approach the season’s research on dormancy breaking agents with the following objectives:

Trial 1:

Investigate methods of making the buds on vines more receptive to the application of a dormancy-breaking agent. It was agreed that dormant buds on vines appear to repel moisture, as the scales are tight and the air cold and dry at the time sprays are applied. The buds in this condition tend to cause the spray to evaporate or run off the surface of the scales rather than be absorbed. It was decided to

apply various spray treatments to the vines prior to the dormancy-breaking spray in an effort to soften the bud scales and make them more receptive to the following spray.

Trial 2:

Evaluate how effective Dormex was compared with Waiken in terms of earliness and evenness of budburst. Preliminary work the previous season indicated that this product was inferior in terms of promoting budburst in table grapes. It was decided to compare the product with Dormex once again.

Method:

The trials were conducted on two commercial table grape properties in the Ti Tree area. The plantings comprised *Vitis vinifera* cultivars Sultana and Menindee Seedless on own roots. Both cultivars were cane-pruned.

Twenty buds were marked randomly on the canes of the vines to be assessed for budburst. Assessments began on the 01/08/02. Marked buds on selected vines were inspected twice weekly for signs of budburst. The date the buds reached budburst was recorded. Assessments continued until around 80% of the marked buds reached budburst. The budburst rates and actual percentage of buds that burst could be calculated from this data.

Trial 1:

This trial was conducted at Territory Grapes, which is located on Pine Hill, 190 km north of Alice Springs. A wide range of pre-Dormex treatments was applied to vines as well as two concentrations of Dormex – 4% and 5% which is the standard treatment. All spray concentrations were on a volume/volume basis. The timing of the application of the pre-treatment was also varied. One trial consisted of applying the pre-treatment in the afternoon and the Dormex that night (approximately 10 hours later). The second trial involved the application of the pre-treatment spray immediately before the application of the Dormex spray. In this instance the vines were still wet from the pre-treatment when they received the Dormex application.

All spray applications were made using a boom-spray arm mounted on a 3,000 L trailed spray unit. This is the accepted method for the application of dormancy-breaking sprays in the Ti Tree area.

Table 1. Varieties and treatments

Variety	Pretreatment	Dormex concentration
Menindee Seedless	Pre-wet water - delayed Dormex	5% Dormex 1% Spreadwet
Menindee Seedless	Pre-wet water and Spreadwet 1% - delayed Dormex	5% Dormex 1% Spreadwet
Menindee Seedless	Pre-wet with sprinklers prior to Dormex application	5% Dormex 1% Spreadwet
Menindee Seedless	Pre-wet with sprinklers prior to Dormex application	4% Dormex 1% Spreadwet
Menindee Seedless	Pre-wet water – delayed Dormex application	5% Dormex 1% Spreadwet
Menindee Seedless	Pre-wet water and Spreadwet 1% prior to delayed Dormex application	5% Dormex 1% Spreadwet
Sultana	Pre-wet with sprinklers delayed Dormex application	5% Dormex 1% Spreadwet
Sultana	No pre-treatment	5% Dormex 1% Spreadwet
Sultana	Pre-wet with water delayed Dormex application	5% Dormex 1% Spreadwet
Sultana	Pre-wet water and Spreadwet 1% - Dormex Applied immediately after pre-treatment	5% Dormex 1% Spreadwet
Sultana	Pre-wet water - Dormex application immediately after pre-treatment	4% Dormex 1% Spreadwet
Sultana	No pre-treatment	4% Dormex 1% Spreadwet
Sultana	Pre-wet water and spreadwet 1% delayed Dormex application	5% Dormex 1% Spreadwet
Sultana	No pre-treatment	4% Dormex 1% Spreadwet
Sultana	No pre-treatment	5% Dormex 0.06% Spreadwet

Treatments consisted of at least four rows (360 vines). Three vines were randomly selected in the plots for assessment.

Pre-treatments were applied at the rate of 2.1L/vine.

Dormex/surfactant sprays were applied at the rate of 0.450 L/vine

Trial 2:

This trial involved the evaluation of:

A range of pre-treatments prior to the application of a Dormex/surfactant mix.
A range of pre-treatments prior to the application of Waiken.
The application of a Dormex/surfactant mix with no pre-treatment.
The application of a Dormex/Waiken pre-treatment followed by another Dormex/Waiken treatment.
The application of a Waiken pre-treatment followed by another application of Waiken.

Table 2. Details of treatments

Variety	Treatmt	Pretreatment	Dormancy Breaking Agent
Sultana	1	3% Chemwet v/v	5% Dormex 3% Chemwet
	2	1% Chemwet	5% Dormex 0.06% Chemwet
	3	6% Waiken	5% Dormex 3% Chemwet
	4	3% Waiken	5% Dormex 0.06% Chemwet
	5	Water	5% Dormex 3% Chemwet
	6	No pretreatment	5% Dormex 0.06% Chemwet
	7	1% Chemwet	5% Dormex 3% Waiken
	8	3% Chemwet	5% Dormex 3% Waiken
	9	No pre-treatment	5% Dormex 3% Chemwet
	10	Water	5% Dormex 0.06% Chemwet
	11	3% Waiken	5% Dormex 3% Chemwet
	12	6% Waiken	6% Waiken
	13	1% Chemwet	5% Dormex 3% Chemwet
	14	3% Chemwet	6% Waiken
	15	3% Chemwet	6% Waiken
	16	1% Chemwet	5% Dormex 0.06%Chemwet
	17	3% Waiken	5% Dormex 3% Chemwet
	18	6% Waiken	5% Dormex 0.06% Chemwet
	19	1% Chemwet	5% Dormex 3% Chemwet
	20	3% Chemwet	5% Dormex 0.06% Chemwet
	21	1% Chemwet	5% Dormex 3% Waiken
	22	3% Chemwet	5% Dormex 3% Waiken
	23	3% Chemwet	5% Dormex 3% Chemwet
	24	1% Chemwet	6% Waiken
	25	6% Waiken	5% Dormex 3% Chemwet
	26	3% Waiken	6% Waiken
	27	Water	5% Dormex 3% Chemwet
	28	No pre-treatment	5% Dormex 6% Waiken
	29	1% Chemwet	5% Dormex 6% Waiken
	30	No Pre-treatment	5% Dormex 6% Waiken
	31	1% Chemwet 6% Waiken	5% Dormex 6% Waiken

Treatments consisted of three vine plots. The middle vine in each plot was selected for assessment. Treatments were applied with a hand wand. Pre-treatments were applied on the 01/07/02. Dormancy-breaking agents were applied on 02/07, approximately 15 hours after the initial spray application. All spray concentrations were on a volume/volume basis. Approximately 0.60 L of spray was applied per vine.

Results:

Trial 1:

Effectiveness of pretreatments:

A number of trends were evident across the various pre-treatments and the standard Dormex application where no pre-treatment was applied.

The budburst rate was very similar:

Where a pre-treatment of water was applied immediately prior to the Dormex application, the vines were still wet from the pre-treatment as the Dormex application was made.

The budburst rate was higher with a higher percentage of buds breaking when a pre-treatment of water and 1% Spreadwet was applied before a delayed application of Dormex. The budburst rate was also higher than the standard treatment when a pre-treatment of water was applied.

The timing of the application of the pre-treatment appears to be critical. Budburst rates and the total number of buds that burst were higher when Dormex was applied between four and 11 hours after the pre-treatment (see Figure 1).

This trend was evident in both the Menindee Seedless and Sultana plots (see Figure 2).

Where Dormex was applied 30 hours after the pre-treatment, the budburst rate and total number of buds that burst was less (47%) than the standard Dormex application without a pre-treatment (approximately 53%).

Those plots where sprinklers were used to pre-wet the vines and were turned off immediately prior to a Dormex application did not have as high a percentage of buds burst by the end of the assessment period.

Trial 2:

The effect of various pre-treatments and dormancy-breaking agents

There was a significant difference between various pre-treatments and dormancy-breaking agent combinations in terms of the budburst rate and total number of buds that had burst at the completion of the assessment period.

Pre-treatments using Chemwet followed by 5% Dormex 3% Chemwet resulted in the highest budburst rate and the highest number of total buds burst.

Pre-treatments using water followed by 5% Dormex 3% Chemwet also gave good results in terms of budburst rate and total buds burst.

Pre-treatments using Chemwet followed by 5% Dormex and 0.06% Chemwet had a satisfactory effect on budburst; however the total number of buds burst was slightly lower than in the earlier treatments.

Where no pre-treatment was applied and the dormancy-breaking spray was 5% Dormex and 3% Chemwet the budburst was slightly lower than in the first three treatments in terms of budburst rate and total number of buds burst.

When Waiken was used as a pre-treatment followed by any combination of Dormex and Chemwet the resulting budburst was poor in terms of budburst rate and total number of buds burst.

When a combination of Waiken and Dormex was applied after a pre-treatment of Chemwet budburst was poor. The budburst rate and total number of buds that burst was even poorer when no pre-treatment was used before the application of the two dormancy-breaking agents.

Where 6% Waiken was used as the dormancy-breaking treatment there was a very poor budburst regardless of the pre-treatment. In many instances Waiken applications appeared to delay budburst with a very low percentage of buds having burst when assessments ceased.

Discussion:

Results from evaluation trials this season indicate that the application of a pre-treatment to vines prior to the application of the dormancy-breaking agent Dormex can increase the budburst rate and the total percentage of buds that burst compared with no pre-treatment. Pre-treatments using water did increase the total number of buds that burst compared with no pre-treatment and the standard Dormex application. A pre-treatment using water and a surfactant was more effective in increasing the budburst rate and total number of buds that burst compared with either of the other treatments.

The trials carried out in the past season were not replicated. Only a few vines from each treatment in Trial 1 were assessed due to the large number of treatments. The treatments in Trial 2 were only three vine plots where sprays were applied using a hand wand. This may account for a higher percentage budburst than may be achieved in a commercial situation using a boom.

The main purpose of the work was to apply a range of pre-treatments followed by the application of a range of Dormex surfactant combinations to determine whether it was possible to condition the bud to be more responsive to the application of the dormancy-breaking agent. This work indicates that the use of a pre-treatment containing a surfactant does improve the response to Dormex. Further work is needed however on a commercial scale to better evaluate the use of a pre-treatment prior to the application of Dormex.

The use of Waiken on table grapes in the Ti Tree region does not appear to advance budburst or increase the total number of buds that do burst and would not be recommended as a dormancy breaking treatment in that region.

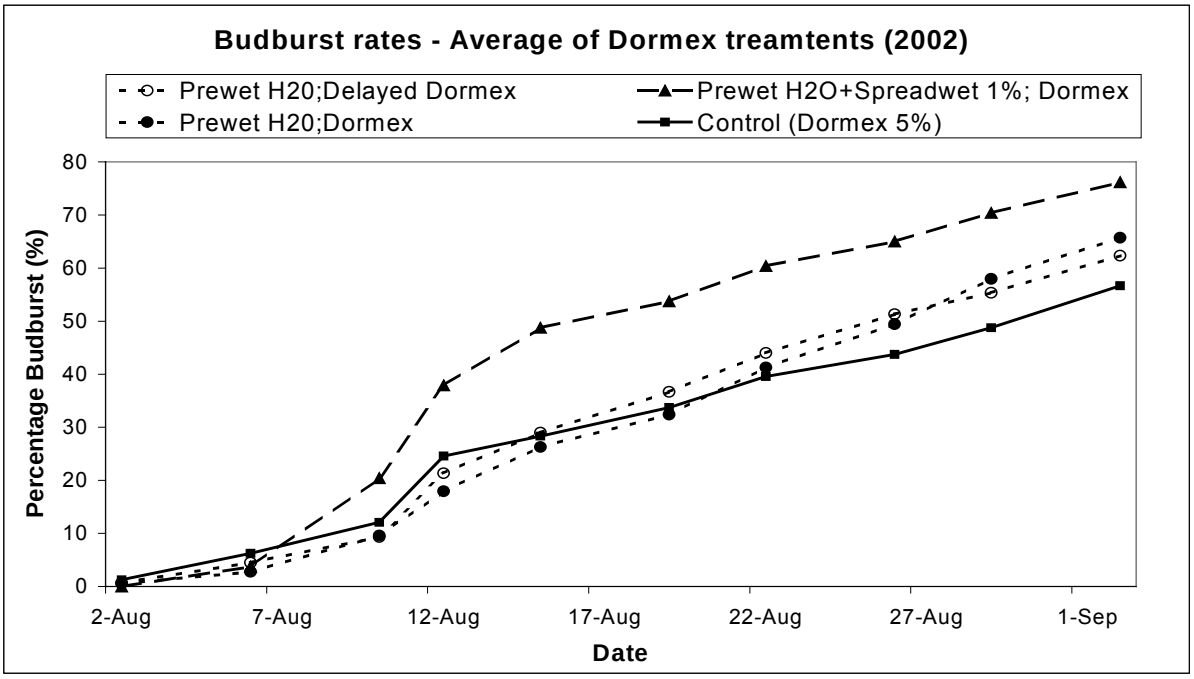

Figure 1. Budburst rates after pre-treatments, no pre-treatment and Dormex application

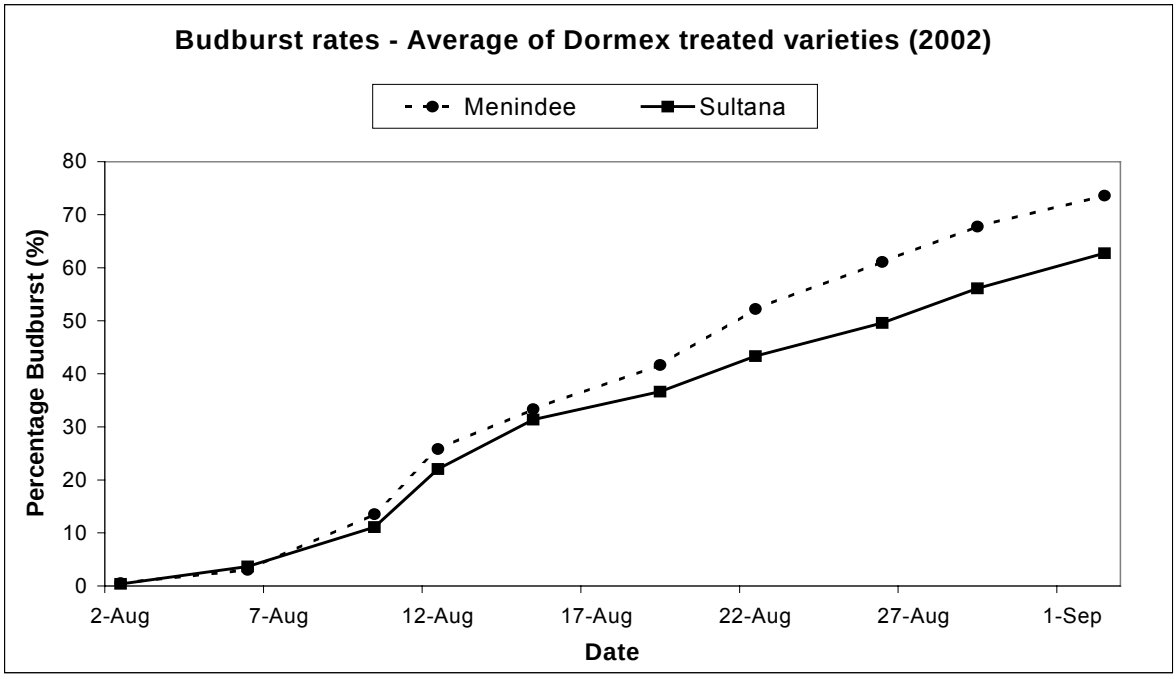

Figure 2. Average budburst rates for Menindee Seedless and Sultana receiving a pre-treatment and Dormex

PROJECT: Develop Irrigation Management Guidelines for Table Grapes

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

Location: Ti Tree

Objective:

Develop irrigation management guidelines for table grapes in Central Australia including validating crop factors.

Introduction:

Irrigation scheduling practices on commercial table grape properties in the Ti Tree area vary considerably. The under-irrigation or over-irrigation of vines can cause a range of problems and eventually affect the economic viability of the property.

Excessive applications of water to vines can cause excessive vigour, especially when nitrate is present in the irrigation water, as well as other nutritional problems. Cropping and fruit quality characteristics may also be affected including a high incidence of “chicken” berries delayed maturity and poor handling and storage characteristics. Extra pumping of bores will also add to production costs and waste a valuable resource.

Under-irrigation can also be just as detrimental to vine growth and productivity. Poor growth, bud fruitfulness, lack of berry set, failure of the crop to mature including shriveling of berries and nutrition problems can result if vines do not receive timely irrigations with adequate amounts of water.

The use of irrigation scheduling aids varies between sophisticated, state of the art telemetry, to more basic aids such as tensiometers. Regardless of the sophistication, the main aim of efficient irrigation scheduling is to enable proper interpretation of readings and then apply the correct amount of water to a crop at the appropriate time.

The Ti Tree Water Advisory Committee (WAC), a statutory body which represents the interests of water users in the region, has a strong interest in promoting sustainable irrigation practices amongst users of the resource. The WAC has identified crop water use and irrigation scheduling as a priority.

Method:

In previous seasons the amount of water applied to vines on properties in the Ti Tree area was provided to owners and managers on a per hectare basis. It was not possible to make accurate comparisons between properties on water use in vines using this method.

In the 2001-02 season a new system was adopted based on the volume of water applied to vines on each property on a per vine basis. This involved the following procedures:

With the cooperation of all property owners and managers the number of vines on each property was identified.

Meter readings have been recorded on a weekly basis at all production bores on properties in the Ti Tree Farms area. Currently there are 15 bores in use.

Water use for the week is recorded on a computer and e-mailed to AZRI and to the Department of Infrastructure, Planning and Environment (DIPE). The records are provided to DIPE as part of an agreement for property owners holding a water allocation licence.

Evaporation and rainfall are recorded on a daily basis at Ti Tree Research Farm. Evaporation can range between 2 mm and 16 mm per day depending on daily temperatures and wind.

The crop coefficient is then used to determine the amount of water actually used by the vines based on the evaporation. The amount of water used by the vine depends upon the age of the vine, the growth stage i.e. budburst, veraison, and crop load. Crop factors have been determined and refined by ongoing research in the region over a number of years. Crop factors for table grape production in Central Australia are shown in Table 1.

Table 1. Crop factors used for table grape production in Central Australia

Month	Crop coefficient
January	0.4
February	0.3
March	0.2
April	0.2
May	0.1
June	0.1
July	0.1
August	0.1
September	0.2
October	0.5
November	0.55
December	0.4

Using vine spacing, row spacing and emitter output data for each planting, it is possible to calculate the period of time the irrigation system needs to be activated to replace the amount of water used by the vine.

The meter readings from the various properties in the area and the vine numbers on those properties were used to calculate the amount of water applied on a per vine basis for any given period of time. This was then compared with the amount of water calculated as being used by a mature vine on a litres/vine basis using evaporation data and crop factors.

Results:

Reports were regularly presented to industry throughout the season at grower discussion groups and WAC meetings detailing water use with graphs to compare water use on a per vine basis across properties.

Data has been collated to reflect irrigation trends in the Ti Tree Farm area throughout the season from pre-budburst (June to August), to the post harvest period (January to May). See Figure 1. The estimated water requirements of the vine are also indicated against the maximum and minimum amounts of water used on properties.

Vine growth stages have been separated into four distinct periods to correlate with crop water demand: (1) pre-budburst (2) budburst to veraison, (3) veraison to harvest (4) post harvest.

Pre-budburst

During the June to August period growth is non existent as the vine enters a semi-dormant to dormant stage. Pruning takes place at this stage. Many vines may still be carrying leaves; however shoot growth does not occur. The leaves that have not fallen from the vine are stripped from the canes during the pruning operation. This tends to force the vine into a semi-dormant growth stage. The application of a small volume of water at this time has been found to be beneficial in terms of promoting a better response to Dormex application.

Figure 1 indicates the range of water use across properties. The amount of water used on at least one property during this time was far in excess of that required by the vines (Figure 1). The minimum amount of water used was a more accurate estimate of the actual water needs of the vines.

Budburst to veraison

This growth period of vines requires very low amounts of water as budburst occurs and shoot growth commences. Although shoot growth is rapid, water demand by the vine remains low. The first of two root growth flushes commences shortly after shoot growth commences. Flowering also occurs during this period. Excessive application of water, beyond the needs of the vine at this stage, is undesirable and can result in excessive berry set and problems with “hen and chicken.” Bud fruitfulness for the next season is also determined at this stage. Adequate amounts of soil moisture for vine growth are required through this period. However, over-irrigation can easily occur. Crop factors range from 0.1 to 0.5.

As can be seen in Figure 1 the application of water to vines during this period varied considerably across the properties. The majority of properties over-irrigated in the first six weeks after budburst. This may cause excessive vine vigour with rapid shoot elongation or stunted growth due to the soil around the vine root system being cold and saturated with excessive moisture. The additional nitrate applied with the excess irrigations could exacerbate the problem of vigour. As bud fruitfulness for the following season is determined at this time excessive canopy growth may cause unnecessary shading of buds resulting in lower levels of bud fruitfulness.

Towards the end of this period, the maximum amount of water applied was similar to the estimated water use of the vines.

The minimum amount of water applied to vines during the early stages of this growth period was reasonably close to estimated water use; however these vines were severely under-watered later in this growth stage.

Berry ripening and harvest

After the rapid shoot development and growth, vine growth slows. Canes continue to mature and bunch development is rapid. The berries now change colour and continue to increase in size and sugar content as the acid levels begin to fall. The accumulation of sugars in the berries is attributed mainly to the increased process of photosynthesis in leaves. For this to take place adequately, sufficient amounts of water need to be available to the vine. Crop water use throughout this period steadily increases with the maximum demand for water occurring prior to and during the harvest period.

Figure 1 details water application rates (maximum and minimum) for this critical period. Although maximum water use on a property coincided with the water demand of the vine in early November, the actual water applied for the remainder of that period was at times excessive based upon crop factors and evaporation data. Vines on the properties receiving the lowest volume of water received considerably less water than they required for the final stages of crop maturation and would have been stressed during this period.

The consequences of not meeting the water requirements of vines would be delayed maturity, uneven maturity within the bunch, softening of berries and the collapse of bunches in severely stressed plantings.

Although rainfall occurred in the November and December period, many falls were not significant enough to be of any use to vines. Rainfall of 10 mm or less in a 24-hour period is regarded as not contributing to vine water requirements. The canopy of the vine can effectively screen the vine roots from light rainfall events as the root system is confined to approximately 0.5 m either side of the butt of the vine and is continuous along the vine row. Irrigations should continue during this time to meet the water needs of the vines.

Post-harvest

During this period, vine growth continues at a steady rate and canes continue to mature. Older leaves in the shaded areas of the vine turn yellow and may fall. These leaves are not contributing to vine growth and are replaced by new growth at the ends of the canes. A second flush of root growth commences shortly after harvest.

During this growth stage the vines are storing carbohydrates and other nutrients for next season's growth. The growth of lateral shoots is greatest at this stage.

Higher levels of sodium and chloride can be found in the soil at this time of the season. The application of a number of leaching irrigations reduces these levels and ensures that salt does not accumulate in the vine.

Figure 1 indicates that irrigations during this growth stage of the vine did not meet the requirements of the vine on at least one property. On at least one other property excessive amounts of water were applied. Generally the water requirements of the vine increased as summer temperatures were experienced through the post-harvest period and irrigations were applied including for leaching.

While excessive vigour is undesirable at this time, adequate water applications are required to ensure the health status of vines is optimum as pruning approaches.

Discussion:

The scheduling and application of irrigation water to meet the requirements of the vine and ensure satisfactory crop development is essential for the production of early, high quality fruit. The actual amount of water pumped may be underestimated on some properties due to the constant breakdown of some meters on bores and the time delay in having them replaced.

The water application data presented indicates that when the water needs of the vine were low in the period immediately after budburst, water applications tended to be in excess of the actual requirements of the vine.

After flowering, the water requirements of the vines increased substantially. However, most vines did not receive adequate amounts of water.

Data for the berry maturation and harvest period indicates that crop water applications did not meet the requirements of the vine for this crucial period.

This trend continued through the post harvest period when adequate amounts of water are required to promote some vine growth and maintain salt levels in the soil at acceptable levels.

The cooperation of industry and the support of the members of the Ti Tree WAC are gratefully acknowledged.

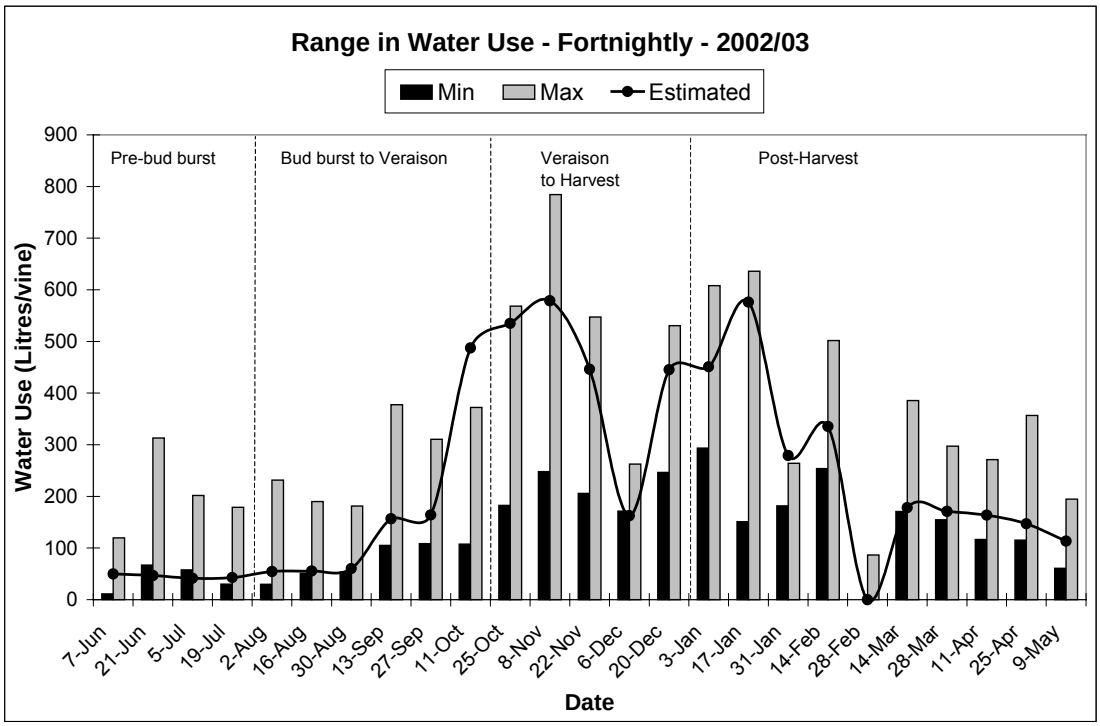

Figure 1. Range of water use on properties in the Ti Tree farms area 1/6/2002 - 31/5/2003

PROJECT: Improved Production Management Systems for Table Grapes

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

Location: Ti Tree

Objective:

Evaluate the performance of various table grape scion/rootstock combinations growing on properties in the Ti Tree area for production of high quality, early maturing fruit.

Introduction:

The table grape industry in Central Australia is relatively new. The first commercial plantings of table grapes were established in the Ti Tree area in the early 1970s. However, the industry expanded at a rapid rate only over the last five years.

Initially most plantings were established using vine rootlings. Industry at that stage did not consider that there was a use for rootstocks with nematode resistance as virgin soils in the area were identified as being free of those nematode types known to cause economic damage to grapevines. Industry also had concerns that the nitrate levels in bore water in the Ti Tree area could lead to management problems if vigorous rootstock selections were planted. This could have a detrimental effect on fruit quality due to excess vine vigour. Other positive attributes that rootstocks may have were considered of secondary importance to the issue of controlling vigour.

The standard trellis system used by all growers in the district is the sloping T trellis. This is considered to be a suitable design in terms of handling vine vigour and enhancing the cropping characteristics of vines grown in the area including an acceptable standard of fruit quality.

As plantings have continued to increase in this region there have been a number of issues that have led to a dramatic change in industry attitude to the use of rootstocks. The pest and disease-free status

of vine rootlings imported into the NT in the past has been questionable. In many instances rootlings were infested with root-knot nematode (*Meloidogyne* sp.). While tests in previous years revealed no trace of root-knot nematode, this pest can now be detected in most, if not all, plantings of vines grown on their own roots or sultana rootstock throughout the Ti Tree area. Some plantings in the region are now marginal in terms of economic viability due to infestations by root-knot nematodes.

At a rootstock workshop conducted by this Department in May 2001 industry agreed that the need to consider the use of rootstocks for table grape production was overdue. Many property owners had already ordered a range of rootstocks grafted to the three main varieties grown in the area (Flame Seedless, Menindee Seedless and Sultana). The main issue identified at that meeting was which rootstocks were best suited to the varieties grown in terms of the production of early maturing, high quality table grapes.

Desirable characteristics of rootstocks identified for research and evaluation included:

- Nematode tolerance: Tolerance to the range of nematodes which can cause economic damage to table grape plantings.
- Have moderate vigour characteristics when irrigated with bore water containing high levels of nitrate.
- Have acceptable cropping characteristics including yield, fruit quality and early maturity.
- Be compatible with a range of scion varieties grown in the area.
- Have some resistance to termite attack.
- Have some slat exclusion characteristics.
- Have a high plant health status.

The need to evaluate other trellis designs was also identified as a means of coping with additional vine vigour and at the same time increasing the potential for improved vine yields and fruit quality.

Method:

With the assistance of property owners and managers the various scion/rootstock combinations growing on properties in the area were identified and vines were tagged. Varieties growing on their own roots were also included in the assessment. The rootstock/scion combinations now included in the evaluation program are listed in Table 1.

Table 1. Scion/rootstock combinations under evaluation

Scion	*Rootstock*	**Scion**	**Rootstock**
Flame Seedless	Own roots	Sultana	Own roots
	Paulson		Schwarzman
	Freedom		Freedom
			Ramsey
Menindee Seedless	Paulson		Paulson
	Schwarzman*	Sultana M12	Paulson
	Freedom		
	Sultana H5	Crimson Seedless	Paulson
	Schwarzman*		Ramsey
	Sultana H5		Teleki
	Schwarzman		Schwarzman
	Harmony		
	Paulson		

* Denotes comparison between vines on V trellis and sloping T trellis

Data collection from the plantings includes:

Assessment of vine vigour:	Pruning weights, light penetration into canopy
Nutrition monitoring:	Petiole analysis
Assessment of crop load:	Bunch counts
Yield assessment:	Yield per vine
Fruit quality assessment:	Berry diameter berry weight, brix and acid measurements.

As noted in Table 1, a comparison between similar scion/rootstock combinations growing on V trellis and sloping T trellis will also be made. Other scion/rootstock combinations will be added to this project in season 2003 and will include vines grown on interstocks.

Results:

Only two seasons' data has been collected from vines. Data from at least another five seasons will be required to enable any long-term trends in scion/rootstock characteristics to be identified. Additional resources will need to be allocated to this project over the next five years to collect the data required to enable the most suitable scion/rootstock combinations for table grape production in Central Australia to be identified.

PROGRAM: The Tropical Crops Industry

PROJECT: Miscellaneous Fruit Research

Project Officer: **G. McMahon**

Location: CPHRF

Objectives:

Research and identify suitable fruit crops for Top-End production.

Evaluate phenology and yield of selected pitaya and low land longan varieties, and multiply and release proven varieties to industry.

Pitaya:

The trial consists of five varieties of pitaya. *Hylocereus undatus*, varieties Ex Qld, Bin Than and Colombia, are red-skinned and white fleshed. *Hylocereus polyrhizus*, is a red skinned - red flesh type, and *Selenocereus megalanthus*, is the yellow pitaya. The trial at CPHRF will end this year and the plants have grown large and matured well over the past year. The different varieties have developed quite different forms and display different growth habits. The white fleshed pitaya *H. undatus* variety Bin Than grew well up the poles and sprawled unevenly over the top, where *H. undatus* variety Colombia was very uniform in its shape. *H. polyrhizus*, the red fleshed pitaya, did not adapt to growing up a pole and tended to show a spreading form, more suited to a fence or trellis (see Figures 1 and 2).

Figure 1. *H. undatus* var Bin Than

Figure 2. *H. polyrhizus* – red pitaya

The physical form of the branches and configuration of the spines on the branches is also different between the varieties. Branch growth is limited during the flowering and fruiting season, which extends from mid September to mid March. The white fleshed pitaya (*H. undatus*) is a long day plant and requires 12 hours or more of daylight to initiate flowering. The red fleshed pitaya (*H. polyrhizus*) does not appear to require a certain day length to initiate flowering, as it will flower as late as June. When harvesting is finished in mid April for the white fleshed varieties, a major 'branch flush' occurs and continues throughout the dry season. Flowering begins again in September and most of the varieties

have three or four flower cycles. Variety ex Qld has almost continuous flowering between mid September and the end of December (see Table 1).

Table 1. Observed flowering times for different pitaya varieties for 2002-03 season

Variety	1 Sep	15 Sep	1 Oct	15 Oct	1 Nov	15 Nov	1 Dec	15 Dec	1 Jan	15 Jan	1 Feb	15 Feb	1 Mar	15 Mar	1 Apr	15 Apr	1 May	15 May	1 Jun	15 Jun	1 Jul	15 Jul	1 Aug	15 Aug
Ex Qld																								
Bin Than																								
Colombia																								
Red																								
Yellow																								

Note: Ex Qld, Bin Than and Colombia are white fleshed varieties.

Yield data was collected from all the varieties (see Table 2). It is interesting to note the relationship between the flowers produced and the resulting fruit numbers.

Table 2. Yield for 2002-03 season

Variety	No. of plants	Total flowers	Total fruit	% fruit	Ave fruit wt (g)	Yield/plant (kg)
Ex Qld	5	226	205	90.7	327.02	13.40
Bin Than	4	125	119	95.2	315.66	9.39
Colombia	3	366	18	4.9	*	
Red	3	35	21	60.0	153.93	1.07
Yellow	3	62	9	14.5	27.32	0.12

* Fruit was not assessed, because it had not reached maturity. Note: Ex Qld, Bin Than and Colombia are white fleshed varieties.

The variety ex Qld and Bin Than showed the most promise, with the highest yields and percent fruit set. Colombia produced the highest number of flowers but appears to have problems with pollination. The red pitaya would grow better on a fence or trellis as it did not thrive on poles, and for unknown reasons the yellow one also did not progress well.

When this trial was set up two different types of timber frames were used at the top of the concrete poles for the plants to hang over. One was a 600 cm x 100 cm x 50 cm timber cross, bolted to the top of the concrete poles, and the other consisted of four upright pieces of timber bolted to the top of the poles. There appears to be no difference in production between the two methods, but the larger area provided by the cross, at the top of the pole gave the plant more stability when it began to hang over the top.

The plants themselves have not suffered any major insect attack and appear to be relatively pest-free. Ants however, have caused considerable damage to flowers and fruit. The meat ant (*Iridomyrmex sanguineus*) in particular is attracted to the flowers and chews the bracts on the flower buds. When the fruit develops the damage is amplified on the fruit causing large areas of surface damage. The ants can be controlled using a sticky barrier around the bottom of the plant and the pole to prevent them from climbing up the plant. Birds have also become a problem and cause extensive damage to fruit. Measures will have to be taken to prevent bird damage to crops, and netting of some form may be the best possible solution.

Figure 3. Damage to fruit caused by birds

Longan:

The Vietnamese low land longan (*Dimocarpus longan*) continues to be assessed for growth, phenology and yield. Three varieties were planted in 1999, Mata Kuching, Xuong com vang, and an unnamed variety called ex Vietnam. These trees have established well with only a few deaths due to termites. In January 2003, 19 more trees were planted from subsequently imported seed from South Vietnam. This introduced two more varieties, Long and Tieu in the trial. Tieu is the most commonly grown variety in South Vietnam and has a small seed and a large amount of flesh. Long has generally inferior fruit characteristics but better taste. It is more commonly used as a rootstock. The new trees have established well.

Flowering began in late August through to November, with another small flowering in January. Flowering intensity ranged from 20% to 90% and only the variety Xuong com vang flowered.

Fruit-set and development began in September and harvest began in December through to February. Yield data is shown in Table 1.

Figure 4. Three year old longan tree in flower

Figure 5. Longan tree with fruit

Table 1. Yield data for 2002-03 season

Tree ID	Number of fruit	Total yield (kg)	Avg wt. / fruit (g)	% flesh recovery
R3T4	421	6.48	15.4	56.0
R3T6	793	11.43	14.4	56.7
R3T8	149	2.32	15.6	57.2
R3T10	320	4.82	15.0	50.8
R3T14	697	11.17	16.0	51.1
R4T8	185	3.46	18.7	56.3
R4T10	174	2.89	16.6	56.2
R4T14	258	4.25	16.4	56.4

Note: Yield was from Xuong com vang only.

The yield figures for the first season (three-year-old trees) look very promising and compare favourably with longan grown in Thailand, where the average yield in the fifth year is about 2–5 kg per tree. The premium commercial grade fruit in Thailand is in the range of 10 to 18 g, but the flesh recovery can be as much as 75%. Further yield data needs to be collected before any selection process can take place and the other varieties have not produced fruit as yet.

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

Project Officers: C. Wicks, J. Orchard, C. Kelly, N. Leibel and G. Dunker

Location: CPHRF

Objectives:

Generate an in-depth knowledge of cocoa production in northern Australia.

Using that knowledge, refine an economic model for cocoa production with the aim of determining the economic viability of cocoa production in northern Australia.

In late 1997, Cadbury Schweppes Australia approached the then DPIF, Agriculture WA and Queensland DPI with a proposal to commence a collaborative feasibility study to develop a cocoa industry in northern Australia. Cadbury Schweppes is concerned that the increasing demand from Eastern Europe and China, combined with the continuing problems with supply from traditional cocoa growing areas may lead to a shortfall in production. Currently cocoa prices are rising as forecast.

After various study tours and an economic analysis by an independent consultant, a number of meetings were held. Those attending included representatives from NTDBIRD, Cadbury Schweppes, RIRDC, QDPI and AgWA. These organisations agreed to form the "North Australia Cocoa Development Alliance", which will coordinate all activities, including future commercial development subject to feasibility of the crop. It was agreed that the NTDBIRD would be directly involved in cocoa yield evaluation and clonal introduction projects.

In late 2002 a full review and updated economic analysis was made of cocoa production in Australia. This review was also used to decide if a three-year extension to the project should occur. During that review the WA Department of Agriculture decided to discontinue its involvement in the trial. An agribusiness company, Timbercorp, was initially interested in the project but after contributing funds and expertise for 18 months, it too decided to discontinue their involvement in the trial. The review concluded that a further three-years' work was both necessary and justified.

In the Northern Territory the hybrid evaluation trial has suffered some setbacks. These were due to a catastrophic loss of shade trees as well as an extremely cold dry season in 2002. However, the removal of shade trees has helped the trees planted in the single-density plots to start catching up with the double-density trees in terms of growth (Table 1).

In 2002 the first harvests were made with a very small number of 471 pods taken from the entire planting area (Table 2). This first round of harvest took only ten weeks and was complete in late November 2002. However, in January-April 2003 there was a dramatic increase in flowering which resulted in much higher yields through May-July 2003. This data will be presented in the next report when harvesting would have been completed.

Table1. Height and trunk diameter of lines planted in the NT hybrid x density trial

Hybrid	Height (mm)		Trunk diameter (mm)	
	Double rows	Single rows	Double rows	Single rows
KA2-106 x KEE12 (H1)	2350	2270	60	54
KA82 x KEE5 (H2)	2800	2420	68	58
KA2-106 x KEE23 (H4)	2650	2570	68	63
KA82 x KEE12 (H5)	2550	2430	61	62

Table 2. Number and weight of cocoa pods harvested from the NT hybrid x density trial in the 2002 season

Hybrid	Number of pods		Weight of pods (kg)	
	Double rows	Single rows	Double rows	Single rows
KA2-106 x KEE12 (H1)	88	34	20.8	6.5
KA82 x KEE5 (H2)	66	11	20.3	2.5
KA2-106 x KEE23 (H4)	85	35	20.4	9.3
KA82 x KEE12 (H5)	94	58	22.6	11.2

The clonal material is growing well under permanent 50% shade. There has been significant flowering only in March and April 2003 and harvest is yet to be done.

As part of Cadbury Schweppes' commitment to cocoa research in Australia, it is sponsoring a Ph.D student, Mr. Nathan Leibel, to work in the NT under the supervision of the University of Technology, Sydney and the Northern Territory University. He is working mainly on the physiological responses of cocoa plants to the long light regimes in the NT. The work will develop ways to use shade for cocoa production in northern Australia.

PROJECT: Improving Durian Productivity

Project Officers: C. Wicks, G. McMahon and G. Dunker

Location: BARC, CPHRF and Mrs Siah's Durian Block at Lambells Lagoon

Objective:

In conjunction with other workers in Australia and overseas develop an integrated disease management system for controlling Phytophthora related diseases of durian.

The main objective can be expanded to:

- ***Identify and multiply the three most suitable varieties for the NT.***
- ***Introduce new cultivars from Malaysia, Indonesia and Vietnam, and assess for future potential.***
- ***Improve durian orchard establishment and sustainability and consistency of quality fruit to supply expanding markets.***

Mulch and green manure trial in the field

The aim of this trial is to identify in the field a best practice for reducing the incidence of *Phytophthora* disease in durian, by using mulches and/or (ground cover) live manure. There are three mulching treatments (none, hay and hay plus chicken manure) and three live manure treatments (none, Wynn Cassia and sabi grass).

Up to now no *Phytophthora* has been detected. There have been some tree deaths but these can be attributed to longicorn attack, poor water management and competition from the Wynn Cassia (Table 1). It has also been noted that without shading, the young trees become sickly, which may predispose them to attack by *Phytophthora* in the future.

Table 1. Death of durian trees in the orchard

Cover	% Deaths		Mulch	% Deaths
Bare ground	30		As per cover	38
Sabi grass	43		Hay	58
Wynn Cassia	58		Hay + compost	33

The Wynn Cassia is growing so well that it has previously competed with the young trees, again possibly predisposing them to attack by *Phytophthora*. This competition has been reflected in the collected data over the past two years. Tree height was greatly restricted prior to removal and control of the cover from the base area of the trees. Since a control of the cover was introduced, trees have grown steadily.

It should be noted that the commercial collaborator has implemented a program of planting Wynn Cassia inter-row and is applying thick hay layers under the trees themselves.

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

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

Efforts to inoculate the pots with *Phytophthora* have been unsuccessful. Alterations to the methodology have been identified and will be trialled. The other problem with the trial is the crowding which is encouraging leaf disease and causes a large degree of competition for light. There has also been a large amount of longicorn damage, which has killed trees that had been stressed by irrigation and fertiliser treatments (Table 2).

Table 2. The effect on potted durian trees of either a long-term cycle of droughting or a high level of basal fertiliser application

Irrigation	% "Sick" trees		Basal inorganic fertiliser	% "Sick" trees
Control	17		Standard	17
3-day drought cycle	33		2x Standard	33
7-day drought cycle	100		3x Standard	67

The definition of "sick" includes tree death and serious leaf blight/twig death. The standard fertiliser rate is 200 g per tree, four times per year.

This research has already identified a useful management practice for growing durian. The large majority of growers do not use living mulch. The benefits of using living mulch are obvious to growers, even with the increased management costs, particularly in the early stages of seedling establishment.

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

PROGRAM: The Sub-tropical Crops Industry

PROJECT: Irrigation/Nutrition Management Guidelines for Date Palms

Project Officer: A. Nesbitt

Location: Alice Springs

Objectives:

Establish water use guidelines for date palms.

Establish leaf and soil nutrient guidelines for date palms.

Very little information exists on detailed irrigation and nutrition guidelines for producing quality dates. This project aims to establish some tentative guidelines on water use requirements for date palms grown in Central Australia, as well as suggest leaf and soil nutrient standards for date production.

Irrigation

Past seasons' results indicated the 30 cm tensiometer had the greatest fluctuation but was consistently kept above –20kPa. With the 90-cm tensiometers showing readings between –35kPa to –20Kpa, the soil was obviously well watered throughout the season. It is known that mature date palms may use 27 ML/ha of water per annum. However, it is not known whether these tensiometer values correspond with actual crop water requirements. Limited resources have prevented further work on this issue.

Nutrition

Leaf and soil samples were collected throughout the season to monitor fluctuations in essential nutrients. This information will also be used to establish nutrition guidelines for date palms in Central Australia. Table 1 shows the range in values of selected nutrients monitored in leaf and soil samples over the past three seasons. Large fluctuations seen in many of the soil samples are most likely due to seasonal timing of the sample as well as interference from fertiliser applications, particularly nitrogen and phosphorus.

Table 1. Ranges of nutrient levels found in leaf and soil samples (October 1999 to January 2003)

Nutrient	Soil range (top 30 cm)	Leaf range, %
Nitrogen*	2.6 – 25, mg/kg (nitrate N)	0.97 – 1.43
Phosphorus	2 – 29, mg/kg (Olsen P)	0.05 – 0.099
Potassium	0.32 – 0.68, cmol(+)/kg	0.43 – 1.03
Calcium	3.4 – 4.98, cmol(+)/kg	0.62 – 0.95
Magnesium	1.8 – 2.65 cmol(+)/kg	0.14 – 0.28
Sodium	0.04 – 0.95, cmol(+)/kg	$2x10^{-3}$ – $6x10^{-3}$

Tentative recommendations can now be made for relative leaf nutrition levels, particularly for nitrogen, potassium and phosphorus (see Table 2).

Table 2. Recommendations for leaf nutrient levels

Nutrient	Adequate range	Comments
Nitrogen	>1 %	Medjool may require slightly higher N levels than other cultivars
Phosphorus	>0.06%	
Potassium	>0.45%	

*Note: Total nitrogen is a better indicator of relative nitrogen levels as nitrates can rarely be measured in date palm plant material.

Future Work

A similar sampling regime may continue for one more season, at which time modifications to the above values will allow us to make tentative recommendations for optimum soil and leaf status for most nutrients for date production. The results gained from this sampling regime are also used as an important tool in assisting with the development of this industry.

PROJECT: Evaluation of Stone and Pome Fruit in Central Australia

Project Officers: **D. King, D. Salter, I. Broad, N. Isgro A. Nesbitt, and G. Kenna**

Location: Arid Zone Research Institute (AZRI) and Ti Tree Research Farm (TTRF)

Objectives:

Assess the potential for commercial production of stone fruit in Central Australia.

Assess the potential for commercial production of apples in Central Australia.

Introduction

At present, there are no commercial plantings of stone fruit in the Alice Springs region. There are, however, indicators that potential markets for Central Australian stone fruit may exist in the Northern Territory and interstate.

Research plantings of stone fruit have been established at AZRI in the past. Initially these plantings grew well and produced satisfactory crops, however they eventually became unthrifty and had a short life. The rootstock used for these earlier plantings was Nemaguard. Nemaguard was unable to adapt to the high pH levels of the soils, and the high soil temperatures through the summer period.

Method

New plantings of peaches, nectarines, apricots and plums were established at AZRI in 1996, 1997,1998 and 1999. Several high and medium chill varieties were removed in September 2002. Presently there are plants of five varieties of apricots, five varieties of plums, eight varieties of peaches and 10 varieties of nectarines.

A planting was also established at TTRF in 1998 which has nine varieties of peaches, four varieties of nectarines and two varieties of apricots. These plantings produced their first crop in 2002.The aim of growing these plantings is to evaluate the potential for the commercial production of dessert stone fruit in Central Australia. This will consist of a range of stone fruit types and varieties with varying chill requirements on a range of rootstocks.

The main rootstock used on low chill selections of peaches and nectarines is Bright's Hybrid, (a peach/almond hybrid). This rootstock resists nematodes and tolerates high soil temperatures and high pH. Plum and apricot varieties are grown on plum rootstocks Microbalan 29C and Marianna.

Results

Assessments, including fruit weight, counts, diameters and brix measurements were carried out on all varieties in the season 2002.

Significant decreases in yields were recorded in the 2002 season in all stone fruit varieties, compared with the 2001 season. A heavier pruning regime, more intense thinning, later than normal frosts and varying weather conditions (41°C in mid October and 137 mm of rain in November) contributed to the decrease in yields (see Figure 1).

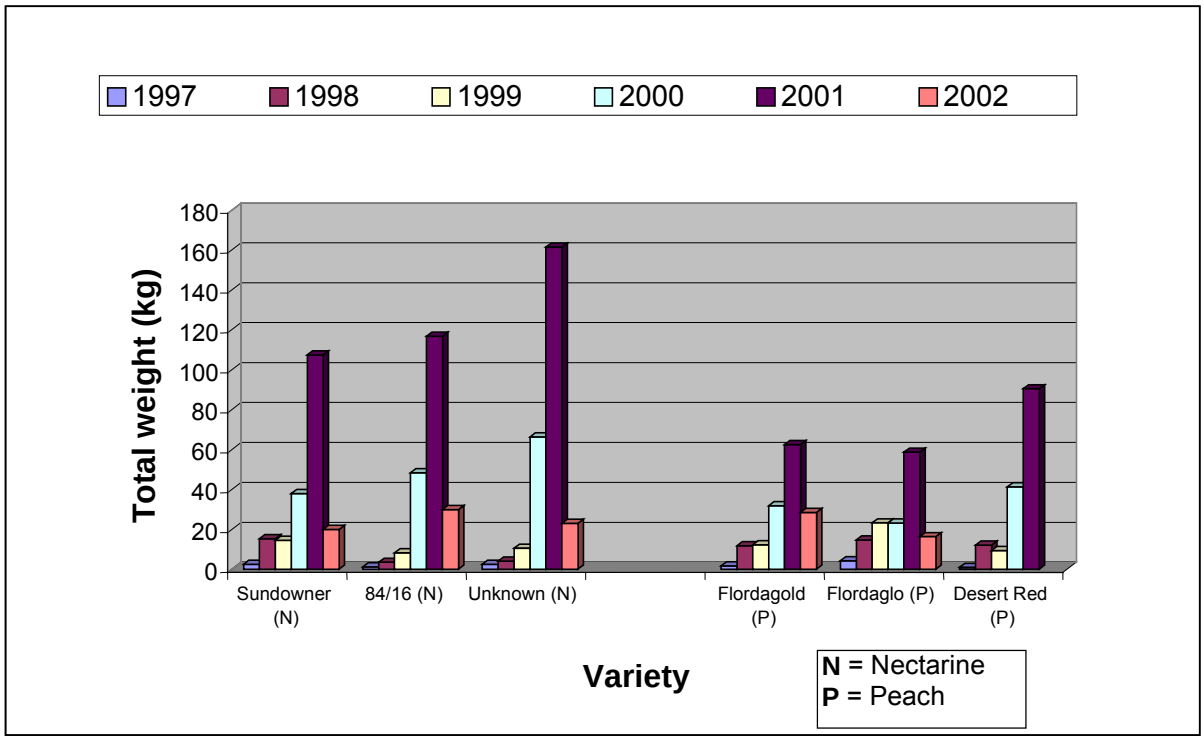

Figure 1. Average yield per tree (kg)

Peaches

In 2002 flowering for low and some medium chill varieties occurred from 2 August through until the end of the month, while harvest commenced in early November lasting until mid December. Trees were harvested two to three times a week. High chill varieties flowered later; harvest was completed by the end of December.

Average yields per tree decreased dramatically in 2002. Flordaglo decreased by 72% from the previous year, Flordagold by 54%, while Desert Red failed to produce any significant yields (see Table 1). Sugar levels in all the assessed varieties exceeded the Australian standards (Table 2). Fruit size was smaller than in previous years (Table 3).

Nectarines

Flowering in nectarines in 2002 was similar to that in peaches (early August through until early September). Harvest commenced in early November and lasted until the end of the month.

There was a decrease in yield per tree in Sundowner (6/3) of 81%, in 'Unknown' of 86% and in Sunraycer (84/16) of 74%, over the previous year (Table 1). Sugar levels in all assessed varieties

were well in excess of the Australian standard (Table 2). Fruit size was also down on previous years (Table 5).

Apricots

The only producer in 2002 was the Trevatt variety. Its production decreased by 81%. Apricots need a longer period to establish. Most trees are expected to carry a light crop in the 2003 season (Table 1).

Table 1. Stone fruit production - average yield per tree (kg)

Variety	1997	1998	1999	2000	2001	2002
Sundowner (N)	2.51	15.32	14.59	38	107.5	20
84/16 (N)	1.17	3.52	8.35	48.4	116.8	30
Unknown (N)	2.45	4.06	10.61	66.5	161.5	23.1
Flordagold (P)	1.66	11.8	12.3	31.9	62.5	28.5
Flordaglo (P)	4.24	14.66	23.24	23.2	58.8	16.4
Desert Red (P)	0.94	12.05	9.41	41.35	90.6	
Trevatt (A)				5.4	36	6.7

N=Nectarine P=Peach A=Apricot

Sugar content of the assessed fruit was measured with a refractometer. The readings, in degrees brix, also gave indications to the relative maturity of the fruit. The refractometer readings were acquired by squeezing juice from the fruit after it had been cut into sections.

Table 2. Average brix for each variety of stone fruit

Variety	Brix	Aust.minimum standard
6/3 (N)	14.4	11.0
84/16 (N)	13.9	11.0
Unknown (N)	14.6	11.0
Flordagold (P)	12.5	11.0
Flordaglo (P)	11.1	11.0
Desert Red (P)	N/A	11.0
Moorpark Early (A)	N/A	N/A
Trevatt (A)	N/A	N/A
Moorpark (A)	N/A	N/A

N=Nectarine P=Peach A=Apricot

In Australia, most stone fruit is sold in single and double layer trays, usually by count (the number of fruit per package). Retailers, having purchased by count, usually sell by weight (kg). In order to develop some degree of industry uniformity, so that retailers would have a high degree of confidence that they were purchasing a known weight even if it was expressed as a count, a stone fruit committee agreed to certain criteria in 1987(AHC 1999) shown in Table 3.

Table 3. Size ranges for stone fruit

	Nectarine	Peach
Small	< 55 mm	<57 mm
Medium	56 to 66 mm	58 to 69 mm
Large	>67 mm	>70 mm

These are based on price look up (PLU) guidelines administered by EAN Australia. PLU numbers are those printed on fruit stickers and used by a checkout clerk at a computerised point of sale in a supermarket to identify the produce (AHC1999).

The count refers to the number of pieces of fruit packed in a single layer tray and the diameter refers to the diameter of each cell in that tray. The aim was for single layer tray weights to be in the range of 3.8 kg to 4.1 kg depending on fruit type, variety, time of season, etc. Some retailers are known to insist on a minimum of 4 kg net weight regardless of count (AHC 1999).

Table 4. Counts and diameters

Count	Diameter(mm)	Count	Diameter(mm)
13	92.5	30	63.5
14	88	32	62
16	83.5	36	58.5
18	79	40	55
20	76	42	52.5
23	72.5	46	50
25	69	52	47
28	65		

Table 5. Counts and diameters (AZRI 2000 - 2002)

Variety	Count	Ave.Diam. (mm)
Desert Red (P) 2002		
Desert Red (P) 2001	28	66.5
Desert Red (P) 2000	28	64.4
Flordaglo (P) 2002	30	64.5
Flordaglo (P) 2001	32	60.5
Flordaglo (P) 2000	36	59.7
Flordagold (P) 2002	32	59.7
Flordagold (P) 2001	25	68
Flordagold (P) 2000	28	64.6
Sundowner 6/3 (N) 2002	40	53.2
Sundowner 6/3 (N) 2001	36	58.7
Sundowner 6/3 (N) 2000	40	54.6
Sunraycer 84/16 (N) 2002	42	48.4
Sunraycer 84/16 (N) 2001	40	55.2
Sunraycer 84/16 (N) 2000	40	54.3
Unknown (N) 2002	46	47.5
Unknown (N) 2001	36	58
Unknown (N) 2000	36	56.8

N= Nectarine P=Peach

Tree Nutrition

Results from leaf nutrient analysis in 2002 have indicated low levels of zinc throughout the planting. A zinc spray in the cooler months (June to September) may rectify the problem. Copper and calcium levels were marginal. Copper-oxy-chloride sprays have been used to overcome the copper deficiency

problem. A light side dressing of ammonium sulphate or ammonium nitrate will help to keep nitrogen at acceptable levels. Sodium and chloride levels were very high (an irrigation-leaching program has started to rectify the problem). Leaf samples were collected in early December and showed that iron levels were marginal, however there were no visual symptoms.

Pest Problems

The use of a gas powered 'scare' gun as the fruit ripens has reduced the amount of damage caused by birds (a major problem that has occurred in the past at AZRI). Early maturing crops however, still incurred heavy losses. 'Bait' sprays have also been used in the control of fruit fly.

Summary

Overall, commercial yields of three varieties of medium and low chill nectarines and peaches planted between 1996 and 1998 were much lower than previous years. One of the three varieties of apricots planted in 1999 produced a small crop. Fruit fly infestation and severe bird damage affected marketable fruit.

Future Work

Removal of high chill varieties has allowed a more detailed and intense variety assessment to continue on selected varieties of nectarines and peaches. Nutrition and irrigation results will be collated and assessed. A further two years variety performance on the apricot varieties is needed.

Pome Fruit

Summary

Performance of the Pink Lady (planted in 1997) and the Sundowner (planted in 1998) varieties will continue to be monitored at AZRI and TTRF. Nutrition and irrigation will also be monitored in both plantings

Future Work

As apples do not come into production until five years after planting, the evaluation of these plantings will need to continue for a further twelve months.

TTRF

TTRF Stone Fruit Harvest: 2002

Results

All plantings at the Ti-Tree Research Farm are low to medium chill varieties and came into production during the 2002 season. Only minimal data has been collected at this stage.

Peaches

Of the nine varieties of peaches established at TTRF, seven produced fruit during the 2002 season. Flowering for the fruit bearing varieties commenced on 24 July and extended until 15 August. The two remaining varieties reached 100% flowering in mid September.Those varieties with the highest yields and best quality fruit were the Earligrand and Flordaglo cultivars. All varieties exceeded accepted Australian sugar standards while fruit sizes were below marketable size. (Refer Tables 1, 2 and 3)

Nectarines

Of the four varieties of nectarines established at TTRF in 1998 only Sunwright produced fruit during the 2002 season. Flowering for this variety was similar to the peaches while the remaining three varieties did not reach 100% flowering until mid to late September. Average fruit size of Sunwright was very small while the sugar levels were well above Australian standards (see Tables 1, 2 and 3).

Apricots

Both varieties of apricots established at TTRF failed to produce any quality fruit. As they are still in the early stages of maturity, they will need more time to establish.

Table 1. Average yield per tree (kg)

Variety		2002
Sunwright	(N)	6.4
Earligrand	(P)	18.3
Flordagold	(P)	5.8
Flordaglo	(P)	22.25
TropicSnow	(P)	17
Aztec Gold	(P)	21.7

N=Nectarine P=Peach

Table 2. Average brix

Variety		Brix	Aust. min. standard
Sunwright	(N)	20.2	11
			11
Earligrand	(P)	12.7	11
Flordagold	(P)	13.7	11
Flordaglo	(P)	13.1	11
Tropic Snow	(P)	14.1	11
Aztec Gold	(P)	17.7	11

N=Nectarine P=Peach

Table 3. Average fruit numbers and diameters

Variety		Number	Diam(mm)
Sunwright	(N)	180	40.8
Earligrand	(P)	206	52.7
Flordagold	(P)	112	48.1
Flordaglo	(P)	353	50
Tropic Snow	(P)	385	44.6
Aztec Gold	(P)	527	40

N=Nectarine P=Peach

Tree nutrition

Results from recent leaf analysis indicated slight deficiencies of zinc, nitrogen and calcium throughout the plantings. A fertiliser program, including a zinc spray in the cooler months (June to September) and a side dressing of ammonium sulphate or ammonium nitrate has been implemented to remedy this problem. High levels of sodium and chloride were found in the peaches and nectarines. Irrigation scheduling has been re-programmed to address this problem.

Pest problems

Bird damage in the early maturing varieties was the only major problem experienced during the 2002 season.

Summary

As the plantings are just reaching producing age and only minimal data has been collected, it is hard to make comparisons. However, from the available information, the Earligrand and Flordaglo peach varieties look promising if larger fruit size can be achieved.

Future Work

As the plantings are still to mature fully, especially the apricots, data will continue to be collected and assessed in the 2003 season.

Reference

Australian Horticultural Corporation (1999) Product Description Language: Stone fruit.

Australian Fresh Stone Fruit Association

PROGRAM: The Ornamental Industry

PROJECT: *Curcuma* Crop Development and Improvement Part 1 - New Cultivars

Project Officers: D. Marcsik, E. Laska, M. Hoult, M. Connelly and C. Ford

Location: Berrimah Farm

Objectives:

Provide the local ornamental industry with new and unique Curcuma hybrid varieties for cut-flower and "potted colour" over the next four years.

Enhance the market opportunities of Curcumas both as cut-flower and "potted colour" in the next four years.

Introduction:

In the last two years over 80 accessions of *Curcuma* have been assessed for potential as commercial cut-flower types. Many of these accessions originated from South-East Asia, in particular Thailand and others are derived from the local species *C. australasica.* Through this evaluation phase and in consultation with the local flower grower group, a number of accessions have been identified as promising cut-flower types. Several have also shown good promise for "potted colour" production and warrant further development.

In the past the *Curcuma* evaluation site had been intensively cultivated for vegetable and flower research and root-knot nematode (*Meloidogyne* spp.) was identified in high numbers. During the *Curcuma* field evaluation, problems with nematodes and bacterial rot resulted in poor growth and even death for a number of accessions. There was a clear need for a safe and efficient method for treating rhizomes for these problems. One such method was hot-water treatment, which has been used with success in *Curcuma* in Thailand.

In 2002, DBIRD horticulturists initiated a breeding program for *Curcumas* to develop new and improved varieties for cut-flower production. The selection criteria were based on improved vase-life, yield, stem length, and a range of different inflorescence forms suited to growing in our conditions. Although cut-flowers were the primary focus of the breeding work, the potential for some of the crosses as "potted colour" was also identified. This report discusses the first stage of the *Curcuma* breeding work in conjunction with observations on hot water dipping as a method for controlling diseases and nematodes in rhizomes.

Method:

Hot water treatment

Curcuma rhizomes of selected accessions were dug up and removed from the evaluation planting at the BARC Horticulture block. Rhizomes of each accession were rated for severity of root and rhizome damage from nematode infestation and bacterial rot. Rhizomes were then washed and all infected roots and storage tubers were removed. All rhizomes were then surface sterilised in a 5% calcium hypochloride solution (100 ppm active chlorine) for two minutes and left to air-dry in seedling trays at room temperature.

Accessions were subjected to the following hot water dip (HWD) treatments based on size and weight of the rhizome: 48^{o}C x 20 min; 50^{o}C x 15 min; and 50^{o}C x 30 min. A precision thermostatic circulating 38 litre hot water bath (Grant Model W38) was used to immerse the rhizomes. Water temperature was confirmed periodically using a digital thermometer probe. Depending on available rhizome numbers the rhizome core temperature was recorded also with a digital thermometer probe inserted into the middle of the rhizome immediately after the HWD treatment.

Following each treatment, rhizomes were hydro-cooled using tap water for 20 minutes and then allowed to air-dry at room temperature. Non-hot water dipped rhizomes were potted up into 200 mm or 300 mm poly-pots, depending on the size of the rhizomes. The steam-pasteurised growing media consisted of equal parts of peat: sand: pine bark with an adjusted pH of 6.8 and a complete, control-released fertiliser added at 4 g/L of media. HWD rhizomes were potted up in a similar manner as the non-HWD rhizomes and all pots were arranged on benches in a shade house. Pots received overhead irrigation twice a day and were fertigated twice a week with a complete fertiliser at 2 g/L.

Hybridising

Crossing commenced with the early flowering accessions in December and continued to the end of March. Pollinating was conducted between 0800 to 1100 hours with female day-flowers emasculated and pollinated with fresh male donor pollen and marked with a label attached with string tied around the bract (see Figure 1). Capsules that set on the inflorescence were left to mature and seeds were collected immediately after the capsule dehisced (see Figure 2).

Figure 1. Pollinated female day-flower with label attached

Figure 2. Seed capsule set on inflorescence bract

Results:

Hot water treatment

The degree of rhizome rot and nematode damage depended on the species and accession. All *Curcuma aurantica* accessions were found to have severe nematode infestation and rhizome rot. These rhizomes had none to very little healthy root extensions and T-roots (i.e. storage roots) attached (see Figures 3 and 4). *C. alismatifolia* accessions had moderate nematode damage where at least 50% of the T-roots were still healthy and attached to the primary rhizome. Low nematode infestation (>50% healthy T-roots visible) was observed on rhizomes of *C. thorelli*, *C. gracillima* and *C. sparganifolia* accessions (see Figure 5).

Figure 3. *Curcuma* rhizomes with severe nematode damage

Figure 4. *Curcuma* rhizomes with bacterial rot damage

Figure 5. *C. thorelli* rhizomes with no nematode damage

Figure 6 shows the temperature readings taken internally from the core of rhizomes at different weights, straight after the hot water treatment. The core of the lighter weight rhizomes at 8 g and 10 g easily reached high temperatures for each of the three HWD treatments compared with the heavier rhizomes. The core of heavier rhizomes (>20 g) effectively reached high temperatures when treated at 50^{o}C for 30 minutes. Only a 5% loss was recorded in rhizomes due to deleterious effects from HWD treatment in this trial.

Hybridising

A total of 32 parents were selected and 225 cross combinations were performed during the pollination work. Approximately, 40% of these crosses were successful resulting in 108 families comprising a total of 16,000 hybrid seeds produced. Fresh seeds were collected daily and left to air-dry for 24 hours then placed in seed envelope packets, labeled and stored for future sowing.

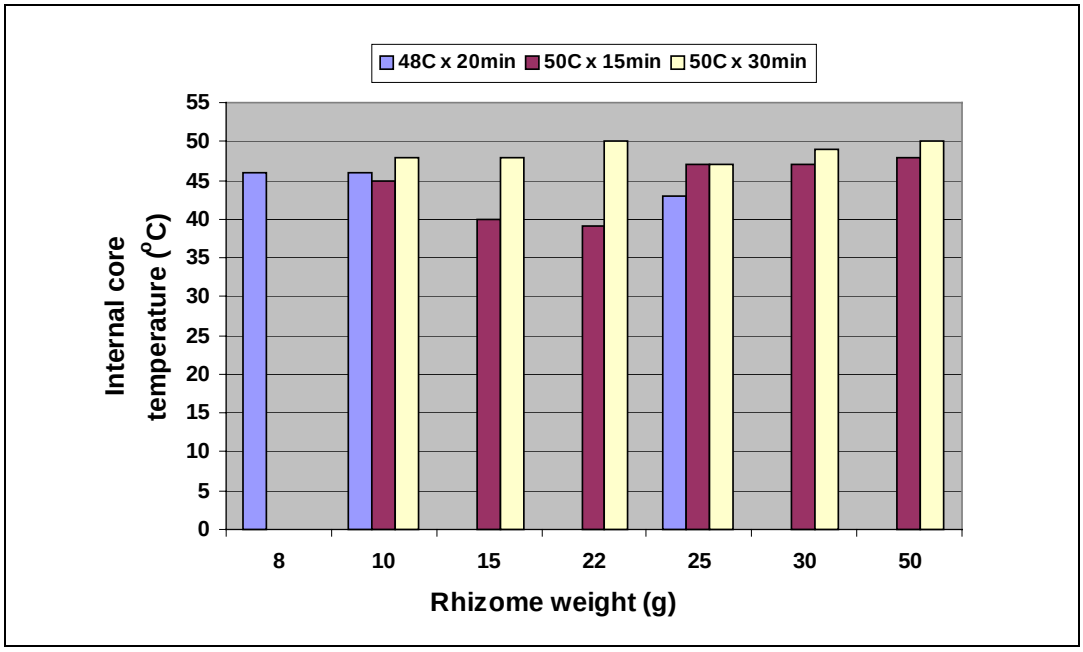

Figure 6. Internal core temperature for different rhizome weights

Conclusion:

The HWD treatment of *Curcuma* rhizomes was not deleterious as only 5% of them actually died. This allowed for the pot cultivation and flowering (hence access to pollen), of many accessions which grew very poorly in the field. The hot water treatment is standard commercial practice in Thailand on *C. alismatifolia,* where it is used to control the bacterial rot disease *Pseudomonas* spp. Further studies will need to be conducted to determine if the HWD treatment completely eliminates local disease and nematodes from the rhizomes. Hybridising *Curcumas* has few practical limitations and conventional breeding within the genus *Curcuma* appears to offer great promise for developing new varieties for cut- flower and “potted colour”.

The next phase of the *Curcuma* breeding work involves the screening and selection of hybrids with specific desirable cut-flower and "potted colour" traits. It is proposed that a selection of hybrids will be established at the BARC Horticulture block to be screened for promising cut-flower types. In addition, a number of hybrids will be released under licence for experimental growing and market testing. A strategy is currently being developed for the release of these new *Curcuma* hybrids.

Acknowledgement:

We would like to acknowledge the assistance of Nick Mendham on the *Curcuma* breeding program, particularly for his consistently diligent work in pollinating the flowers. Also thanks to Rodney Aiton for his assistance and valuable contribution to the Ornamentals Program over the last two years.

PROJECT: Curcuma Crop Development and Improvement Part 2 - Rhizome Dormancy

Project Officers: A. Black (Diploma Student NTU), D. Marcsik (DBIRD) and S. Kandiah (Lecturer at the School of Horticulture NTU)

Location: Northern Territory University (NTU)

Objective:

Investigate the influence of storage temperature and duration on breaking dormancy in Curcuma australasica

Introduction:

Shorter day-length and low temperature are two limiting environmental factors for growth and development of *Curcumas*, which become dormant during the dry season. However, during the dormancy period biochemical processes still occur in the rhizome and storage roots and which are influenced by certain factors that trigger the rhizome to break dormancy and prepare for sprouting in response to favourable conditions. In general, *Curcumas* start to sprout at the beginning of the wet season when environmental conditions are conducive to growth and development.

The factors that influence dormancy-breaking have been investigated in other flowering bulbs, such as tulips, gladioli, lilies and daffodils. Techniques have been developed to force these flowering bulbs out of dormancy by subjecting them to different storage regimes and with the application of plant growth regulators.

The aim of this study was to investigate the influence of storage temperature and duration on breaking dormancy on *Curcuma australasica* rhizomes, to stimulate bud development and to promote early growth and flowering.

Method:

In May 2002, senesced *C.australasica* plants were removed from their pots and rhizomes between 45-100 g were selected. Graded rhizomes were then placed in seedling trays and stored at room temperature in the potting shed at NTU, at three pre-treatment storage periods of two, four and six weeks. Temperature readings for rhizomes stored at room temperature during the pre-treatment and treatment storage trial period varied considerably in the potting shed, ranging from 30^{o}C to 34^{o}C during the day and 17^{o}C to 22^{o}C at night. At the end of each pre-treatment storage period, five rhizomes were randomly selected and subjected to each of the following temperatures:

Two weeks storage at room temperature	10^{o}C	15^{o}C	20^{o}C	25^{o}C
Four weeks storage at room temperature	10^{o}C	15^{o}C	20^{o}C	25^{o}C
Six weeks storage at room temperature	10^{o}C	15^{o}C	20^{o}C	25^{o}C

After treatment rhizomes were removed and laid sideways, uncovered on seedling trays lined with coco-peat and placed in a 50% shade house where they were irrigated three times a day for seven minutes.

Rhizomes were assessed once a week for bud initiation over a six-week period and the following information was recorded:

- Days to emergence of buds
- Total number of buds
- Days to sprouting of buds
- Number of buds sprouted

The experiment was a split-plot design with the pre-treatment duration as the main factor, and both treatment temperature and treatment duration as subplot factors. There were five rhizomes for each pre-treatment duration x treatment temperature x treatment duration (5 x (3 x 5 x 3) = 225 rhizomes). Data on the total number of buds was subjected to analysis of variance (ANOVA, S-Plus, Insightful Co, Seattle).

Results:

Emerging buds were observed on all rhizomes at the completion of the total storage time of 4/6, 6/4 and 6/6 weeks for all treatment temperatures. No buds were observed on rhizomes removed at the end of the total storage time of 2/2 weeks, irrespective of the treatment temperatures.

Table 1 indicates that both pre-treatment duration (P=0.0003) and treatment temperature (P=0.0238) had a significant effect on bud initiation in *C.australasica* rhizomes. There was no effect of treatment duration (P=0.5501) on bud initiation. However, there was a significant interaction between treatment duration and temperature (P=0.1845).

Table 1. Summary of split-split plot ANOVA for the effect of pre-treatment storage, treatment storage temperature and treatment duration on the total number of initiated buds

Factor	df	SS	MS	F	P
Pre-treatment	1	185.9	185.9	13.69	**0.0003***
Temperature	4	157.6	39.4	2.90	**0.0238***
Treatment duration	1	4.9	4.9	0.35	0.5501
Pre-treatment* temperature	4	54.5	13.6	1.00	0.4068
Pre-treatment* treatment duration	1	4.7	4.7	0.34	0.5554
Temperature* treatment duration	4	85.2	21.3	1.57	**0.1845***
Pre-treatment* temperature* treatment duration	4	41.3	10.3	0.76	0.5527
Residuals	191	2597	13.6		

The most significant effect on the total number of initiated buds produced was the interaction between treatment temperature and storage duration. Rhizomes stored at 10^{o}C for four to six weeks produced the most number of buds when compared with the other treatment temperatures and periods (see Figure 1).

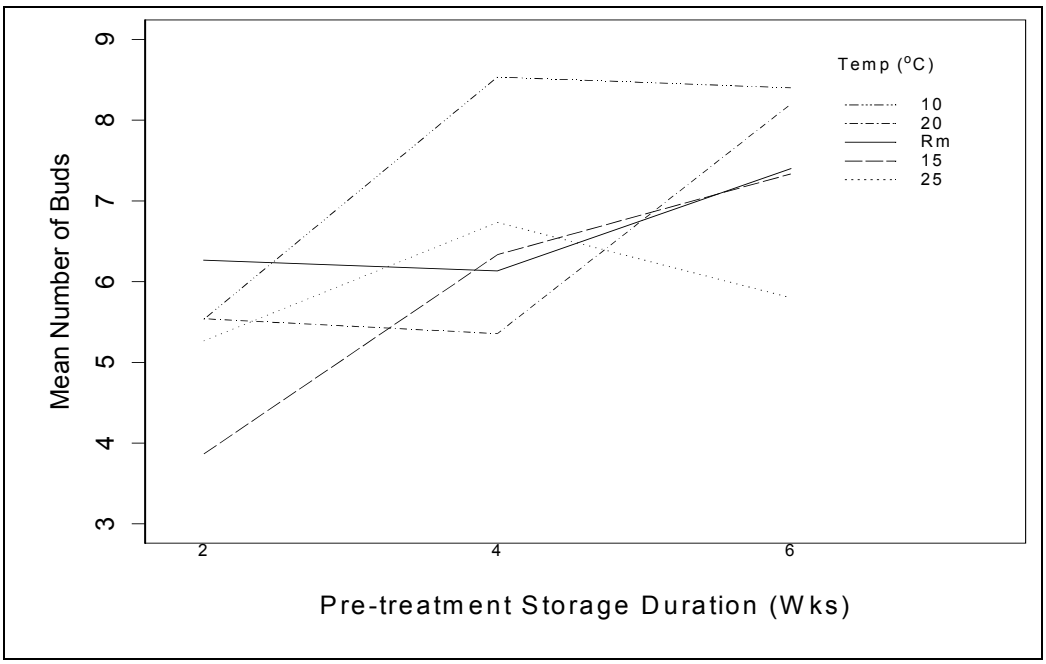

Figure 1. The effect of pre-treatment storage period on the final number of buds for the different treatment storage temperatures

Figure 2 shows the final bud count of rhizomes after total storage (pre-treatment + treatment storage) for the different treatment temperatures. Again, rhizomes at 10°C had the highest final bud count when compared with the other treatment temperatures after total storage duration of 10 weeks. The final bud count for rhizomes stored at 25°C and room temperature was highest after eight weeks total storage and for 20°C and 15°C, 12 and 10 weeks total storage, respectively (see Figure 2).

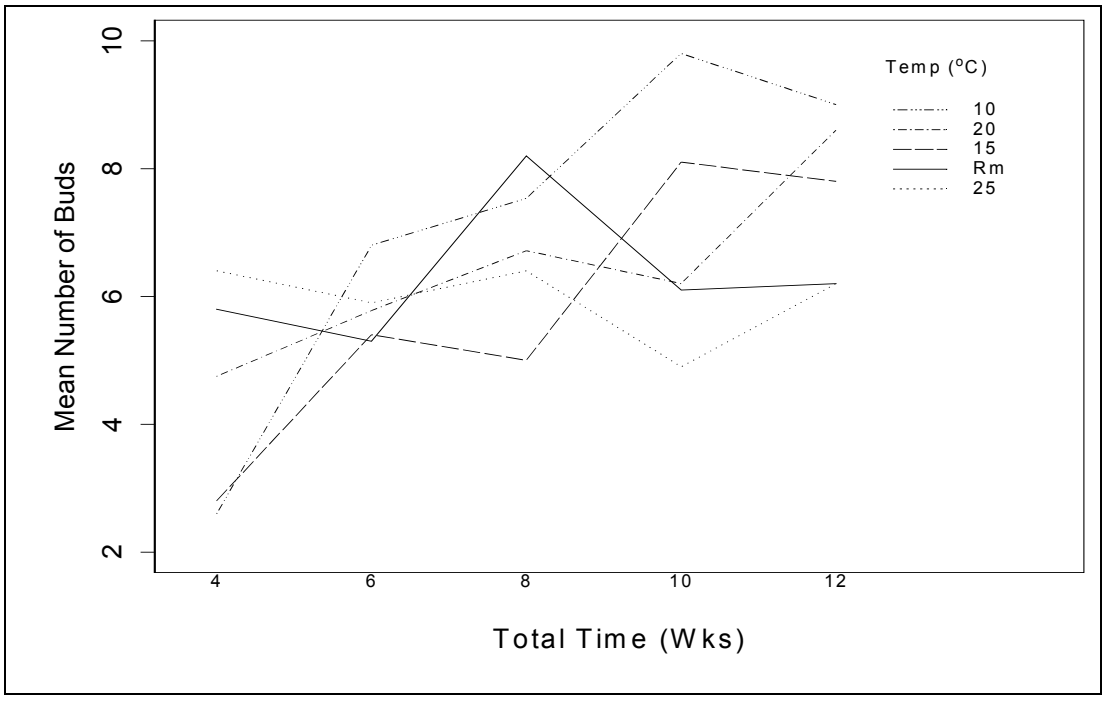

Figure 2. The relationship between the final bud count and total storage time averaged for all treatment storage temperatures

The response of total storage duration on the final initiated bud number over all the treatment temperatures is represented in Figure 3 where there is a significant increase in bud production from four to eight weeks, and only a slight increase occurring from eight to 12 weeks.

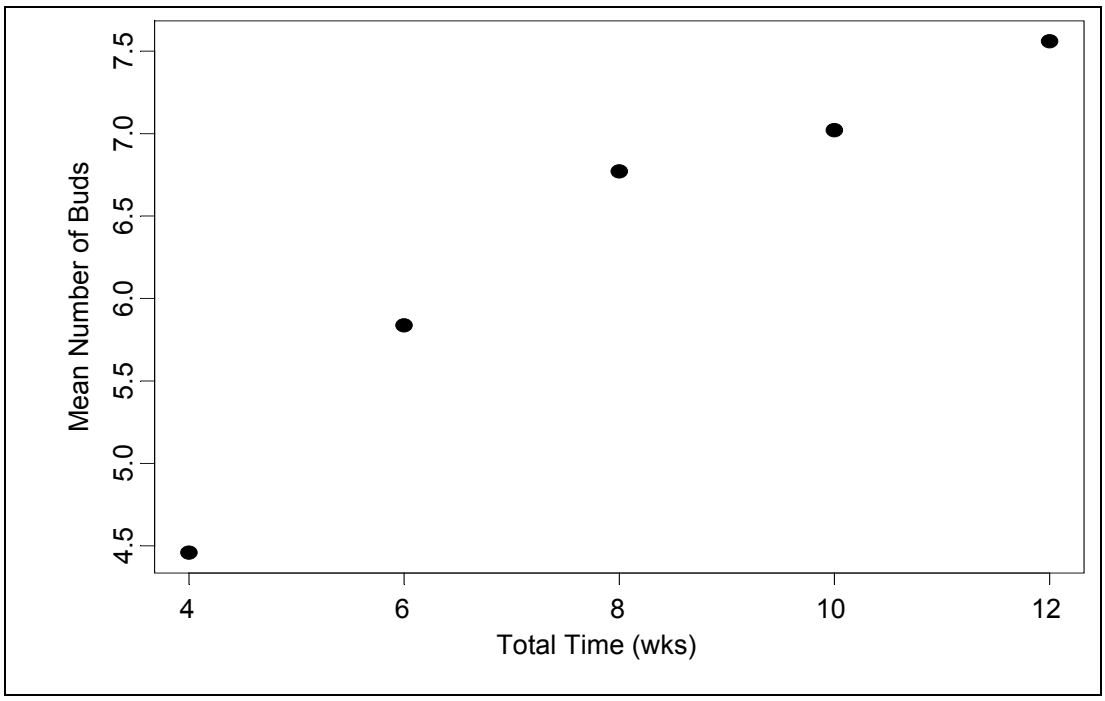

Figure 3. The effect of treatment storage period on the final number of buds for the different treatment storage temperatures

Time of bud emergence on rhizomes assessed in the shade house over a six-week period was similar for all treatments. However, a significantly higher number of emerging buds were recorded on rhizomes stored at 10°C compared with other treatment temperatures (see Figure 4).

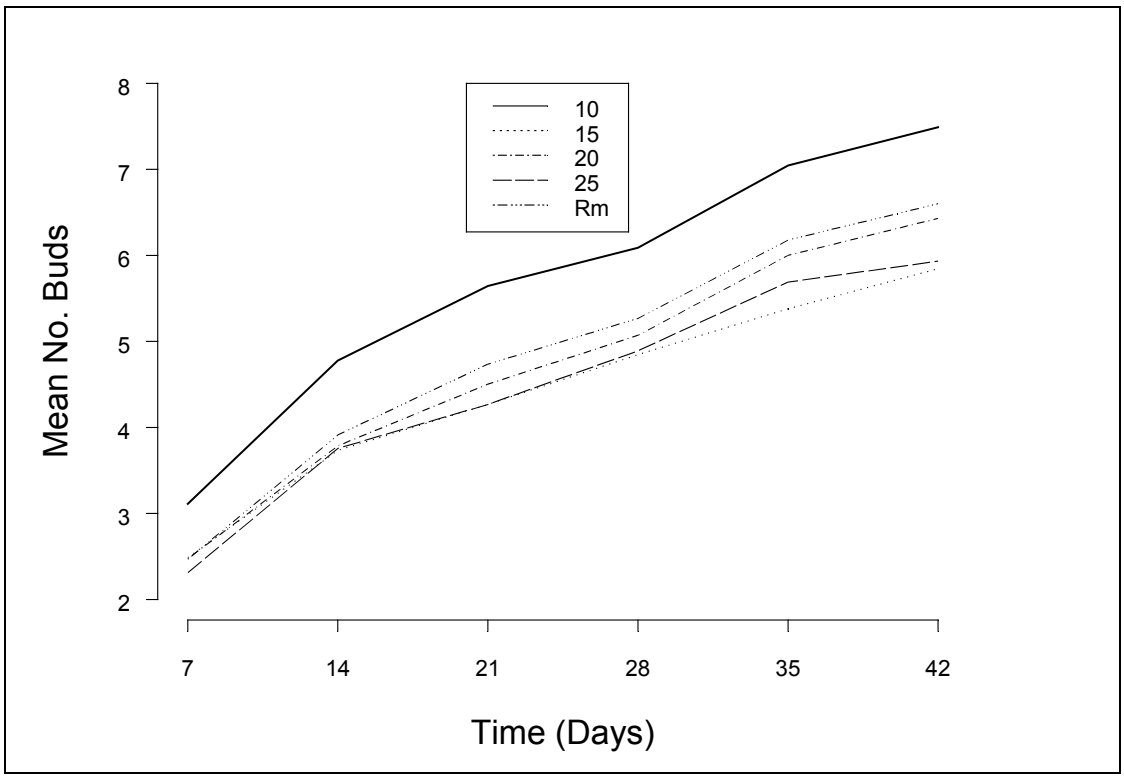

Figure 4. The relationship between the mean number of buds and days to emergence for the different treatment storage temperatures

Temperature readings taken in the potting shed for rhizomes stored at room temperature during the pre-treatment and treatment storage trial period varied considerably, ranging from 30°C to 34°C during the day and 17°C to 22°C at night. These rhizomes stored at room temperature responded similarly to rhizomes stored at 20°C and 25°C, in relation to the effect of treatment storage duration on the final bud number (see Figure 1).

Conclusion:

Results from this study show that storing *C. australasica* rhizomes at 10°C had a significant effect in promoting the most number of buds. Furthermore, there was a significant effect between temperature and storage duration on bud production that comprised of a total storage period of eight weeks (pre-treatment + treatment storage). Therefore, rhizomes need to spend part of their storage time at 10°C that can be either divided into four weeks storage at room temperature and four weeks at 10°C, or six weeks storage at room temperature and two weeks at 10°C. As for time of bud emergence, it was similar in all treatment temperatures except at 10°C when a greater number of buds sprouted.

Sprouting buds on rhizomes stored at 10°C that were potted on produced shoots significantly earlier than rhizomes potted on from the other treatment temperatures. Rhizomes from the 15°C, 20°C and room temperature treatments produced shoots about the same time, and rhizomes from the 25°C treatments took the longest to shoot in the pots. No earlier flowering resulted from any of the treatments. This study has quantified storage parameters for one species of *Curcuma* and will assist "potted colour" producers in scheduling and developing a product for specific markets.

Note: The complete report on this study can be found in "The influence of storage temperature and duration on breaking dormancy in *Curcuma australasica*" by Annie Black for her Diploma V in Horticulture (Nursery).

Acknowledgement:

Thank you to Mike Braun for donating the *Curcuma australasica* rhizomes for this study.

PROJECT: Commercialising New Ornamentals

Project Officers: D. Marcsik, M. Hoult, M. Connelly, E. Lasker and C. Ford

Location: CPHRS and growers' properties

Objective:

Assist the ornamental industry to identify and to commence commercialising five new nursery lines and three improved cut-flower products by 2004.

Introduction:

During the planning and consultation stage with the cut-flower industry on the ornamental ginger breeding work, industry identified for each of the important commercial ginger genera both positive and negative attributes. *Etlingera* was identified as a minor commercial ginger due to the negative aspect of poor vase-life. To overcome this problem in *Etlingera*, stems are generally harvested as closed buds known as "candlesticks" for interstate markets. There are very few selections that have extended vase-life when harvested in a more mature state. In 1999 hybridising of *Etlingera* was conducted to determine if vase-life could be improved. This report discusses the outcome from the crossing work and the screening and evaluation of the hybrid seedlings. The ongoing development of *Zingibers* as cut-flowers also continued with the release of a new type and the commercial evaluation of the "Darzing" series.

Etlingera

Method:

Thirteen parents were selected on the basis of vase-life, seasonality, colour, form, yield, stem length and seed set (see Table 1). Family progenies generated from the crossing were screened and assessed based on the selection criteria defined in consultation with industry (see Table 2).

Table 1. Characteristics of selected *Etlingera* parents used for hybridisation

Parent	Code	Colour	Form	Yield (stems/ plant)	Stem length (cm)	Vase-life (days)	Flowering period[b]	Seed set[c]
E. elatior 'Thai White'	TW	Light pink	Torch	100-150	>50	6-10	early-mid	yes
E. elatior 'Burmah'	BM	Dark pink	Torch	150-200	<50	3-5	early	yes
E. elatior large flowers, OP[a] selection	A3	Pink	Torch	100-150	>50	6-10	early	yes
E. elatior 'Burmah' OP[a] selection	R3.6	Red	Torch	150-200	>50	3-5	early-mid	yes
E. elatior 'Burmah' OP[a] selection	R3.9	Dark red	Torch	150-200	>50	3-5	early-mid	yes
Etlingera species No.2, OP[a] selection	R2.16	Mid pink	Torch	150-200	>50	6-10	mid	yes
Etlingera species 'Hintze Red'	HR	Red	Tulip	<100	>50	6-10	mid	yes
Etlingera species, pink leaves, OP[a] selection	B6	Light pink	Tulip	<50	>50	3-5	mid	no
Etlingera species, OP[a] selection	C7	Red	Tulip	<50	>50	3-5	mid	no
E. venusta "White Venusta"	WV	Light pink 2 tone	Tulip	<20	<50	3-5	mid	no
Etlingera helani 'Black Tulip'	BT	Red	Tulip	<100	<50	3-5	early-mid	no

a = Open-pollinated seedling; b = Seasonality of flowering; early: March-April, mid: August-October, late: November-December.
c = Seed set by open pollination

Table 2. Selection criteria for new *Etlingera* cultivars

Criteria	Minimum standard	Priority
Vase-life	>14 days	Essential
Yield	>200 stems/plant	Essential
Adaptability	full sun	Essential
Seasonality	extended harvest, continuity of supply	Essential
Ease of harvest	shoot/flower density ease of harvest	Essential
Colour/form	new range/uniform symmetrical, unique	Important
Stem length	>50cm	Important

Hybrid seedlings were established at CPHRS in November 2000 in family progeny blocks. Plants were spaced 3 m within the row and 3 m between rows and mulched with field hay annually. All plots were irrigated with overhead sprinklers and fertilised using current industry standards.

In the second year of flowering, data was collected on yield, vase-life and seasonality. Flowers of selected hybrid seedlings were harvested at different maturity depending on the openness of the bracts (see Figure 1), and placed in large upright cylinders filled with tap water in the vase-life room set at 20^{o}C and a 12 hour photo period (07:00-19:00 hours). Vase-life was assessed by a quality rating system (see Table 3), and scored by the degree of dryness and discolouration of the inflorescence bracts. The number of days from harvest to rating 3 'not saleable' and rating 5 'not suitable for vase' was recorded. In addition, during the flowering period an industry field walk was conducted for the cut-flower growers group to screen the *Etlingera* hybrid seedling block at CPHRF.

(a) Bud: only outer bracts visible

(b) ½ open: top of cone visible

(c) ¾ open: half of cone visible

(d) Fully open: cone fully visible

Figure 1. Rating description for *Etlingera* inflorescence maturity

Table 3. Rating description for vase life quality

Rating	Description
1	Flower shows no damage
2	Slight discolouration, but still marketable
3	10% discolouration, no longer saleable but still suitable for a vase
4	10 to 20% discolouration, vase-life questionable
5	>30% discolouration, no longer suitable for a vase

Source: R.Schmiechem, 1996

Results:

Crossing

A total of 89 cross combinations were conducted resulting in only nine successful crosses setting seed pods. However, only seven successful families were generated, two of them being reciprocal crosses and one an unknown cross where the paternal parent could not be identified. Less than 50% of the 583 seeds sown, germinated and survived to seedling stage. Furthermore, during the establishment phase about 60% of the hybrid seedlings died due to the field conditions of the evaluation site.

Vase-life and seasonality evaluation

A wide range of variation in vase-life was exhibited by the selected *Etlingera* hybrids assessed at the different stages of maturity. At the half-open inflorescence stage the mean vase-life to score 'not saleable' (rating 3) ranged from three to 12 days and from six to 19 days to score 'not suitable for vase' (rating 5). The mean vase-life at the fully open inflorescence stage to rating 3 and 5 ranged from three to 12 days and five to 16 days, respectively.

The seasonality of the selected hybrids extended from March to December, with most hybrids flowering during August to November. Hybrids resulting from crosses with parent 'R2.16' exhibited early flowering in March and April.

Selections

A total of 16 hybrids were selected by industry. Three hybrids were selected by two thirds of growers and another two hybrids were selected by half of the group. The most popular industry selections are shown in Figure 2. Grower comments on form, colour and other attributes for each of the selected hybrids are presented in Table 4. Rhizome material of the selected hybrids has been released to industry. Six selections have been retained by the DBIRD Ornamental Section and planted in a secure site.

(a) Selection 50

(b) Selection 132

(c) Selection 57

Figure 2. The most popular industry selections of Etlingera

Conclusion:

Controlled crossing of *Etlingera* proved difficult. Given the structure of the inflorescence, a more effective means of identifying individual flowers, which have been pollinated is needed. Further, a more thorough understanding of stigma receptivity and pollen viability would be beneficial. None the less, we have been able to provide the local industry with a range of new *Etlingera* cultivars to complement existing varieties and, importantly, with good vase-life.

Table 4. Grower comments

Parentage	Hybrid ID	Vase-life[a]	Yield[b]	Season[c]	Growers' comments colour/form/others	Grower selections[d]	Ranking criteria
TW x R3.9	No.9	9	<100	early-mid	Similar form to 'Thai White'; peachy colour; obscure day flowers	6	VL, early
"	No.50	12	>100	early	Large pink head when open; huge flower; light pink colour; similar to large 'Thai White'	14	Best VL, early, large head, >50% growers select
"	No.57	7	>100	early-mid	Early bud form; large head; dark pink colour; soft apricot as bud and deepens in colour when open to deep salmon; pink/brown; prolific flower	14	Early, good colour, large head, >50% growers select
"	No.58	11	>100	early-mid	Large pink form; deeper colour to No.57; prolific flowering	9	VL, early, large pink
"	No.59	8	>100	early	No comments	2	VL, early
"	No.96	7	>100	early	Pink colour; thin stems	8	Early flowering
"	No.98	8	>100	early	Large head; big centre cone; good tulip form; very pale pink; whitish colour; nice; big; good; light weight	8	VL, early, large form
"	No.99	12	>100	early-mid	No comments	4	Best VL, early
"	No.105	8	>100	early	Slightly frilly form; dark pink colour	9	VL, early, frilly form
R2.16 x WV	No.39	10	<100	early	Good form; light pink; darker than 'Almost White'; thin stem	8	Early, good form
"	No.40	9	>100	mid	Tulip form; white outer, deep pink inside	7	VL, tulip form
"	No.13	6	>100	early	No comments	3	Early
"	No.132	6	<100	early	Excellent form; 'pearl' form; good head size and stem length; porcelain, light pink – pink colour; lovely rosy appearance; nice, tall and light	15	Early, best form, >50% growers select
"	No.82	8			Spiky form; pink, two tone colour	6	Form, two tone colour
TWxR2.16	No.60	11	<100	early	Tulip form; cream colour	2	Good VL, early, tulip form
"	No.106	8	<100	early	Bud form looks like green candles	4	VL, bud form interesting

(a) = Vase- life at ½ open maturity to rating 3 'not saleable'. (b) = No. of inflorescent stems/plant. (c) = Seasonality of flowering; early: March-April, mid: August–October late: November-December. (d) = Number of growers that selected the hybrid (total of 20 growers).

Zingiber

Following on from the previous year's selection work (refer DBIRD Technical Bulletin No. 303), a number of commercial growers evaluated "on farm", six advanced hybrids of Zingiber spectabile known as the "Darzing" collection. All collaborators indicated interest in continuing to cultivate all or some of the selections. Market demand for the flowers continues to be strong. Of the six advanced selections all except one averaged from 30 to 40 flowers per plant in the first harvest. The exception was Chocolate Delight, which produced very few flowers in the first season.

There was great variability between farms with regard to productivity of hybrids with yield on some sites being five times that of other sites (Figure 3). Observations suggest that this yield disparity may be due to better soil aeration and organic matter levels ensuring less rhizome rot and decay. Sites where the Zingibers were grown on slight slopes and/or raised beds with free draining soils were more productive then sites prone to water logging during the wet season.

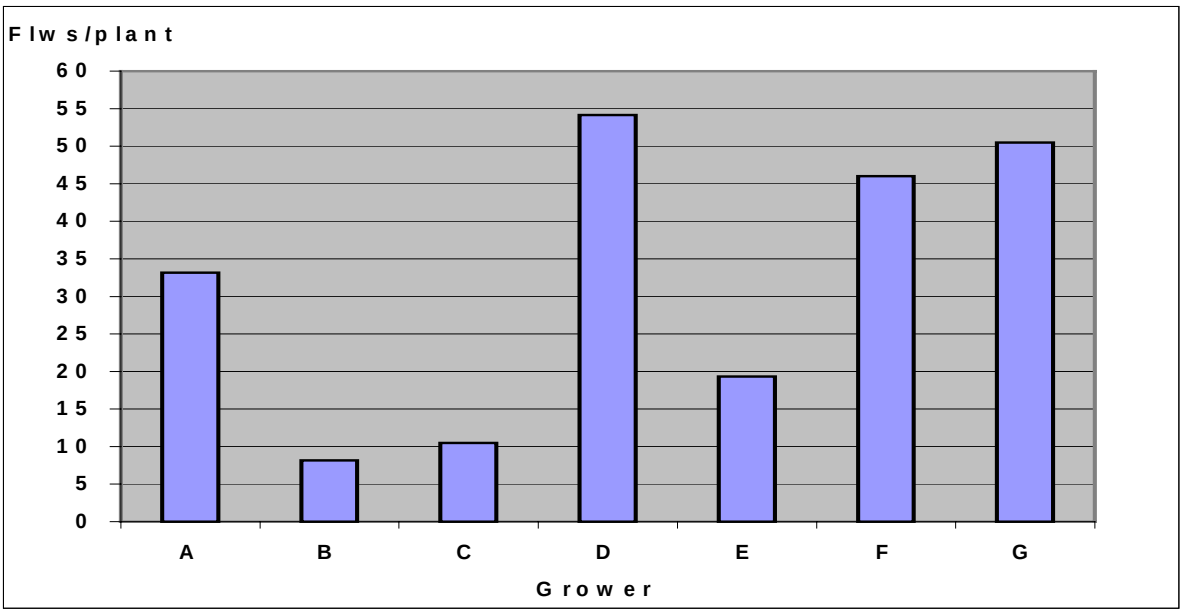

Figure 3. Average number of flowers harvested per one-year-old plants for all Darzing cultivars on several farms

In addition to the "Darzing" series, the Horticulture Division also released Zingiber species "Singapore Gold" for commercial evaluation and developed the first cut-flower "fact sheet" for release of new cultivars. It is envisaged that similar information sheets will be developed for any new departmental releases. (See Figure 4, Zingiber 'Singapore Gold' Fact Sheet for this accession).

Reference:

Schmichen, R. J. (1996). Extending the vase life of the Red Torch Ginger: An investigation of postharvest handling with the aim of extending vase life. TTH750: Study Project. Associate Diploma of Applied Science (Tropical Horticulture).

Zingiber 'Singapore Gold'

The NT Department of Business, Industry and Resource Development's (DBIRD) Horticulture Division presents *Zingiber* "Singapore Gold" a new cut-flower *Zingiber* for Top End flower growers. It is a public cultivar and can be freely propagated and distributed.

Origin:

Collected in Hawaii by DBIRD Horticulturists in 1999 and evaluated over the last two years. It has yet to be botanically named and is from the *Zingiber* "Champagne" group which contains commercial cultivars such as "Apricot".

Type:

Principally a cut-flower type with limited amenity use for protected gardens.

Season:

Mid season type that flowers during the main *Zingiber* flowering months.

Harvest season:

Late September to early February.

In the nursery:

Propagated from rhizomes.

Success with plantlets suckering from stems laid under mist. This method ensures plants are free of disease and nematodes.

Tissue culture untried.

In the paddock:

Grows to 2.5 m. Best under 50-70% shade.

Suffers slightly from rhizome rots. Like all *Zingibers* needs a well-drained site, preferably on raised beds.

Organic matter additions beneficial

Moderate yields of 30-40 stems in year 2.

Suggest 3 m for rows and 2 m between plants.

In the vase:

Vase-life around 10-12 days before first signs of ageing and up to 18-21 days before "throw out" stage.

Average stem lengths of 45 to 70 cm.

As the inflorescence ages the bracts develop a red tinge.

Retention of old day-flowers and splitting of basal bracts may be quality detractions.

Figure 4. Zingiber 'Singapore Gold" Fact Sheet

RESOURCE PROTECTION

PROGRAM: Resource Protection

SUBPROGRAM: Plant Pathology

PROJECT: Disease Diagnostic Service - Darwin

Project Officers: B. Condé, R. Pitkethley, A. Daly, L. Ulyatt and I. Arao-Arao

Location: Darwin

Objective:

Provide a plant disease diagnostic service for primary producers and the public.

Background:

The plant disease diagnostic service is a core function of the Plant Pathology Unit. It forms a node of the Northern Australian Diagnostic Network (NADN) recently established by the Cooperative Research Centre for Tropical Plant Protection of which DBIRD is a partner. The Darwin and Katherine plant disease diagnostic facilities together form a 'node' of this network.

Results:

In 2002-03 a total of 788 diagnostic cases were handled in the Darwin (Berrimah) laboratory. They included 23 samples collected in the course of the East Timor surveys.

At the beginning of the 2003 dry season, intensive surveys of grapevines were started as part of the National Grapevine Leaf Rust Eradication Program. Leaf samples from each grapevine found were submitted to the laboratory for confirmation of presence or absence of rust (*Phakopsora euvitis*). To the end of June 2003, 279 grape leaf samples had been processed under this program. Further information on this service and program is provided elsewhere in this report.

Some interesting diseases recorded in 2002-03 were:

- *Albizia lebbeck* with rust *Sphaerophragmium acaciae*.
- *Lyocpersicon esculentum* (tomato) with grey leaf mould *Fulvia fulva*.
- *Carpentaria acuminata* (Carpentaria palm) with trunk splitting/rot *Chalara paradoxa*.
- *Artocarpus heterophyllus* (Jakfruit) with fruit rot *Rhizopus stolonifer* on a stressed tree.
- *Chrysalidocarpus lutescens* (golden cane palm) trunk rot with Basidiomycete fruiting bodies.
- *Ganoderma* aff. *lucidum*.
- *Citrullis vulgaris* (watermelon) with *Botryodiplodia theobromae* causing stem end rot of fruit.
- *Averrhoa carambola* (carambola) with *Cladosporium* sp. mould and aphids associated with aborted flowers/fruits.
- *Citrus limon* (lemon) with oleocellosis (physiological).
- *Vitis* sp. (grapevine) with trunk internal wood rot, associated with graft incompatibility.
- *Pterocarpus*? indicus (weeping rosewood) with root/trunk infection causing wilt, and leaf spots. Identification is pending.

PROJECT: Disease Diagnostic Service - Katherine

Project Officer: S. Bellgard (0.8FTE)

Location: Katherine Research Station (KRS)

Objective:

Provide a plant disease diagnostic service for the Katherine – Daly Region.

Results:

In 2002– 03, 190 plant disease enquiries were received at KRS. There were no new exotic disease incursions. New disease records for the Katherine – Daly region included:

- *Arachis hypogaea – Pratylenchus* root – lesion nematode.
- *Arachis hypogaea – Aphis craccivora* root aphid.
- *Citrus paradisi – Corticium salmonicolor* pink disease.
- *Eucalyptus miniata – Meliola densa* dark leaf mildew.
- *Mangifera indica – Meliola mangifera* black mildew.
- *Vitis* sp*. – Cladosporium* sp. berry rot.

PROJECT: Plant Disease Reference Collection and Database

Project Officers: R. Pitkethley and L. Ulyatt

Location: Darwin

Objective:

Add to and maintain the plant disease reference collection and associated database as a diagnostic tool and as a reference source.

Background:

The NT plant disease collection was initiated in the mid-1960s and has been maintained and further developed since then. It is now the largest such collection in northern Australia and has been unofficially designated DNAP.

A functional database (Microsoft Access®) was set up in 1999-00 allowing entry of plant disease accession records to be resumed after a pause of several years. A consultant was engaged to refine the database to improve its functionality. Entry of disease accession records was resumed.

DBIRD is working in a joint project with the Queensland Department of Primary Industries, under the auspices of the CRC for Tropical Plant Protection, to develop a catalogue of plant pathogens in northern Australia.

Progress:

In 2002-03 a further 50 accessions were added to the collection, to total 3499.

The improvements in the database have made it possible to extract and merge data with the Queensland database.

Some further refinements to the database were identified and will be incorporated in due course.

PROJECT: National Grapevine Leaf Rust Eradication Program (NGLREP) – Pathogen Testing Service

Project Officers: A. Daly, C. Burnup and S. Bellgard

Location: Darwin

Objective:

Provide the NGLREP with diagnosis of the disease status of grapevine specimens submitted during the program and preserve the specimens in the Plant Pathology and Mycology herbarium.

Background:

Following the detection in urban Darwin in 2001, of the exotic disease grapevine leaf rust (GLR), which is caused by the fungal pathogen *Phakopsora euvitis,* NGLREP was initiated. The Commonwealth and State governments funded the program to remove all infected vines. Specimens from properties in Darwin, Palmerston and rural areas (including Katherine) are submitted almost on a daily basis during the program to determine whether they are infected with the GLR pathogen. Confirmed infected grapevines are subsequently removed from the property of origin. All collected specimens are pressed, dried and stored in the herbarium for future reference if required.

Results:

- Protocols were developed and implemented to minimise the risk of spreading the disease during collection and lab processing of infected material.
- A total of 279 specimens have been examined (including 13 re-tests).
- Out of them 96 (36%) were infected with GLR.
- A total of 80 (30%) were infected with grapevine downy mildew (*Plasmopara viticola*).
- There were 126 disease-free plants.

(NB. Some specimens had dual infections of GLR and downy mildew).

PROJECT: Assessment and Pathogen Testing for the Nursery Industry Accreditation Scheme, Australia

Project Officers: A. Daly, M. Connelly and S. Bellgard

Location: Darwin/Katherine

Objective:

Assess the pathogen status of nurseries for the purpose of accreditation under the Nursery Industry Accreditation Scheme (NIASA).

Background:

Nurseries in the Darwin and Katherine areas are assessed for possible accreditation or for continuation of accredited status. Samples of soil, potting media and plant material are collected for pathogen testing at the Berrimah laboratory.

Results:

- Six nurseries were surveyed.
- From them 20 samples were collected and tested for the target pathogens *Phytophthora* and *Pythium* spp., in line with NIASA best-practice guidelines.
- Only one sample from a nursery in rural Darwin tested positive for a *Phytophthora* sp. This was recovered from a sample of soil from the media preparation area. Remedial action was requested.

PROJECT: Grapevine Leaf Rust – Assessment of Cultivars for Resistance or Immunity and Suitable Fungicides for Control

Project Officers: A. Daly, C. Hennessy and R. Pitkethley

Location: Darwin

Objectives:

Assess a number of cultivated and native grapevine selections for resistance / immunity to the grapevine leaf rust (GLR) pathogen, P. euvitis.

Gather information on how some climatic factors affect its life cycle.

Assess fungicides for their ability to control the disease.

Background:

Following the discovery of GLR in Darwin, the Primary Industries Ministerial Council (PIMC) agreed on an eradication program provided there was industry support for research, replacement grapevines, communication and public relations assistance. PIMC requested industry to undertake research to identify immune or resistant cultivars that will be suitable to replace those in current use in Darwin. PIMC believes that replacement grapevines are a critical component of the effective on-going biosecurity management in the region. Prior to this, some preliminary investigations were required, including assessment of research methods that may be effectively employed during the project.

Method:

Funding to conduct the preliminary research was received from the Grape and Wine Research and Development Corporation. Further funds for continuation of the project are being sought through the same agency.

Fourteen readily available potted table grape cultivars were successfully inoculated with *P. euvitis*. This was to determine their reaction to the pathogen and provide a source of inoculum for continued testing of other cultivars. A table of disease ratings is provided below.

Cultivar	Disease incidence (%)	Highest disease severity (%)	Average disease severity rating
Perlette	67	10	2
Thomuscat-1	82	15	1
Thomuscat-2	73	10	2
Pearl of Csaba-1	60	15	1
Pearl of Csaba-2	76	30	2
Red Prince-1	56	10	2
Red Prince-2	61	15	2
Ruby Seedless-1	76	10	2
Ruby Seedless-2	90	15	2
Black Muscat-1	64	15	2
Black Muscat-2	77	5	1
Thompson's Seedless-1	72	10	2
Thompson's Seedless-2	78	10	1
Red Emperor-1	58	5	1
Red Emperor-2	34	5	2
White Muscat-1	41	10	1
White Muscat-2	47	5	1
Black Sultana-1	55	5	1
Black Sultana-2	71	15	1
Emerald Seedless-1	72	10	1
Emerald Seedless-2	51	10	1
Flame Tokay-1	71	10	2
Flame Tokay-2	45	15	2
Sultana M12-1	63	10	2
Sultana M12-2	63	10	2
Ladies finger-1	64	15	2
Ladies Finger-2	65	15	2

Key to disease severity rating (percentage coverage of leaf by disease symptoms):

0 = no disease
1 = <1%
2 = 1-5%
3 = 5-10%
4 = 10-15%
5 = 15-30%

Thirteen fungicides were chosen for assessment; some based on reports in the literature regarding their efficacy against other rust pathogens, and others based on their existing registration for use on grapevines.

Approximately 430 grapevine cultivars (including rootstock types) were selected for resistance / immunity testing based on their availability and reported reactions to the GLR pathogen in the literature and were ordered to Darwin for testing.

Various methods of detached leaf culture were investigated for their potential use in the resistance, immunity and fungicide screenings.

Results:

Results of the investigation are presented in the table below.

Detached leaf method	Average survival (days)	Comments
Whole leaf with petiole only in water	14	Very inconsistent. Petiole tends to become weak and abscise from the leaf.
Leaf disc in Petri dish on moist cotton wool	23	Consistent. All leaves lasted for at least 23 days, three surviving for 27 days.
Leaf disc floated on sterile distilled water in Petri dish	21	Inconsistent.
Leaf disc on water agar in Petri dish	20	Consistent. Leaves develop fungi and bacteria without the addition of lactic acid in the water agar.

Some trials were conducted using the benomyl fungicide amendment of the medium as this is reported to increase the survival period of the detached leaves whilst not being inhibitive to members of the rust group in general. However, it was found that germination of *P. euvitis* spores on water agar amended with benomyl was effectively eliminated and therefore the fungicide may influence the results of trials when used with detached leaf culture methods for rust assessments.

PROJECT: Management Systems for Diseases of Mangoes

Project Officers: B. Condé, R. Pitkethley, V. Kulkarni and S. Bellgard

Location: Darwin/Katherine

Objective:

Develop management systems for diseases of mangoes in the Darwin-Katherine regions.

Introduction:

Experience in the control of mango diseases is growing gradually to form a sound basis for the development of a mango disease management system. In recent years many problems from the various forms of anthracnose and mango scab have been effectively addressed.

Nutritional dieback of the mango variety Keow Savoey

A dieback of the Thai mango variety, Keow Savoey was investigated at a farm on Buckley Road, Humpty Doo on 30 April 2003. About half of the 110 trees suffered from early stages of dieback and 15 had severe dieback. Symptoms included leaf necrosis, marginal leaf necrosis, necrotic spotting of twigs, cracking and gumming of the trunk and main branches, and dieback of branches. The farm also had about 1,000 KP and some R2E2 mango trees in the same area of the affected Keow Savoey trees. None of the KP or R2E2 mango trees were affected.

Nutritional dieback of the Keow Savoey variety was also reported on a second farm in the Darwin rural area, a couple of weeks later.

The Keow Savoey mango dieback is a varietal nutritional problem, relating to the variety's high requirement of boron.

An illustrated field guide on diseases of mangoes

The mango industry requested DBIRD in 2002 to produce an illustrated booklet on common pests, diseases and disorders of mangoes to assist growers in identifying problems in their orchards. This provided a vehicle to transfer extensive knowledge and experience of mango diseases to industry. Suitable text was prepared complemented with many colour photographs for the booklet, which was published in July 2002 (see Publications list).

PROJECT: Management Systems for Diseases of Asian Vegetables

Project Officers: B. Condé and I. Arao-Arao

Location: Darwin

Objective:

Develop management systems for diseases of Asian vegetables.

Background:

A few vegetables were grown post-war and pre-1980s, such as beans, cabbages, lettuce and potatoes in Katherine and Alice Springs and tomatoes near Darwin. Rockmelon growers largely dominated the vegetable industry in the greater Darwin area the early 1980s.

Since then, Asian vegetables grown by Vietnamese and other Asian growers have dominated the vegetable industry in the Darwin rural area. The growers were mainly former fishermen or crabbers who had poor horticultural skills and often could speak little English. They compensated for these deficiencies by keenness to learn, determination, and long hours and sheer hard work. Recently a communication channel was opened through a Vietnamese with tertiary education, good scientific knowledge, good language skills and some farming experience. She has provided a good link to departmental officers to understand the problems of Vietnamese growers.

Methods and Results:

Work on production of a poster on *Diseases of Asian Vegetables in Northern Australia* continued. The poster will contain photos displaying symptoms of 12 diseases and associated text. This will assist growers to identify important vegetable diseases on their farms.

Tomato diseases

Tomato seed of plants resistant or tolerant to tomato yellow leaf curl geminivirus (TYLCV) was obtained from the Rijk Zwaan Seed Company in Israel for on-farm trials in 2003. Because the Australian tomato leaf curl virus (TLCV-Au) (the cause of tomato leaf roll disease) is related to TYLCV, it was hoped that these varieties could also be resistant or tolerant to TLCV-Au. However, few farms were growing tomatoes in early 2003 and one farm volunteered to grow a small number of the varieties grafted onto wild Malay eggplants. The four Israeli lines were planted out several weeks later and in smaller numbers than the Rijk Zwaan varieties. Previous observations on seasonal incidences of TLCV-Au in Darwin indicated that there was a high incidence of the disease in tomatoes early in the season, and dropped off as the season progressed. There was about a 98% leaf roll incidence in the earliest planting in the most susceptible variety. The following observations were made of these plants for symptoms of TLCV-Au infection on 12 June 2003:

Rijk Zwaan seed company varieties

Variety	No. of plants with symptoms	Percentage of plants with symptoms
NT02-01 DRW 7215	1 out of 22	4.54
NT02-02 73-81 RZ	1 out of 22	4.54
NT02-03 VT 765	0 out of 5	0.00
NT02-04 VT 766	0 out of 18	0.00
NT02-05 VT 950	0 out of 25	0.00
Total	2 out of 92	2.17

This is in contrast to a 20-25% and 40% infection rate in Floradade and Tracer varieties, respectively, planted at about the same time.

Israeli lines

Lines	No. of plants with symptoms	Percentage of plants with symptoms
Line 8472	0 out of 3	0.00
Line 8484	0 out of 3	0.00
Line 231	0 out of 3	0.00
Line 407	0 out of 3	0.00
Total	0 out of 12	0.00

This is in contrast to 2-3% infection in Roma and 5% infection in a Yates unnamed and unnumbered variety planted at about the same time.

The pilot on-farm study of tomato varieties bred overseas for resistance/tolerance to TYLCV showed they were more resistant to our TLCV-Au than the commercial varieties on the farm. No clear conclusions could be drawn from the trial because of the small number of plants tested, and the very late time of planting of the Israeli lines. The late time of planting meant that these lines were exposed to fewer viruliferous white flies. No remarks have been included as to the quality and commercial acceptability of the fruit of these lines. Ideally, it would be useful to screen these lines in a field situation with a much larger number of plants. However, under the present circumstances this was not possible as the only volunteer farmer could not divert much of his attention from his normal commercial enterprise to grafting and growing these experimental lines.

PROJECT: Management Systems for Fusarium Wilt of Snake Beans

Project Officers: B. Condé and I. Arao-Arao

Location: Darwin

Objective:

Develop management systems for Fusarium wilt of snake beans.

Background:

Fusarium wilt of snake beans, which is caused by *Fusarium oxysporum* f. sp. *tracheiphilum* (Fot) was first detected in the Northern Territory on a commercial snake bean crop growing at Berrimah, in mid-1999. Fusarium wilt is a serious disease that causes considerable losses to the snake bean industry in Darwin. The industry was worth $1.1m in 1999 when the disease was first discovered. By 2001, the disease affected 75% of the farms that grew snake beans. Production is now below 50% of that in 1999. The initial investigations into the disease, together with early experiments, were reported in the 1999-00 and 2000-01 Technical Annual Reports.

Method and Results:

Races and VCG of Fot

World wide, four races of Fot are known that attack cowpeas or snake beans. All of the four races are present in the USA, with different States having different combinations of races. Three strains were found in the Darwin area in 1999, 2000 and 2001, differentiated on culture characteristics. These three strains are typified by isolates 24946, 24983 (and 26571) and 26536. Efforts to obtain the standard set of cowpea differential lines used by WW Hare and other researchers from 1953 to 1985 proved fruitless. Disease reactions on inoculation with a 1999 isolate in the varieties obtained did not match up with reported reactions, and so proved useless. We gathered a new set of differential cowpea lines based on reports in the literature. Reactions of the 1999 isolate 24946 on our set of cowpea differential varieties indicated that this isolate was race 2. We imported a new set of cowpea race differential varieties from Dr. Jeff Ehlers, UC-Riverside, USA through the Australian Tropical Crops Genetic Resource Centre, Biloela and multiplied the seed in the Plant Pathology garden. Reactions in this new set of cowpea differential varieties inoculated with the 1999 Fot isolate 24946 confirmed that Fot isolate 24946 was Race 2. We have yet to inoculate the other two strains on our differentials and Jeff Ehlers' differentials to determine the races of these two strains. Experiments in 2001-03 showed that the three strains belonged to three different VCGs.

Screening for resistance

Snake bean lines were obtained from Darwin, Biloela Queensland, Sunland Seeds, NSW, Taiwan, the West Indies, and the USA. In 2000-01, 59 lines and sub-lines of snake beans and two lines of cowpea were screened for resistance to a 1999 isolate of Fot in two major screenings. Five snake bean lines were identified with resistance to the 1999 isolate. However, none of these five lines had the desirable culinary and horticultural characteristics that would enable them to immediately replace the standard commercial variety, Green Pod Kaohsiung. Two of these lines, CP18 and NGS&B-Dwarf tested resistant with no plants infected. A further three lines were highly resistant having 1/10, 2/10 and 3/10 infected plants in the following lines, CP57-3 (i.e., CP57 selection 3), "Phong River" and "Black Mottled". The snake bean line "Black Mottled" was also highly tolerant to infection with Fot 24946, in that the three infected plants did not show any external symptoms of wilt. Two cowpea lines, PI 293520 Iron and SVS-3 were screened and found to be resistant to Fot isolate 24946. There were no external symptoms, no internal symptoms and *Fusarium* was not isolated. A further six lines of "Bodi" snake beans obtained from Dr. P. Umaharan, from the University of the West Indies, Trinidad-Tobago, together with a local edible selection of cowpea called "Borroloola Bean" were inoculated with Fot isolate 24946 on 2 June 2003. Seed of nine lines of snake bean from Dr Jeff Ehlers, together with three Australian selections of snake beans and cowpea ("Alf Cameron old brown type", "Black snake bean ex Sarah Jacobsen" and "Alf Cameron black new type") were planted on 22 May 2003 in preparation for inoculation with Fot isolate 24946.

Results of these two screenings will be reported in the 2003-04 Technical Annual Report.

Breeding for resistance

Because no suitable cultivar was found in the screening tests, we commenced a back-crossing breeding program in 2001 with advice from Dr. Jeff Ehlers, of UC-Riverside with the aim of incorporating resistance from a cowpea into the standard commercial snake bean line, Green Pod Kaohsiung. The final variety from this program needs to have the desirable horticultural and culinary characteristics of the Green Pod Kaohsiung snake bean, with strong stable resistance to all Fot found in commercial farms in Darwin. The cowpea line SVS-3, found to be resistant to isolate 24946 was chosen as the resistant parent. F1 hybrid seed was produced. This was back-crossed onto the GPK snake bean twice to produce the first (bc1F1) and second (bc2F1) back-cross generations. The F1 generation and individual bc1F1 plants were multiplied clonally by cuttings so that this genetic material could be screened for resistance to Fot. F1 plants were allowed to self-pollinate, and F2 seed was collected from these plants. Screening of F2 plants will allow us to investigate the inheritance of resistance.

The F1 generation was found to be resistant to isolate Fot 24946. A ratio of 95 resistant to 45 diseased plants was obtained when F2 plants were inoculated with Fot isolate 24946. This deviated somewhat from the expected ratio of 112.5: 37.5 for a single gene inheritance with resistance dominant over susceptibility. This excess in the number of observed plants in the diseased class may be due to plants, which died as a result of Pythium base rot, or other causes rather than from

Fusarium infection. Plant #2-2 of generation bc1F1 was found to be resistant to Fot isolates 24946 and 26536. This bc1F1 plant is yet to be tested for resistance to Fot 26571.

Control of Fusarium wilt

Until a resistant variety is found or developed that can replace the current susceptible variety, many farmers will no longer grow snake beans. Some farmers grow beans on new blocks to try to avoid the disease. Some are grafting snake beans onto resistant cowpea as reported in last year's Technical Annual Report and some are trying one of the moderately resistant varieties, "Bat Kong".

PROJECT: Management of the 'Tropical' Race 4 Strain of Banana Fusarium Wilt

Project Officers: A. Daly, G. Walduck and C. Kelly

Location: Darwin

Objective:

Identify banana varieties with resistance/tolerance to tropical race 4 Fusarium wilt and conduct other studies associated with the management of the disease.

Background:

Tropical race 4 of *Fusarium oxysporum* f. sp. *cubense* (*Foc*) is a disease for which there is no effective chemical control. It has been detected in several localities in Darwin's rural area since 1997, which has highlighted the need for resistant varieties to the pathogen and assessment of ways in which the disease can be better managed. A site at the Coastal Plains Horticultural Research Farm, gazetted as the Coastal Plains Banana Quarantine Station (CPBQS), has been built and artificially infected with the soil-borne disease. Currently the response of a number of different varieties is being assessed. Management options for the disease are being investigated on commercial properties growing bananas as well as at CPBQS.

Results:

Table 1 shows the results of banana selections for which assessment is complete. All selections were confirmed in laboratory tests as being diseased with 'tropical' race 4 *Fusarium* wilt.

Table 1. The rate of infection by Fusarium wilt in a number of banana varieties

Selection	Number of plants infected	Number of plants tested
Cavendish (Williams 1017)	28	28
Cavendish (GCTCV119)	3	28
FHIA 01 (Goldfinger)	11	29
FHIA 17 (944)	30	30
FHIA 18 (1033)	12	30
FHIA 25 (944)	0	30
SH3460.10 (High Noon)	29	29
Malaccensis (845)	29	29
Malaccensis (846)	29	29
Malaccensis (848)	30	30
Malaccensis (850)	0	30
Malaccensis (851)	0	30
Malaccensis (852)	0	30
Pisang Berangan	29	29

A further nine selections have been planted in the testing site. Four of these have shown susceptibility and two have shown resistance to *Foc* 'tropical' race 4 in early testing.

The assessment of biological control agents is continuing. These include one mycorrhizal and two bacterial organisms. Initial results suggest that the organisms are not effective biological control agents in the field.

The preliminary identification of alternative hosts of *Foc* 'tropical' race 4 by NTU honours student Chelsea Hennessy is complete. Four weeds (*Chloris inflata, Cyanthilium cinereum, Tridax procumbens* and *Euphorbia heterophylla*) were identified as possibly aiding the growth and persistence of the pathogen in the soil.

Other management options being assessed include identifying possible vectors of the pathogen such as the banana weevil borer (*Cosmopolites sordidus*). Results of preliminary testing indicate that the borer is not likely to be a significant vector. Following recent new occurrences at four sites in the rural area previously free of the pathogen, magpie geese are considered a possible vector and the role they play in its spread will be assessed in the near future.

Banana bunch stalks and fruit have been tested for the presence of *Foc* 'tropical' race 4. Results to date indicate that the pathogen is present in many of the bunch stalks from diseased plants and fruit from these plants does not mature to a commercially acceptable size. Fruit of an acceptable size that is harvested commercially does not appear to serve as a risk in terms of movement of the pathogen.

Assessments at a major commercial plantation have indicated that where there is a moderate to high disease pressure and the disease is widely distributed, the standard practice of destroying a number of plants surrounding an infected plant to limit the spread of the disease may not be effective. Initial results indicate that sporadic single infections occur more often than those adjacent to previously infected plants.

Investigations are being carried out on the potential to limit the spread of *Foc* 'tropical' race 4 on a newly infected property by reducing the level of the pathogen inoculum. A method for treating the first three occurrences of the disease on a property has been developed that includes stewing material from the infected plant on-site at a temperature of at least 70°C, which is identified in laboratory testing as being lethal to the pathogen. Fumigation of the soil in the infected site after it is secured to minimise animal and water movement will also be investigated as part of a potential management system.

PROJECT: Australian Cotton CRC

Project Officer: S. Bellgard (0.2FTE in-kind contribution)

Location: Katherine Research Station

Objective:

Develop sustainable cotton farming in Northern Australia.

Results:

In 2002–03, the following results were achieved:

- Cultivar tolerance to *Alternaria macrospora* leaf spot.
- Variation in the rate of the initiation of the commencement of infection by *Arbuscular amycorrhizal* fungi in conventional and *Bt* – cotton.
- Poster and paper presented at the 8th International Congress of Plant Pathology, Christchurch, NZ (February 2003) entitled "Mycorrhizas associated with native *Hibiscus* species and commercial cotton in Katherine, NT".

SUBPROGRAM: Entomology

PROJECT: Arthropod Identification and Control Service

Project Officers: **D. Chin, M. Connolly, G. R. Brown, H. Brown, B. Thistleton, L. Zhang, H. Wallace and M. Neal**

Location: Territory wide

Objective:

Provide accurate advice on the identification and control of agricultural, horticultural and domestic arthropods to primary producers, government personnel, pest control operators and the general public.

Background:

The Unit provides an advisory service on entomological matters pertaining to agricultural, horticultural or domestic situations. Extension services include response to phone calls on identification and advice on control of insects, grower visits, examination of specimens submitted to DBIRD offices, talks to industry organisations, schools, the university and presentations at departmental field days, rural, horticultural and agricultural shows. A record of extension services provided is kept on a database. This information may be used for future planning of research and allocation of resources.

Results:

During the year, the Unit received 907 enquiries (710 in the Darwin area and 197 in the Katherine area). The proportion of the various client groups and the % difference in comparison to the 2001-02 period are shown below.

Enquiry status	2002-03 Number	2002-03 %	2000-01 %	Difference %
Government	220	24	34	-10
Household	264	29	25	+4
Growers	286	32	22	+10
Other	108	12	17	-5
PCO	29	3	2	-1
Total	**907**	**100**	**100**	

The largest category of enquiries was from growers, followed by householders, government, others, and pest control operators.

Commercial producers

Mangoes and other tropical fruits

Pheidole megacephala (Fabricius) (Hymenoptera: Formicidae) occurred in large numbers in a mango orchard at Acacia Hills. The ants were excavating the bark and nesting in mango trees. Bait was applied in July 2002 to assist control.

In July 2002 at another property at Acacia Hills, a large population of small black ants, *Iridomyrmex* sp. (Hymenoptera: Formicidae), was affecting the growth of young mango trees by excavating soil and blocking sprinklers.

In August 2002 *Scirtothrips dorsalis* Hood, (Thysanoptera: Thripidae) was found in large numbers on developing grapefruit (fruit size 11-20 mm). They were suspected of feeding under the calyx lobe, causing a skin blemish that enlarged into a distinctive circular scar as the fruits developed.

In July and August 2002 mango flower thrips, *Frankliniella schultzei* Trybom (Thysanoptera: Thripidae) and *Thrips hawaiiensis* Morgan (Thysanoptera: Thripidae), were found in high numbers in mango flowers in the Darwin rural area such as Noonamah, Berry Springs, Lambells Lagoon, Humpty Doo and Acacia Hills. A similar situation occurred in Katherine but the thrips were first noticed in June.

High numbers of *Campylomma austrina* Malipatil (Hemiptera: Miridae) were also observed in mango orchards in Darwin and Katherine. Trials on properties were set up to monitor the extent of damage to developing fruit. The damage occurred in June-August and the trial was in July-October 2002.

Dried fruit beetles, *Carpophilus* spp. (Coleoptera: Nitidulidae), were found in high numbers in ripe figs in a commercial netted orchard at Bees Creek. The beetles entered the fruit through the "eye" and fed on the flesh, turning the fruit sour, making it unmarketable. Control using trichlorfon was carried out in August 2002 with subsequent trapping using fermented apple juice baits.

Spherical mealybug, *Nipaecoccus viridis* (Newstead) (Hemiptera: Pseudococcidae), was found infesting grapefruit and lime trees on a property near Corroboree, 20 km east of Adelaide River bridge on the Arnhem Highway. The seven-year-old, once heavily producing trees, were so badly infested that almost all the 60 were completely blackened with sooty mould and their trunks were covered in thick clusters of mature female mealybugs. In September 2002 the grower carried out chemical and biological control measures to try and manage the infestation.

Old damage caused by redscale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae), and white louse scale, *Unaspis citri* (Comstack) (Hemiptera: Diaspididae), was seen in October 2002 as cracks on stems of lime trees in a commercial orchard.

Mites were collected from Barhee dates on a commercial date plantation (Limestone Bore) at the end of January 2003. They were identified as *Oligonychus calicicola* Knihinicki and Flechtman (Acarina: Tetranychidae) and were associated with webbing on the immature fruit. The infestation had previously been treated on a routine basis with broad-spectrum insecticides with limited control. It was suggested that the infestation be treated at five to seven day intervals (until controlled) with Natrasoap + SprayTech oil. The species was last collected in January 2000 from dates at AZRI.

In January 2003, two species of *Iridomyrmex* (Hymenoptera: Formicidae) and a species of *Leptogenys* (Hymenoptera: Formicidae) were seen to be a problem in rambutan orchards. The *Iridomyrmex* species (collected from Humpty Doo) was spreading mealybugs and scales and required control. *Leptogenys* sp. was found in reasonable numbers on rambutan fruit and was causing a nuisance by stinging pickers.

In February 2003 rambutan trees were infested with *Achaea janata* (Linnaeus) (Lepidoptera: Noctuidae), larvae feeding on the new flush.

In February 2003 several mango growers in Katherine enquired about control methods for the green tree ant, *Oecophylla smaragdina* (Fabricius), (Hymenoptera: Formicidae), and mango shoot caterpillar, *Penicillaria jocosatrix* Guenée (Lepidoptera: Noctuidae).

In March 2003 *Amblypelta lutescens lutescens* (Distant) (Hemiptera: Coreidae) was recorded from immature carambola fruit and carob pods.

In April 2003 advice on control of meat ants and ginger ants was provided to a dragon fruit grower. The ants have been an ongoing problem on his property for sometime. He had tried chlorpyrifos sprays and baiting with hydramethylnon. New fipronil baits may assist control when they become available.

In April 2003 longicorn and bostrychid borers were recorded in branches of mangoes from commercial properties. The affected trees had been pruned or stressed within the previous few months.

In April 2003 fruit-piercing moths were recorded to have caused significant fruit drop in a number of different fruit trees from a property at Berry Springs.

In May 2003 a grower requested a visit, claiming that his dragon-fruit were covered with fruit flies and that the crop had been attracting fruit flies for the previous 12 months. It was found that the supposed fruit- flies were actually paper-nest wasps attracted to the fruit.

In June 2003 the large mango tip borer, *Penicillaria jocosatrix* Guenée (Lepidoptera: Noctuidae), was found feeding on early mango flowers at several orchards in Katherine. Due to warmer weather in February, populations were carried over into the dry season.

In June 2003 information on attracting blowfly pollinators was supplied to mango growers in Darwin and Katherine.

Cucurbits and vegetables

In May 2003 *Nysius* sp. (Hemiptera: Lygaeidae) caused damage to the growing tips of vines and recently set fruit in Lebanese cucumbers. Feeding damage was indicated as numerous spots of exudate on the affected areas that later led to abortion of fruit.

In May 2003 a visit was made to a grower at Middle Point with false wireworm, (Coleoptera: Tenebrionidae) and *Mastotermes,* (Isoptera: Mastotermitidae) attacking his cucurbit seedlings. Control recommendations involved discussions on application of chlorpyrifos through the irrigation system.

Ornamentals and nursery plants

In August 2002 a nursery in Howard Springs had persistent infestations of spider mites on ornamentals. Advice on control using Neemtech potassium soap and canola oil was provided. The recommendation was effective in controlling the infestation without causing leaf burn.

In October 2002 millipede control advice was supplied to a nursery as a disinfestation procedure for export interstate.

In February 2003 croton twigs from a nursery were infested with longicorn larvae (new host record). Specimens were kept for rearing but adults failed to emerge.

A new genus of thrips to Australia, *Octothrips* sp. (Thysanoptera: Thripidae) was collected from Blechnum ferns at Howard Springs. Identification confirmed in March 2003.

In April 2003 a dead salticid spider was collected from a nursery with a fungus growing on its body. The fungus was identified as *Aspergillus* sp.

Field crops

In December 2002 to January 2003 cockchafers (Coleoptera: Scarabaeiidae) were recorded from the pasture grass *Brachiaria humidicola* in Virginia. The property owner was concerned about treatment residues, as it was an area used for grazing by deer and wallabies

In February 2003 a property near Alice Springs had an infestation of *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) in patches within 8 ha of lucerne. The grower was interested only in organic methods of control.

In February 2003 ants *Meranoplus* sp. (Hymenoptera: Formicidae), were found harvesting pasture grass and legume seeds from three properties in Katherine. Controls were recommended and specimens were collected.

From 24–31 March, large numbers of the day feeding armyworm, *Spodoptera exempta* (Lepidoptera: Noctuidae), were seen in pasture and lawns in rural areas at Adelaide River, Noonamah, McMinns Lagoon, Humpty Doo, Middle Point and Katherine. Caterpillars were collected from the following hosts: signal grass (*Brachiaria decumbens*), pangola (*Digitaria eriantha* subsp. *eriantha*), humidicola (*Brachiaria humidicola*), mission grass and paspalum. The main agricultural suppliers were informed of the outbreak and provided with suggestions on which products they could recommend to growers. An article was written for the *Litchfield Times*.

Agro-forestry and native plants

In February 2003 *Poneridia* sp. (Coleoptera: Chrysomelidae) beetles were found decimating plantings of sandalwood, *Santalum album* at Batchelor Farms (Exotic Timbers of Australia). Farm staff were having difficulty with chemical applications due to monsoonal rain activity.

In February *Eucalyptus miniata* trees within an area of woodland extending from Edith Farms Road to the Edith River crossing, also south of Katherine was defoliated. The damage appeared mainly caused by tussock moth caterpillars (Lepidoptera: Lymantridae) and the cup moth *Doratifera* sp. (Lepidoptera Limacodidae).

Household and backyard producers

In March 2003 large numbers of fruit-piercing moths, *Eudocima fullonia* (Clerk) and *Eudocima materna* (Linnaeus) (Lepidoptera: Noctuidae), attacking hard green bananas in a Nhulunbuy backyard, were sent to the Unit.

In March 2003 *Xylotrupes gideon* (Linnaeus) (Coleoptera: Scarabaeidae) (about 20 per night) were recorded from a property in Stuart Park over a two week period.

In April-May 2003 *Oncocoris* spp. (Hemiptera: Pentatomidae) were seen swarming in huge numbers around houses located in bushland in the Katherine area.

In April –May 2003 the papernest wasp *Polistes schach* (Fabricius) (Hymenoptera: Vespidae) was common around houses and gardens in the Katherine area.

In May 2003 a sample of caterpillars, *Brithys* sp. (Lepidoptera: Noctuidae) was recorded from leaves of a lily in a home garden. This is a new record for the Economic Insect Reference Collection.

Ants

Ant specimens (Hymenoptera: Formicidae) commonly submitted for identification as suspected red imported fire ants or for general control advice included:

Iridomyrmex sanguineus Forel (April - May 2003)
Iridomyrmex spp. (December 2002 - January 2003)
Leptogenys sp. (December 2002 - January 2003)
Monomorium destructor Jerdon (November, December 2002 - January, June 2003)
Monomorium spp. (Hymenoptera: Formicidae) (August 2002)
Myrmecia sp. (December 2002, January - June 2003)
Odontomachus turneri Forel (December 2002, January, April, May 2003)
Oecophylla smaragdina (Fabricius) (April 2003)
Papyrus sp. (May 2003)
Paratrechina sp. (December 2002 - January 2003)
Pheidole megacephala (Fabricius) (August, September, November, December 2002, January, April, May, June 2003)
Pheidologeton sp. (April 2003)
Solenopsis geminata (Fabricius) (November, December 2002 – January - April 2003).

Information on the control of *Monomorium destructor* (Jerdon) (Hymenoptera: Formicidae) was provided for the national indigenous housing guide (November 2002).

In November 2002 advice was provided for control of *Pheidole megacephala* (Fabricius) (Hymenoptera: Formicidae) in a mobile home (bus).

In November 2002 *Solenopsis geminata* (Fabricius) (Hymenoptera: Formicidae) chewing on bean pods was collected from the Plant Pathology glasshouse. Advice on control was provided.

Spiders

Spider specimens submitted from pest control operators and householders included:

Mouse spiders, *Missulena pruinosa* Levitt-Gregg (Araneida: Actinopodidae) (November - December 2002, January 2003).
Trap door spiders (Araneida: Barychelidae) (November 2002).
Huntsman spiders (Araneida: Heteropodidae) (September, December 2002, January 2003).
Spiders family Zoridae (Araneida) collected from a tourist centre in Tennant Creek (June 2003).
Spiders family Nemesiidae (June 2003).

Other enquiries of interest or common enquiries submitted for identification or control advice included:

Fruit flies *Bactrocera tryoni* (Froggatt) (Diptera: Tephritidae)(September 2002).
Paper-nest wasps (Hymenoptera: Vespidae) (September 2002).
Honeybees *Apis mellifera* Linnaeus (Hymenoptera: Apidae) swarming at various properties in the Darwin area. (February - June 2003).
Trigona sp. (Hymenoptera: Apidae) nesting in door frames (June 2003).
Carpenter bees (December 2002 - January 2003).
Scorpions (December 2002 - January 2003).
Millipedes (December 2002 - January 2003).
Gordian worms (Gordiacea) were found in a kitchen sink at Mataranka (July2002).

Other public enquiries

Swarms of grasshoppers, *Macrotona* sp. (Orthoptera: Acrididae) were found around Alice Springs and Lasseters Hotel Casino. *Macrotona* belongs to the spur-throated subfamily Catantopinae and is often found in association with spinifex, *Triodia* spp. (December 2002 - January 2003).

Adrail workers near Alice Spring were attacked by beetles, which they claim were causing blisters. Samples were identified as *Calosoma* sp. (Coleoptera: Carabidae) which is a predatory beetle that normally does not attack humans. These beetles were attracted to floodlights at night. Referred to Medical Entomology Branch. The beetles that actually caused the blisters were probably whiplash rove beetles – Staphylinidae (March 2003).

A pest control operator submitted Clerids and carabids, which were claimed to attack humans in a motel room in Tennant Creek (March 2003).

Advice on *Mastotermes* (Isoptera: Mastotermitidae) control was given to the Darwin City Council, where they were having continual problems with trees being attacked in amenity areas. (December 2002 - January 2003)

Information on rearing conditions and identification of stock (crickets and cockroaches) was provided to an insect breeder (for pet food suppliers). (February 2003)

Twigs from hibiscus shrubs were inspected from landscaped areas of Casuarina Square. Many of the shrubs were infested with longicorn larvae, however this was probably secondary damage as the plants were stressed and possibly suffering from a disease. (May 2003)

PROJECT: Northern Territory Economic Insect Reference Collection

Project Officers: **H. Brown, H. Wallace, L. Zhang, G. R. Brown and M. Connolly**

Location: Berrimah Farm, Katherine Research Station

Objective:

Develop, curate and maintain a reference collection of economically important arthropods relevant to NT agricultural and horticultural industries and develop and maintain a database of all specimens held in the collection.

Background:

The insect reference collection was initiated in 1970 to become the main insect reference collection in the NT. Over the years, the collection expanded to include economically important arthropods from the agricultural, horticultural and domestic sectors. In 1992, the majority of the non-economic specimens were donated and transferred to the NT Museum.

Results:

A full time technician was employed for a 12-month period to record specimens on a database. During the year 7599 specimens were recorded. To date, over 37 884 specimens have been recorded in the database, constituting about 99% of the entire collection. Plant Health Australia has funded this work and the database will form part of the on-line national Australian Plant Pest Database.

The number of specimens in the collection is increasing and there is now a catalogued sub-collection maintained at Katherine Research Station. This collection has about 1600 specimens of which 990 have been recorded on the main database. The regional collection retains only representative specimens of the more common insects as storage conditions are not ideal and all specimens of interest will be kept at the main Darwin collection.

During 2002-03 the Unit forwarded 159 specimens to specialist taxonomists for species confirmation or identification. Most specimens were of economic importance.

There were 122 specimens loaned to specialists for study.

The following were new records determined during the year 2002-03. These are indicated as a new regional or country locality (New NT, New Aust.) or new host records for the NT (New host). Specimens collected during the post barrier East Timor surveys in the NT have (ETS#) after them.

ACARINA

Eriophyidae

?*Epitrimerus* sp.
on *Terminalia ferdinandiana* (New NT)

?*Tetraspinus* sp.
on fruits & leaves *of Acacia* sp. ETS-5 (New NT)

Stigmaeidae

Agistemus sp.
feeding on oriental spider mites on *Citrus paradisi* (New host**)**

Tenuipalpidae

Brevipalpus californicus (Banks)
on leaves of *Aralia* sp. ETS-5 (New host)

Brevipalpus phoenicis (Geijskes)
on leaves of *Clerodendrum floribundum* (New host)
on *Cyprus* sp. (New host)

Tenuipalpus? grevilleae
on *Terminalia ferdinandiana* (New NT)

Tetranychidae

Eutetranychus orientalis (Klein)
on leaves of *Moraga* sp.(New host)

Schizotetranychus sp.
(M130) on *Murraya paniculata* (New host)

Tetranychus sp.
on *Curcuma* sp. (New host)

HEMIPTERA

Diaspididae

Aonidiella aurantii (Maskell)
on *Passiflora edulis* (New host)

?Aonidiella comperei McKenzie (nymph)
on *Citrus* sp. (New host)

Aonidiella orientalis (Newstead)
on *Murraya* sp. ETS-5 (New host)
on fruit of *Cucubita maxima* (New host)

Aspidiotus destructor Signoret
on *Jasminium* sp. ETS-5 (New host)
on *Erynginm foetidum* (New host)

Aspidiotus sp.
on *Atalaya hemiglauce* (New host)

?*Chionaspis* sp.
on grass, Poaceae (New host)

Chrysomphalus aonidum (Linnaeus)
on *Jasminium* sp. ETS-5 (New host)
on *Syzigium* sp. ETS-5 (New host)
on *Terminalia ferdinandiana* (New host)
on *Citrus aurantiflolia* (New host)
on *Phoenix dactylifera* (New host)

Dysmicoccus brevipes (Cockerell)
on *Caryotes* sp. ETS-4 (New host)

nr. *Dysmicoccus*
on grass ETS-4 (New host)

Ischnaspis longirostris (Signoret)
on *Polyalthia longifolia* ETS-5 (New host)
Lepidosaphes beckii (Newman)
on *Citrus aurantifolia* (New host)
on *Citrus limon* (New host)

Lepidosaphes gloverii (Packard)
on *Citrus aurantifolia* (New host)
on *Citrus sinensis* ETS-6 (New host)

Lepidosaphes tokionis (Kuwana)
on *Croton* sp. (New host)

nr *Odonaspis* sp.
on *Melaleuca* sp. (New NT)

Parlatoria proteus (Curtis)
on grass (New host)

Pinnaspis ?aspidistrae (Signoret)
on *Blechum* sp. (New NT)

Pinnaspis strachani (Cooley)
on *Decaisnina signata* (New host)
on *Cycas revoluta* (New host)
on *Clerodendrum floribundum* (New host)
on *Nerium oleander* (New host)
on *Mimosa* sp. (New host)
on *Casuarina cunninghamiana* (New host)
on *Terminalia ferdinandiana* (New host)
on *Macrozamia macdonnellii* (New host)
on *Dendrophthoe* sp. (New host)
on *Bunchanania obovata* (New host)
on *Ophiopogan japonicus* (New host)

Pseudaulacaspis cockerelli (Cooley)
on *Terminalia ferdinandiana* (New host)

Unaspis citri (Commstock)
on *Citrus aurantifolia* (New host)

Coccidae

Coccus hesperidum Linnaeus
on *Citrus paradisi* (New host)
on *Leptospermum longfolium* (New host)
on *Citrus aurantifolia* (New host**)**

Parasaissetia nigra (Nietner)
on *Citrus* sp. (New host)
on *Abiu* sp. (New host)
on *Ficus platypoda* (New host)

Platylecanium pseudexpansum (Green)
on *Pandanus spiralis* (New host)

Pulvinaria dodonaeae Maskell
on *Eremophila longifolia* (New NT)

Pulvinaria dodonaeae Maskell
on *Eremophila* sp. (New NT)

Saissetia miranda (Cockerell and Parrott)
on oleander (New NT)
on *Eragrostis xerophila* (New host)
on *Croton* sp. ETS-4 (New host)
on *Ocimum basilicum* (New host)
on *Nephelium lappaceum* (New host)

Vinsonia stellifera (Westwood)
on *Mangifera indica* (New host NT)

Margarodidae

Icerya aegyptiaca (Douglas)
on *Acalypha* sp. (New host NT)

Icerya n. sp.
on *Digitaria milanjana*, *Bothriochloa pertusa* and *Sorghum bicolor* (New NT)

Icerya seychellarum (Westwood)
on *Nephelium lappaceum* (New host NT)

Pseudococcidae

Chorizococcus herbicola (Maskell)
on *Aristida holathera* (New host)

Epicoccus sp.
on *Melaleuca leucadendra* (New NT)

Ferrisia virgata (Cockerell)
on *Citrus limon* (New host)
on *Citrus sinensis* (New host)

Maconellicoccus hirsutus (Green)
on *Grewia retusifolia* (New host)
on *Hibiscus tiliaceus* ETS-4 (New host)
on *Ixora* sp. ETS-4 (New host)
on *Abelmoschus esculentus* (New host)
on *Adansonia gregorii* ETS-4 (New host)
on *Euphorbia heterophyllus* ETS-4 (New host)
on *Aristida inequaliglumis* (New host)
on *Mangifera indica* (New host)
on *Annona reticulata* (New host)

Nipaecoccus viridis (Newstead)
on *Phoenix roebelenii* (New host)
on *Leuceana leucocephala* ETS-4 (New host)
on *Ficus* sp. ETS-4 (New host)
on *Timonius timon* (New host)
on *Citrus hystrix* (New host)

Planococcus citri (Risso)
on *Vigna unguiculata* (New host)
on *Psidium guajava* sp. New host)
on *Citrus aurantifolia* (New host)
on *Brassica rapa* (New host)
on *Croton* sp. ETS-4 (New host)
on *Citrus aurantifolia* (New host)

? *Phenacoccus* sp.
on *Vernonia cinerea* ETS-4 (New host)

nr *Rastrococcus* sp
on *Acacia sp*. ETS-4 (New NT)

HYMENOPTERA

Ichneumonidae

Trathala sp.
ex. Antigastra catalaunalis larva (New NT)

LEPIDOPTERA

Noctuidae

Athetis maculatra (Lower)
larvae on ground under maize stubble (New NT)

Athetis reclusa (Walker)
feeding on leaves of peanuts, *Arachis hypogaea* (New NT)
on ground in old peanut paddock (New NT)
larvae on ground under maize stubble (New NT)

Heliocheilus melibaphes (Hampson)
ex. sabi grass, *Urochloa mosambicensis* (New NT)

Metachrostis paurograpta Butler
ex. *Mangifera indica* flowers (New host)

Hermeniidae

Hydrillodae dimissalis (Walker)
fed on peanuts pods, Arachis hypogaea (New NT)

Geometridae

?Scopula hypochra (Meyrick*)*
feeding on leaves *Arachis hypogaea* (New NT)
larvae feeding on *Vigna radiata* shoots (New NT**)**

Pyralidae

Calguia deltophora (Lower)
ex. *Citrus x paradisi* (New NT)

Yponomeutidae

Prays nephelomima (Meyrick)
ex. grapefruit, *Citrus x paradisi* (New NT)

Gelechiidae

Aproaerema siplexella (Walker)
pupae in rolled leaf of *Glycine max*, soybean (New NT)

Tortricidae

Lobesia sp.
ex Tahitian lime, *Citrus latifolia* (New host)

Homona sp. nr. *nubiferana*
ex. Tahitian lime, *Citrus latifolia* (New host)
ex lemonade, *Citrus limon* 'Meyer' x *paradisi* (New host)

THYSANOPTERA

Phlaeothripdae

Dolichothrips ?reuteri
ex. *Hibiscus* sp. (New NT)

Teuchothrips ?disjunctus Hood
ex. *Callistemon* sp. (New NT)

Thripidae

Bolacothrips pulcher Girault
ex. flowering grain sorghum heads (New NT)

Australothrips bicolor Bagnall
feeding on leaf of *Terminalia ferdinandiana* (New host)

Thrips tabaci Lindemann
ex. *Eremophila christopheri* leaves (New host)
ex. *Eremophila maculata* leaves (New host)

Octothrips sp.
?damaging leaves of *Blechnum* sp. (New Aust.)

Scirtothrips dobroskyi Moulton
?damaging leaves of *Blechnum* sp. (New host)

Rhamphothrips sp.
ex. flowering grain sorghum heads (New NT)

Retithrips javanicus Karny
damaging *Albizzia* sp. ETS-5 (New host)

Kazinothrips sp. n.
in flowers of *Citrullus lanatus* (New host)

PROJECT: Taxonomy of Scale Insects and Mealybugs (Hemiptera: Coccoidea) with Additional Records of Aphids (Hemiptera: Aphididae) and White Flies (Hemiptera: Aleyrodidae)

Project Officers: G. R. Brown and L. Zhang

Location: Territory wide

Objective:

Reliably identify scale insects and mealybugs and recognise new occurrences particularly those of agricultural importance.

Background:

Many scale insects, mealybugs (Hemiptera: Coccoidea) and white flies (Hemiptera: Aleyrodidae) are serious agricultural pests. Over 800 species of coccoids placed in 13 families as well as 31 species of

white fly are recorded from Australia. It is unknown how many of these occur in the Northern Territory, or the range of hosts they attack here. An overview was given in the 1999-00 and 2000-01 Technical Annual Reports.

Results:

A list of species identified (after mounting on slides) is given below, together with host and collection localities. Numbers prefixed by the letter "C" indicate quarantine interception numbers, the letter "T" for the taxonomy catalogue and "K" for Katherine. Other numbers refer to the database of the Entomology Branch.

The material examined and identified was as follows:

HEMIPTERA

Aleyrodidae (white flies)

Bemisia tabaci (Gennadius)
(T353) *on Cineraria* sp. at Katherine
(T355) on *Torenia* sp. at Katherine

Unknown
(T328) on white currant at Katherine
(T335) on *Leptospermum longfolium* at Katherine
(T341) on *Clerodendrum floribundum* at Katherine

Coccidae (soft scales)

?*Ceroplastes rubens* Maskell
(T312) on *Mangifera indica* at BARC

Coccus hesperidum Linnaeus
(T301) on *Citrus* sp. at Katherine
(T304) on *Lagerstroema indica* at Marrara (New host NT)
(T331) on *Citrus paradisi* at Katherine (New host NT)
(T335) on *Leptospermum longfolium* at Katherine (New host NT)
(T371) on *Citrus aurantifolia* at Berrimah (New host NT)
(T373) on *Citrus paradisi* at Woodroffe

Parasaissetia nigra (Nietner)
(T378) on *Citrus* sp. at Katherine (New host NT)

Pulvinaria dodonaeae Maskell
(T319) on *Eremophila longifolia* at Alice Springs (New NT)

Pulvinaria psidii Maskell
(T366) on *Nephelium lappaceum* at McMinns Lagoon

?*Pulvinaria urbicola* Cockerell
(T316) on *Capsicum annuum* at Katherine

Saissetia miranda (Cockerell & Parrott)
(T122) on oleander at Ti Tree (New NT)
(T137) on *Eragrostis xerophila* at Alice Springs (New host NT)
(T305) on *Croton* sp. at Marrara (New host NT)
(T337) on *Ocimum basilicum* at Parap market (New host NT)

Vinsonia stellifera (Westwood)
(T313) on *Mangifera indica* at BARC (New host NT)

Unknown
(T358) on *Melaleuca* sp. at Howard Springs

Diaspididae (armoured scales)

Aonidiella aurantii (Maskell)
(T300) on *Citrus* sp. at Katherine

?Aonidiella comperei Mckenzie (nymph)
(T334) on *Citrus* sp. at Katherine (New host NT)

Aonidiella orientalis (Newstead)
(T309) on fruit of *Carica papaya* at Humpty Doo
(T315) on fruit of *Cucubita maxima* at Darwin (New host NT)
(T325) on palm leaves at Katherine North
(T329) on *Murraya* sp. at Perkins Shipping (New host record)
(15869) on *Vitis vinifera* at Katherine

Aspidiotus destructor Signoret
(T302) on *Jasminium* sp. at Coonawarra Base (New host record)
(T303) on *Capsicum annuum* at Larrakeyah Base
(T306) on *Carica papaya* at Coonawarra Base
(T310) on Calophyllum inophyllum at Alawa
(T311) on *Capsicum anuum* at Darwin
(T317) on *Capsicum anuum* at Katherine
(T365) on *Erynginm foetidum* at Moil (New host NT)

Chrysomphalus aonidum (Linnaeus)
(T333) on *Jasminium* sp. at Darwin (New host NT)
(T339 & T340) on *Citrus paradisi* at Katherine
(T347) on *Syzigium* sp. at Mary River (New host NT)
(T362) on *Terminalia ferdinandiana* at Wildman River (New host NT)
(T370) on *Citrus aurantifloia* at Berrimah (New host NT)

Dysmicoccus brevipes (Cockerell)
(T274) on *Caryotes* sp. at Nth Lakes (New host NT)

nr. *Dysmicoccus*
(T277) on grass at Berrimah (New host NT)

Ischnaspis longirostris (Signoret)
(T321) on *Polyalthia longifolia* at Mararra (New host record)

Lepidosaphes beckii (Newman)
(T372) on *Citrus aurantifolia* at Berrimah (New host NT)

Lepidosaphes gloverii (Packard)
(T368, T369B & T369C) on *Citrus aurantifolia* at Berrimah (New host NT)

Lepidosaphes tokionis (Kuwana)
(T399) on *Croton* sp. at Alawa (New host NT)

nr *Odonaspis* sp.
(T314) on *Melaleuca* sp. at Katherine (New record NT)

Parasaissetia nigra (Neiter)
(T343) on *Ficus* sp. at BARC

Parlatoria blanchardii (Targioni – Tzzetti)
(T381) on *Phoenix dactylifera* at Alice Springs

Parlatoria proteus (Curtis)
(T291) on grass at Palmerston (New host record)
(T298) on *Murraya paniculata* at Millner
(T326) on *Murraya paniculata* at Katherine North
(T330) on pot plant at Perkins Shipping

Pinnaspis strachani (Cooley)
(T293) on *Decaisnina signata* at Coastal Reserve (New host record)
(T297) on *Cycas revoluta* at Berrimah (New host record)
(T342) on *Clerodendrum floribundum* at Katherine (New host NT)
(T173) on *Cochlospermum fraseri* at Virginia
(T318) on *Nerium oleander* at BARC (New host NT)
(T323) on *Mimosa* sp. at Berrimah (New host NT)
(T349) on *Casuarina cunninghamiana* at Katherine (New host NT)
(T363) on *Terminalia ferdinandiana* at Wildman River (New host NT)
(T397) on *Macrozamia macdonnellii* at Kings Creek (New host NT)
(24298) on *Vitis vinifera* at Katherine

Pseudaulacaspis cockerelli (Cooley)
(T361) on *Terminalia ferdinandiana* at Wildman River (New host NT)

Unaspis citri (Comstock)
(T294) on *Citrus aurantifolia* at Berrimah
(T367 & T369A) on *Citrus aurantifolia* at Berrimah (New host NT)

Unknown
(T364) on *Urochloa maxima* at Berrimah
(T359) on *Melaleuca* sp. at Howard Springs

Margarodidae (fluted scales)

Icerya aegyptiaca (Douglas)
(T275) on *Acalypha* sp. at Berrimah (New host NT)

Icerya seychellarum (Westwood)
(T253) on *Nephelium lappaceum* at Humpty Doo (New host NT)

Pseudococcidae (mealybugs)

Chorizococcus herbicola (Maskell)
(T285) on *Abelmoschus esculentus* at Alawa (New host NT)
(T292) on *Hibiscus tiliaceus* at Marrara
(T284) on *Aristida holathera* nr. Ti Tree (New host NT)
(T245) on *Aristida* sp. at Gunn Point

Ferrisia virgata (Cockerell)
(T344) on *Citrus limon* at Katherine (New host NT)
(T374) on *Citrus sinensis* at Humpty Doo (New host NT)

Maconellicoccus hirsutus (Green)
(T232) on *Grewia retusifolia* at Katherine (New host NT)
(T243) on *Hibiscus tiliaceus* at Port Darwin (New host NT)
(T246) on *Hibiscus* sp. at Fisherman's Wharf
(T256) on *Hibiscus tiliaceus* at Stokes Hill Wharf
(T260) on *Ixora* sp. at Marrara (New host NT)
(T295) on *Euphorbia heterophllus* at Berrimah (New host NT)
(T296) on *Hibiscus* sp. at Larrakeyah
(T307) on *Adansonia gregorii* at Mt Bundey (New host NT)
(T327) on *Hibiscus* sp. at Katherine
(31777) on *Aristida inequaliglumis* at Humpty Doo (New host NT)

Melanococcus darwiniensis Williams
(T336) on *Acacia* sp. at Yarrawonga

Nipaecoccus viridis (Newstead)
(T174) on *Phoenix roebelenii* at Katherine (New host NT)
(T180) on *Citrus* sp. at East Timor
(T270) on *Leuceana leucocephala* at Stuart Park (New host NT)
(T271) on *Ficus* sp. at Darwin (New host NT)
(T273) on *Leuceana leucocephala* at Marrara
(T308) on *Leuceana leucocephala* at Frances Bay

? *Phenacoccus* sp.
(T250) on *Vemonia cinerea* at Frances Bay (New host NT)

Planococcus citri (Risso)
(T113) on *Vigna unguiculata* at Berrimah (New host NT)
(T171) on *Gardenia* at Darwin
(T229) on *Brassica rapa* at Tiwi (New host NT)
(T262) on *Guava* sp. at Berrimah New host NT)
(T322) on *Croton* sp. at Marrara (New host NT)
(T338) on *Citrus aurantifolia* at Katherine (New host NT)
(T345) on *Citrus aurantifolia* at Bees Creek
(T356) on *Citrus aurantifolia* at Katherine (New host NT)
(C1400A) on *Persea* sp. from East Timor

nr *Rastrococcus* sp
(T282) on *Acacia sp*. at Mt. Bundey (New NT)

Unknown
(T290) on *Sorghum* sp. at Gunn Point
(T332) on *Euphorbia* sp. at Frances Bay
(C1740) on pineapples from Indonesia

Psylloidea

Unknown
(T276) nymphs on *Hibiscus tiliaceus* at Berrimah

PSOCOPTERA

Archipsocidae

Unknown
(T357) on *Citrus paradisi* at Katherine.

PROJECT: Taxonomy of Mites (Acarina)

Project Officers: L. Zhang and G. R. Brown

Location: Territory wide

Objective:

Prepare and identify mite samples and recognise new occurrences particularly those of agricultural importance.

Background:

Mites are important agricultural pests. Over 2700 species of mites placed in 240 families are recorded from Australia. It is unknown how many of these occur in the Northern Territory or which species are potential pests or beneficials.

Method:

After clearing in Nesbitt's fluid, mite samples were mounted on slides with Hoyer's mounting medium. Mites were identified using the slide-mounted specimens. Appropriate keys were used to identify genera and species.

Results:

A list of identified species during the year is given below, with host and collection locations. Numbers with "M" are for the mite taxonomy catalogue.

ACARINA

Acaridae

Unknown

(M132) on body of termites at Humpty Doo.

Cheyletidae

Unknown

(M112) feeding on diaspid scales on palm stem at Katherine.

Eriophyidae

Aculops lycopersici (Massee)

(M142) on leaves of *Lycopersicon esculentum.*

Cisaberoptus kenyae Keifer

(M116) on leaves of *Mangifera indica* at Katherine

(M129) producing wax layers on leaves of *Mangifera indica* at Raffles Bay.

?*Epitrimerus* sp.

(M140) on flush leaves of *Terminalia ferdinandiana* at Wildman River.

Eriophyes sp.

(M125 & M138) on distorted leaves of *Terminalia ferdinandiana* at Wildman River.

Paraphytoptus sp.

(M122) on leaf buds of *Exocarpos latifolius* at Howard Springs.

Phyllocoptruta oleivora (Ashmead)

(M114) on fruit of *Citrus paradisi* at Bees Creek

(M124) on immature *Citrus paradisi* at Humpty Doo

(M147) on fruit of *Citrus* sp. at Berrimah.

?Tetraspinus sp.

(M113) on fruit of *Acacia* sp. at Marrara.

Phytoseiidae

Unknown

(M121) associated with oriental spider mites *Eutetranychus orientalis* on leaves of *Citrus paradisi* at Katherine

(M154B) associated with spider mites *Oligonychus ?mangifermis* on *Vitis* sp. leaves at Moil

(M155) feeding on two spotted mites, *Tetranychus urticae* on leaves of *Vigna unguiculata* at Berrimah.

Stigmaeidae

Agistermus spp.
(M121) associated with oriental spider mites, *Eutetranychus orientalis* on leaves of *Citrus paradisi* at Katherine
(M131) on leaves of *Hibiscus tiliaceus* at Parap.

Unknown
(M120) associated with oriental spider mites, *Eutetranychus orientalis* on leaves of *Citrus paradisi* at Katherine.

Tenuipalpidae

Brevipalpus californicus (Banks)
(M111) on leaves of *Aralia* sp. at Marrara.

Brevipalpus phoenicus (Geijskes)
(M115) on leaves of *Clerodendrum floribundum* at Katherine
(M133) on leaves of *Cyprus* sp. at Berrimah
(M135) on leaves of *Passiflora edulis* at Berry Springs
(M136) on fruits of *Passiflora edulis* at Berry Springs
(M146) on leaves of *Eucalyptus ptychocarpa* at Berrimah.

Teniupalpus? grevilleae Gutierrez and Schicha
(M141) on flush leaves of *Terminalia ferdinandiana* at Wildman River.

Tetranychidae

Eutetranychus orientalis (Klein)
(M117) on leaves of *Murraya* sp. at Frances Bay
(M128) on silvered leaves of *Carica papaya* at East Timor
(M152) on leaves of *Citrus limon* at Alice Springs.

Oligonychus? calicicola Knihinicki and Flechtman
(M145) on calyx and fruit stalks of *Phoenix dactylifera* at Limestone Bore.

Oligonychus? mangiferus (Rahman and Sapra)
(M154A) on leaves of *Vitis* sp. at Moil.

Schizotetranychus sp.
(M130) on chlorotic leaves of *Murraya paniculata* at Croker Island.

Tetranychus sp.
(M108) on fruit of *Solanum melongena* at Dundee Downs
(M110) on leaves of *Aralia* sp. at Marrara
(M123) on *Cineraria* sp. at Katherine
(M127) on leaves of *Carica* papaya at Galiwinku
(M144) on leaves of *Curcuma* sp. at Berrimah.

Tuckerellidae

Tuckerella ?pavoniformis (Ewing)
(M154C) on leaves of *Vitis* sp. at Moil.

PROJECT: Control of Arthropods and Development of IPM in Tropical Fruit Crops

Project Officers: D. Chin, H. Brown, G. R. Brown, L. Zhang and E. S. C. Smith

Location: Darwin area (Katherine is attached as a separate report)

Objective:

Identify potential arthropod problems in mangoes and other tropical tree crops and devise appropriate control measures.

Background:

Mangoes are the most important horticultural crop in the NT and receive a proportionate amount of the Entomology Unit'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.

Horticulture officers, commercial growers and urban backyard producers frequently refer pest situations to the Unit for advice or comment and these may lead to the detection of new or potentially damaging insect problems. The Unit is committed to provide advice and assistance to all growers consistent with the aim of developing integrated pest management (IPM) systems for all tropical tree crops.

During 2002-03, the Unit concentrated its main tree crops research on mango, citrus and rambutan, although identification and pest management advice was provided for other tropical fruits such as carambola, fig, passionfruit, dragon-fruit, pawpaw, custard apple, durian, jackfruit and mangosteen. Advice on insect identification and monitoring was also provided to farm staff who managed a trial planting of Kakadu plum (*Terminalia ferdinandiana*).

Results:

Mango flower thrips
Mango flower thrips, *Frankliniella schultzei* Trybom (Thysanoptera: Thripidae) and *Thrips hawaiiensis* Morgan (Thysanoptera: Thripidae) were found in high numbers in mango flowers in the Darwin rural area during July and August 2002. Feeding damage can be seen as slight scarring on the flower petals. A small amount of thrips feeding damage to fruit-lets was noticed at one property in the Darwin area. The thrips seen on the fruit-lets were immature and probably *Scirtothrips dorsalis* (Thysanoptera: Thripidae). This species usually feeds on new flush.

Dimpling bug in mangoes
The dimpling bug, *Campylomma* sp. (Hemiptera: Miridae) was also found in high numbers in July and August 2002 in mango flower panicles from properties in Noonamah, Berry Springs, Lambells Lagoon, Humpty Doo and Acacia Hills. Large numbers of *Campylomma* were probably attributable to the colder dry season temperatures as well as an overall increase in the numbers over the previous years due to the expansion of the industry. These bugs caused feeding damage to fruit-lets, which were difficult to diagnose especially when the fruit-lets were less than 13 mm in length. In previous years, *Campylomma* has been present in lower numbers on mango flower panicles in the Top End.

Campylomma *trial at Noonamah*
A small trial was carried out during August to October 2002, in a mango orchard at Noonamah to monitor the damage caused by *Campylomma* to the small developing fruit. The damage was monitored from the time of attack to the small developing fruit to maturity at harvest.

Five small immature fruits most with *Campylomma* feeding damage (seen as dimples or scars) were selected from 10 trees in a block. A total of 50 fruit were tagged and scored on 3 September and re-assessed on 24 September and 24 October 2002. The fruit selected on 3 September were all about 35 mm in length and had 0 to 16+ dimples or feeding marks. In the second observation on 24 September, 52% of the fruit had a reduction in the number of dimples or feeding marks on the fruit. Most of these marks had enlarged and faded and were less obvious. However, a large proportion of the fruit had pronounced lenticels, which were probably caused by other factors such as unusual

fluctuations in alternating cold and warm weather during fruit development. When inspected on 24 October, 38% of the fruit in the trial had been harvested.

Monitoring for dried fruit beetles in figs
A heavy infestation of dried fruit beetle, *Carpophilus* (Coleoptera: Nitidulidae) became obvious in ripe figs at a commercial netted orchard in Bees Creek at the end of July 2002. The beetles entered the "eye" of the fruit and turned the fruit sour, rendering it unmarketable. Advice on control was given and a spray of trichlorfon was recommended, with a later follow-up spray.

Lure traps made from 2 L plastic milk bottles baited with apple juice and yeast were supplied (between July and September 2002) to assist the growers on monitoring and reducing the numbers of dried fruit beetles in the orchard. The traps with different sized slits, collected between 42 and 524 beetles in a 10-day period. After the traps were installed, no more fruit was attacked. The direction of the wind and how well the scent was dispersed by the wind influenced the effectiveness of the traps.

Terminalia IPM
Two trips were made to the COGNIS Terminalia Farm at Wildman River in September and December 2002 to provide assistance with insect identification and to demonstrate insect monitoring to farm staff. The farm consisted of three blocks of 1200 trees, which were three to four years old. The main insects recorded in September 2002 are shown below.

Tip borer (Lepidoptera: Tortricidae)
Leaf miner, *Phyllocnistis* sp. (Lepidoptera: Gracillariidae)
Scales, *Pseudaulacaspis cockerelli* (Cooley), *Chrysomphalus aonidum* (Linnaeus), *Pinnaspis strachani* (Cooley) (Hemiptera: Diaspididae)
Bud mite, *Eriophyes* sp. (Acarina: Eriophyidae)
Wood moth borer (Lepidoptera: Oecophoridae)
Horned treehopper (Hemiptera: Membracidae)
Plant hoppers (Hemiptera: Ricaniidae and Flatidae)
Caterpillars (Lepidoptera – damaged specimens)
Red meat ants, *Iridomyrmex sanguineus* Forel (Hymenoptera: Formicidae)
Epactiothynnus sp. (Hymenoptera: Tiphiidae) *
Altica cyanea (Weber) (Coleoptera: Chrysomelidae) *
Gall midges (Diptera: Cecidomyiidae) *

* Specimens submitted by farm staff in October 2002

The visit in December 2002 was carried out to monitor the plants prior to flowering. The main problems seen were tip borer damage to most shoots and bud mites (*Eriophyes* sp. and *Epitrimerus* sp. (Acarina: Eriopyidae)) damage to young leaves especially pink flush. Low numbers of the thrips, *Rhipiphorothrips* sp. and *Australothrips bicolor* Bagnall (Thysanoptera: Thripidae) and *Tenuipalpus* sp. (Acarina: Tenuipalpidae) were collected from young leaves.

None of the pests were controlled but observations were made on levels of infestation and damage.

In May 2003, a summary of the main pests of Terminalia at the Wildman River Kakadu Plum Farm was provided in a power-point presentation for the local COGNIS manger to present to the American investors.

Rambutan IPM
During September and October 2002, four rambutan orchards were monitored from McMinns Lagoon, Bees Creek, and two from Humpty Doo. The main pests generally in low numbers and not requiring control were fluted scales *Icerya seychellarum* and *Icerya aegyptiaca* (Hemiptera: Margarodidae), *Pulvinaria psidii* (Hemiptera: Coccidae), mealybugs and plant hoppers.

Pests:	*Icerya seychellarum* (Westwood) (Hemiptera: Margarodidae)
	Pulvinaria psidii Maskell (Hemiptera: Coccidae)
	Colgaroides acuminata (Walker) (Hemiptera: Flatidae)
	Mealybug (?*Planococcus citri (Risso))* (Hemiptera: Pseudococcidae).
Beneficials:	Spiders (huntsman, orb weaver, salticid)
	Lacewing (Neuroptera)
	Cryptolaemus larva (Coleoptera: Chrysomelidae).

Pollinators: *Trigona* (Hymenoptera: Apidae)
Hover fly (Diptera: Syrphidae)

Muscids (Diptera: Muscidae).

Ants: *Iridomyrmex* (Hymenoptera: Formicidae)
Opisthopsis (Hymenoptera: Formicidae).

Three rambutan orchards were monitored during October and November. The main pests seen on the fruit were *Icerya seychellarum* (Westwood) (Hemiptera: Margarodidae), *Icerya aegyptiaca* (Douglas) (Hemiptera: Margarodidae) and *Pulvinaria psidii* Maskell (Hemiptera: Coccidae) although the infestation was low in all orchards. *Colgaroides* sp. (Hemiptera: Flatidae) and *Myllocerus* sp. (Coleoptera: Curculionidae) were seen in low numbers on the leaves. Old caterpillar damage was also observed on flower panicles and shoots.

A range of small spiders, in moderate numbers, was observed on fruit and flower panicles in all orchards. Other beneficials included *Cryptolaemus montrouzeri* Mulsant (Coleoptera: Coccinellidae), lacewing larvae and praying mantises. Pollinators observed included *Trigona* sp. (Hymenoptera: Apidae), syrphids and muscids. Even though all orchards were netted, in one orchard in Humpty Doo, fruit-piercing moths entered through the gaps at the edges of the net and fed on the fruit. At another property, possums were able to access the netted orchard by crawling under the net at ground level and managed to destroy a large percentage of the mature fruit.

An article was submitted to the *Northern Territory Horticulturist*, November edition entitled “Growers practise insect monitoring in rambutans”.

Rambutan IPM workshop
A rambutan IPM workshop was held at a grower’s property at McMinns Lagoon in October 2002. The workshop demonstrated the procedure of insect monitoring and how to record and identify main pests and beneficials of rambutans.

Rambutan IPM (joint RIRDC project between NT DBIRD and QDPI)
Data collected from monitoring sessions was compiled and a pest and beneficial list as well as a monitoring chart were prepared. This information will be incorporated in a workshop manual and poster for NT and Qld growers.

Met David Astridge at QDPI South Johnstone to discuss the progress of the project and to view rambutan orchards in the area.

Control of red scale in passionfruit with potassium soap and Spraytech oil
A grower in Berry Springs with a heavy infestation of red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae), on his passionfruit crop contacted the Unit for advice. The crop was inspected and large numbers of red scales were seen on the leaves, stems and fruit. There were also symptoms of cracking on the older stems. A few coccinellid beetles were seen to predate on the scales. There were also wasp parasites present. Leaf samples were collected to determine the infestation rate and also observe the levels of parasitism and predation.

Trial sprays were carried out in November and December to control the scales, which were also farmed by various species of ants. The property had sandy soil and tall weeds, which presented favourable conditions for ants. The sprays used for control were Natrasoap + SprayTech Oil and Neemtech + SprayTech oil.

Natrasoap + SprayTech was slightly more effective with 90-97% mortality in treated scales. Neemtech + SprayTech was effective in controlling 82-97% of the scales. Results were based on examination of leaf samples before and after spraying.

PROJECT: Control of Arthropods and Development of IPM in Mangoes in the Katherine Region

Project Officers: M. Connolly, G. R. Brown, D. Chin and H. Brown

Location: Katherine Region

Objective:

Identify potential arthropod problems in mangoes in the Katherine area and devise appropriate control measures.

Background:

It is well recognised that mango arthropod pest problems in Katherine vary considerably from those experienced in Darwin. Katherine experiences a drier and cooler climate and therefore existing pest populations differ in their seasonality and abundance. Industry has also identified a need for a greater understanding of pest occurrences and impacts on mango production in the Katherine region.

Method:

Three separate mango orchards located around Katherine were monitored during 2002-03 and this will continue until harvest in 2004. Varieties observed included Kensington Pride and R2E2. New information will be posted on the developing Entomology website and will also be extended to growers during regular workshops and through other appropriate media channels.

Results:

The main pests of concern during the 2002 growing season were the dimpling bug *Campylomma austrina* Malipatil, (Hemiptera: Miridae) and various thrips (Thysanoptera) species present in large numbers during flowering. A trial was established at the Katherine Research Station to assess the relationship between the presence of apple dimpling bug and levels of fruit damage and fruit retention. Data has been analysed and preliminary results have shown that although initial rates of fruit abortion increased within the untreated trees there was no significant difference between final yield or fruit quality.

The large mango shoot caterpillar, *Penicillaria jocosatrix* Guenée (Lepidoptera: Noctuidae) was especially troublesome during March 2003. During extensive periods of flushing heavy infestations of large mango shoot caterpillars can result in complete loss of the new leaf tissue including the apical meristem. It is not fully understood whether this destructive feeding affects subsequent crop yields, but anecdotal evidence suggest that it may.

A trial was conducted to investigate the efficacy of Success (spinosad) 120 SC for the control of the large mango shoot caterpillar, in young vegetative growth flush of *Mangifera indica* cv. Kensington Pride. Spinosad is a desirable chemical to be used as part of an IPM program due to its low toxicity on beneficial arthropods and humans. Initial data analysis shows positive results and a report will be forwarded to the chemical company involved to assist with the registration of this product for use on mango crops.

PROJECT: Development of IPM Strategies for Citrus

Project Officers: M. Connolly, D. Chin, and G. R. Brown

Location: Katherine, Darwin and Mataranka

Objective:

Identify potential arthropod problems in citrus tree crops and devise appropriate control measures in line with Integrated Pest Management (IPM) strategies.

Background:

Citrus is well suited to the Darwin and Katherine regions with red-fleshed grapefruit, lemons, limes and possibly mandarins having potential for domestic and overseas markets. As at July 2001 there were 70 000 trees planted, with the majority of large plantings now situated near Katherine. However most trees planted in the Top End are still young and over 80% of them have yet to come into production.

The citrus industry requires ongoing research into potential insect pest species, as this relatively new crop continues to expand in area and value. Advice and assistance must also be provided to all growers, consistent with the aim of developing IPM systems.

Method:

Regular monitoring of citrus plantings in the Katherine region began in December 1999. At this time fortnightly surveys commenced at the experimental cultivar plots at Katherine Research Station. A further seven private properties in the Katherine region, including one in Mataranka were monitored monthly or at opportunistic intervals.

Due to industry demand, monthly monitoring of five Darwin citrus orchards commenced in July 2002. All regular monitoring of orchards was completed in March 2003. In addition, various small-scale field trials were completed during the reporting period.

Results:

A significant collection of insect specimens has now been assembled and identifications are continuing. Collections of beneficial and predatory insect species need to be expanded. Several parasitoid wasp species associated with citrus leaf miner *Phyllocnistis citrella* Stainton, (Lepidoptera: Gracillariidae) were identified at ANIC, Canberra. To date no populations of the most promising wasp parasitoid, *Ageniaspis citricola* Logvinovskaya (Hymenoptera: Encyrtidae) have been found in the NT.

A few species of scale and mealybugs have been found heavily infesting citrus in Darwin whilst they are not common in Katherine. The most notable examples are circular black scale *Chrysomphalus aonidum* (L.) (Hemiptera: Diaspididae) and citrus mealybug *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae).

During May 2002 and up until March 2003 the insect pathogen *Fusarium coccidicola* (red-headed fungus) was found to be infecting up to 90% of circular black scale populations both in Katherine and Darwin.

The citrus flower moth *Prays nephelomima* Meyrick (Lepidoptera: Yponomeutidae) which feeds on flower petals and small fruits has been found throughout flowering periods on Darwin citrus and especially limes, (*Citrus latifolia)*.

Heavy populations of green tree ants *Oecophylla smaragdina* (Fabricius), (Hymenoptera: Formicidae*)* have been observed to increase populations of red scale, *Aonidiella aurantii* (Newstead), (Hemiptera: Diaspididae) on citrus, possibly due to their ability to exclude all predators and parasites from predating on young scales. One trial using Amdro™ mixed with cat food to control green tree ants in citrus trees resulted in a significant rise in green lacewing*, Mallada signata* Schneider, (Neuroptera: Chrysopidae) populations after treatment.

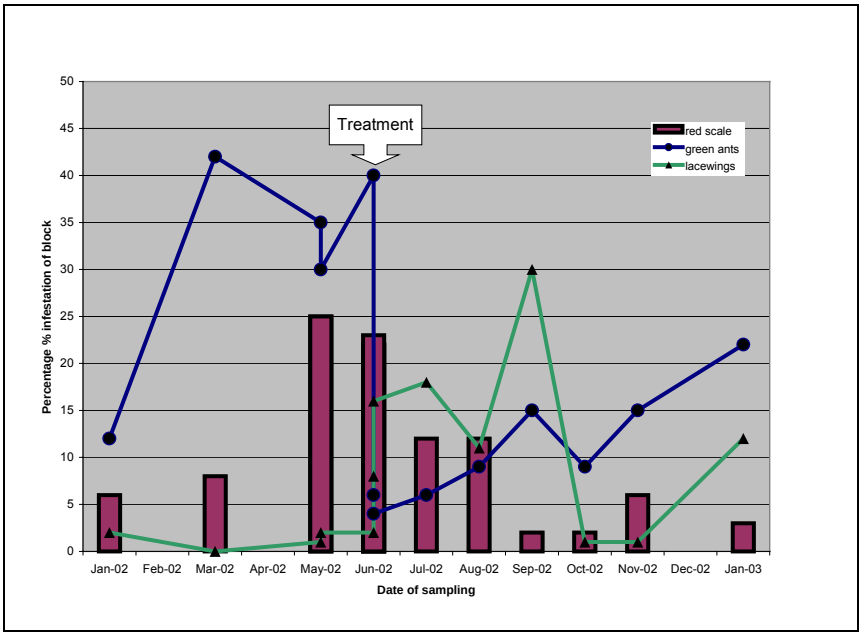

Figure 1. Relationship between green tree ant, red scale and lacewing numbers on citrus trees from January 2002 to January 2003

Recommended quantities of green lacewings, *M. signata* were introduced into orchards during 2002. One release in Mataranka during early August was successful in that red scale and spherical mealybug, *Nipaecoccus viridis* (Newstead), (Hemiptera: Pseudococcidae) were completely eradicated from the orchard, but populations of lacewings did not persist.

Various species of thrips appear to be a major and emerging group of pests of citrus in the Northern Territory. *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) has the common name of strawberry thrips, and has been found feeding under the calyx lobes of very small (< 10 mm diameter) citrus fruits causing circular scars or 'halo damage'. One orchard experienced a severe infestation during July 2002 when 50% of developing fruit was affected.

PROJECT: Development of IPM Strategies for Citrus – Biological Control of Red Scale

Project Officer: **M. Connolly**

Location: Katherine

Objective:

Trial release of Aphytis lingnanensis Compere (Hymenoptera: Aphelinidae) to control a heavy infestation of red scale, Aonidiella aurantii (Maskell) (Hemiptera: Diaspididae) on citrus in Katherine.

Background:

Red scale is a type of armoured scale insect with a wide host range including all citrus varieties currently in production in the Northern Territory. It has been a very serious pest of citrus in all areas of Australia, but since the 1940s a range of introduced natural enemies have substantially reduced its impact. However, it still remains a major pest (Smith, et al. 1997).

Parasitic wasps of the genus *Aphytis* have long been recognised as highly efficient natural enemies of armoured scale insects. *A. lingnanensis* performs well in Queensland and northern New South Wales, whilst other species do better in drier citrus-producing areas of Australia, (Llewellyn, 2002).

No positively identified specimens of *Aphytis lingnanensis* wasps have been recovered from red scale in the Katherine area to date, although several unidentified specimens of *Aphytis* have been collected. Parasitism rates observed against red scale have been low to non-existent, especially on younger citrus trees.

Method:

A property near Katherine (14°28.637'S: 132°13.524'E) was identified as having a heavy infestation of red scale within a planting of 330, five-year-old grapefruit trees (*Citrus x paradisi*) comprised of mixed varieties and rootstocks. All trees had an extensive canopy of at least 3 x 3 m and had been producing fruit for two seasons. This property had also been regularly monitored as part of regional pest and beneficial insect data collection for the citrus industry.

Pure cultures of *A. lingnanensis* wasps were sourced from 'Bugs for Bugs', Mundubbera, Qld. *Aphytis* wasps were released in two batches: 100,000 on 30 July followed by 150,000 on 14 August, 2002. Paper strips with wasps clinging on were placed into the tree canopy of every second tree on alternate rows. Cups with remaining wasps inside were used on the last release site. On 14 August, additional wasps to the main release requirements were concentrated in areas of heaviest scale populations.

Sampling of wasp activity involved collection of 50 leaves visibly infested with red scale, from at least 10 trees. Sampling from individual trees was random but generally followed a zigzag pattern through the orchard. Leaves were then observed under a microscope and counts of scales, scale condition (dead or alive) and the number of *Aphytis* wasp emergence holes were recorded. Intensive sampling occurred on three separate occasions.

Results:

Results show that there was already a reasonable amount (20.8%) of parasitism prior to the first release on 30 July. Results from September show the population of red scale has reduced significantly and parasitism rates had reached 100%. On 23 October another visit was made to the orchard to collect scale-infested leaves. However very few leaves with scales could be found so a general orchard scout was conducted instead. Red scale infestation at that time was 2%, compared with 23% post release, on 23 June.

Table 1. Red scale counts from 50 leaves and percentage parasitism by Aphytis wasps

Date of sample	Total No. scales	No. live scales	No. emergence holes	% total scale parasitism	% live scale parasitism
30 Jul	1071	658	137	12.8	20.8
27 Aug	567	265	102	18.0	38.5
17 Sep	245	78	86	35.1	110.3[1]

([1]The value >100% was due to counting some parasitised scales that were actually already dead)

Table 2. Weather data from Katherine Aviation Museum, 14°26'37"S: 132°16'25"E

Month	Max °C	Min °C	Mean
Jul	32.5	10.3	30.0
Aug	34.2	10.6	31.4
Sep	38.4	20.4	35.7

Discussion:

Owing to the innovations in packaging and shipping by 'Bugs for Bugs', *Aphytis* wasps can now be sourced all year round, yet it is necessary to release them during less extreme weather conditions than normally encountered in the dry-tropics of the Northern Territory.

In southern states it is recommended that *Aphytis* releases coincide with warmer weather around spring or early summer because during winter months wasp and scale numbers will generally decline. In the dry-tropical regions of Australia the spring to early summer conditions will most definitely encourage red scale activity to increase. However, maximum daily temperatures during these months

are normally above 35°C and are deemed unsuitable for wasp survival, (pers. comm. Dan Papacek, 2002).

This small investigation has shown that releasing *Aphytis* during the dry season is successful. Further investigations will be needed to assess whether *Aphytis* could be released successfully at other times of the year, for example September or if in fact the window for releases must remain strictly limited to the dry season months - May through July.

References:

Llewellyn, R. (ed). (2002). *The Good Bug Book*. 2nd edn. Integrated Pest Management Pty.

Smith, D., Beattie, G. and Broadley, R. (eds). (1997). *Citrus pests and their natural enemies: Integrated pest management in Australia.* Queensland Dept. of Primary Industries, Brisbane.

PROJECT: Development of IPM Strategies for Citrus – Control of Citrus Leaf Miner with Confidor®

Project Officers: M. Connolly, G. R. Brown and B. Thistleton

Location: Katherine

Objective:

Assess the length of protection from citrus leaf miner, Phyllocnistis citrella Stainton, (Lepidoptera: Gracillariidae) using soil application of Confidor® (imidacloprid) on young, non-bearing citrus trees Citrus limon (var. Lisbon lemon).

Background:

Imidacloprid is a relatively new class of systemic insecticide for foliar, soil and stem application particularly against sucking insects. The marketing company, Bayer Australia Limited is now confident that when applied as a soil drench, imidacloprid has excellent root-systemic properties, broad-spectrum activity and good long lasting effects.

Bayer claims that when applied as a soil drench during late October to early November good control of citrus leaf miner is obtained and the need to use oil sprays during the heat of summer is eliminated. The seasonal timing of chemical application has not been determined for the Northern Territory. Confidor® is most reliable on smaller, non-bearing trees and it is considered uneconomical to treat trees beyond four to five years of age.

The most limiting factor to the success of this chemical in the Katherine and Darwin areas may be the prolonged wet season. High rainfall may leach the chemical prior to its complete utilisation by the plant. This may prevent the extended protection promised by the chemical label, the most attractive property by far.

The efficacy of imidacloprid against the leaf miner has already been proved. The aim of this trial was to establish how long protection would last from leaf miner attack at different application rates.

Method:

A local citrus grower kindly offered a newly planted block of Lisbon lemon trees for the trial. The block consisted of 1148 trees, in 28 rows of 41 trees each. The trial was a randomised block design with four treatments and four replications. The design allowed a buffer of two to three trees between each treated row.

Treatments
10 mL *Confidor*® per tree (n = 10 x 4)
15 mL *Confidor*® per tree (n = 10 x 4)
20 mL *Confidor*® per tree (n = 10 x 4)
control (n = 10 x 4)

Application
Each application rate of chemical was diluted in 500 mL of water then poured around the base of the tree. Trees were marked with flagging tape to identify their treatment.

Sampling
A measure of pre-treatment leaf-miner damage was taken. Thereafter sampling for leaf-miner damage occurred every 30 days (or when flush leaves were available) from the date of application. The sampling procedure involved visually assessing 10 new flush leaves per tree for presence or absence of leaf miners.

Results:

Figure 1 shows that all treatments substantially reduced leaf miner damage. Residual effect was still evident and significant the following year when populations started to increase again.

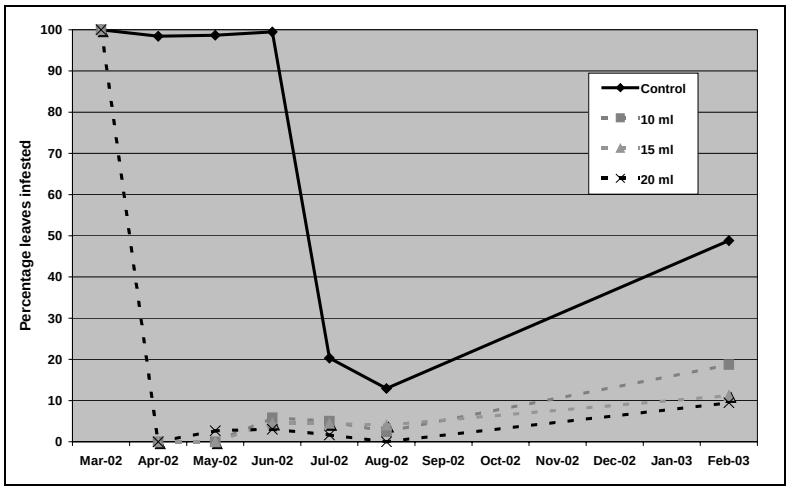

Figure 1. Proportion of citrus tree leaves infested with citrus leaf-miner after treatment with *Confidor*® at various rates

The March 02 value is pre-treatment.

PROJECT: Management and Control of Termite Pests of Horticultural Crops in the Northern Territory

Project Officers: B. M. Thistleton and M. J. Neal

Location: Territory wide

Objective:

Develop effective environmentally sustainable control methods against Mastotermes darwiniensis and other termites in horticultural crops in the Northern Territory.

Background:

Mastotermes darwiniensis Froggatt (Isoptera: Mastotermitidae) is the most destructive species of termite in tropical Australia. In the Northern Territory this species accounts for substantial annual production losses in horticultural tree crops and is also responsible for losses in vegetable and agricultural crops. *M. darwiniensis* can cause major damage to buildings, wooden structures, electrical

cables and a variety of other materials. The main product registered for use against this pest in horticulture is *Mirant*®, which is the organochlorine mirex. As organochlorines are being phased out of use, it is necessary to test alternative pesticides against *M. darwiniensis.*

A successful management strategy against the giant termite was developed from results of research conducted in a joint project for its control and reported in previous Technical Annual Reports. The method involves aggregating the termites in 20-L drums and applying *Mirant*® to cardboard in the drum. Termites chewing through the cardboard liner either ingest or have some of the gel adhering to their bodies (see DBIRD *Agnote* No. I58).

Field testing of several promising insecticides to replace mirex commenced at Coastal Plains Horticultural Research Station (CPHRS) in 1999. Recently another promising insecticide, fipronil, was tested in the laboratory and as a soil injection treatment in field trials from early 2000 to 2002. Emphasis has been given this year to the continued field testing of this insecticide to provide efficacy and residue data for a submission to the Australian Pesticides & Veterinary Medicines Authority. These studies have been carried out in conjunction with the manufacturer of this product.

Method and Results:

Aggregation methods
Aggregation drums are the standard technique for research and control of *M. darwiniensis*. The drums (20 L or 200 L) are filled with pieces of untreated pine or other timber and are placed on soil beside infested trees, over the cut stumps of dead trees, or attached to the trunks of infested trees. *Mastotermes* move into these drums in large numbers and these aggregations can then be used for studies on their biology or to test termiticidal activity.

Studies on biology
Observations on the biology of *M. darwiniensis* are made at the monitoring sites particularly in the aggregation drums and by digging nests.

Colony mapping using fluorescent dyes
M. darwiniensis nests can be found in the soil and inside trees, but this species does not form mounds and its cryptic habits make it difficult to determine the size of colonies. Previous studies by CSIRO had used radioactive tracers and fluorescent dyes to map colonies and the technique has been used in the current trial. Fluorescent dye has been dusted onto termites in aggregation drums, which is spread through the colony through grooming and by stomodeal and proctodeal feeding. After a few days' samples of termites are collected from other drums, smears of their faeces are made on microscope slides. The fluorescent dye particles can be detected by examination of these slides under a compound microscope using ultra-violet illumination.

The technique was used this year to map colonies in trials at CPHRS. In one area it was demonstrated that the colony extended over at least 220 m.

Soil injection trials
The main emphasis this year has continued to be the testing of liquid formulations of Termidor Residual *Termiticide*® (Termidor) containing 100 g/L fipronil. These have been applied by soil injection, using a Croplands 120 L electric sprayer with an injection lance, in a range of concentrations and volumes, around the bases of mango and citrus trees or to the soil underneath aggregation drums. Untreated trees and aggregation drums have been used to monitor the effect of the insecticide at various distances from the application site.

Soil injection of mature mango trees and residue analysis – trial 1
A soil injection trial to mature mango trees had previously been carried out in Humpty Doo commencing in June 2001. The aim of this trial was to assess the control given by the insecticide and to provide samples of fruit for measurement of residues. During the current year assessment of this trial was continued and termites were managed as they reinvaded the block. The area remained free of termites for over a year from the soil injection, but then *Mastotermes* were picked up in a line of timber billets along the fence line. Two 200-L aggregation drums were established and, when termite activity was high, the soil beneath them was injected with Termidor. Two more drums were established during the year and treated likewise. Since the original treatment had knocked the termites out over the whole block, and since *M. darwiniensis* tends to spread by budding off from existing colonies, monitoring and treatment of the edges of a block should be an effective way to prevent re-invasion.

Soil injection of mature mango trees and residue analysis – trial 2
A follow-up trial was conducted in 2002 to test a lower rate of Termidor applied to mature trees and to measure the distance over which the product affected the activity of termites. In April two heavily infested blocks of mangoes at CPHRS (KP/Sabre block and a variety trial) had been chosen for this trial. All trees in both blocks had been drilled to assess termite activity and new 4-L paint tins had been established on the trunks of some to aggregate the termites and to allow more detailed observations on their activity.

Three trees in the variety block were soil-injected in July 2002 and *Mastotermes* activity was monitored on them and on other trees at varying distances from them. Monitoring involved checking activity in holes plugged with dowels, checking mudding up on new open holes, checking activity in tins on the side of the tree and checking for activity under the bark of the trees. Initially assessments were carried out every two weeks and then extended to monthly. The assessments showed that termite activity ceased completely in trees up to 20 m (2 rows), and in many of the trees 30 m, from the treated trees with termites only remaining in four out of a total of 47 trees in the block. The KP/Sabre block was monitored as an untreated control and termites remained active in all the trees.

Since this trial has shown that good control can be achieved with half the application rate of Termidor to that used in 2001, the manufacturer requested that further fruit be collected for residue analysis. Samples were taken from each treated tree and from two adjacent trees on four occasions between September and November 2002, and sent for analysis.

Soil injection of mature mango trees – trial 3
Since only three trees were originally injected in trial 2, *Mastotermes* later reinfested the block from the four trees, which remained active. A second trial, injecting every second tree in the variety block was therefore carried out in May 2003. In this trial, termite activity ceased in all trees. Monitoring will be continued on the trial to check how long before re-invasion occurs and if this period is different for non-treated and treated trees. This will indicate if there is any long-term residual effect of the chemical.

Soil injection of young citrus trees –trial 1
A soil injection trial had been carried out in a block of 960 young citrus trees in Katherine and reported in the 2001-02 Technical Annual Report for. A further assessment was made in this block in May 2003, 17 months after the treatment, but no evidence of *M. darwiniensis* could be found.

Soil injection of young citrus trees –trial 2
A second trial had also been commenced in an adjacent block of 960 trees (this had been used as an untreated control in trial 1) and every third tree in every second row had been injected in June 2002. Ten 20- L aggregation drums had also been set up in this block. In July and August all the trees and aggregation drums were monitored for termite activity. No activity was detected in any of the trees but four of the aggregation drums remained active. It was suspected that the relatively small number of termites in the treated trees was insufficient to carry enough chemical to the highly active aggregation drums. So, an extra injection on these four drums was carried out in August and by the end of the month activity had ceased throughout the whole block. In May 2003, 11 months after the treatment, another full assessment of the block detected new activity in one tree. This was on the border of the block where re-invasion would be expected, and an aggregation drum was set up for further treatment.

Soil injection of young citrus trees –trial 3
The third trial was carried out on two blocks of newly planted citrus trees. The trial consisted of four treatments: injected every tree; injected every third tree; injected every third tree every other row; and no injection. The trial was a randomised block replicated four times, with a total of 2284 trees. The injections were carried out in December 2002. The treatments stopped further damage from *Mastotermes* but in later assessments it became evident that *Microcerotermes* were still killing plants (see next Section).

Microcerotermes on young citrus trees
While *Microcerotermes* had been commonly observed on citrus trees at Katherine, this species had not previously been considered to cause serious damage to the plants. However, in trial 3 *Microcerotermes distinctus* Silvestri (Isoptera: Termitidae) was found to be causing sufficient damage to the young citrus plants to cause their death. Since their colonies are much smaller than those of *Mastotermes,* the *Microcerotermes* were not transferring the chemical over long distances and therefore the treatments applied for *Mastotermes* had left many colonies intact. It was decided to treat these by applying Termidor through the irrigation line, which was done in June 2003.

Grapevines
Pest problems in table grapevines were investigated at Ti Tree in April. Two species of termites had long been a problem there. *Microcerotermes implacidus* Hill (Isoptera: Termitidae) attacks trees of all ages. It can kill young vines, but extensively damaged older vines still produce fruit. It has previously been controlled by the use of butt sprays of chlorpyrifos. The other species, *M. darwiniensis*, has been present for some years but its damage is becoming worse. In both cases fipronil could give control and trials have been proposed for later in 2003.

Soil injection under drums in agroforestry
After the success of controlling *Mastotermes* in agroforestry blocks (see the 2001-02 Technical Annual Report) treatments were applied this year to an aggregation at the agroforesty block at Howard Springs in conjunction with the Agroforestry Section, DBIRD.

Control in cocoa
The cocoa trees at Coastal Plains Horticultural Research Station were drilled, assessed for *Mastotermes* damage and soil-injected with *Termidor.*

Minor use permits for Termidor
The Australian Pesticides and Veterinary Medicines Authority issued a minor use permit for the use of *Termidor* on citrus.

Baits
Trials were continued with bait incorporating an insecticide, which inhibits the production of chitin and prevents development of termites. This bait was applied to aggregation drums in a plot of native trees at Gunn Point. *Mastotermes* activity was assessed regularly using more aggregation drums and grids of billets. The trial is ongoing and the company is preparing a different formulation of the bait for trial.

Mastotermes in the Alice Springs region
Elkedra Station, NW of Alice Springs was visited to inspect and advise on *Mastotermes* control in fruit and ornamental trees. Trees were drilled to assess activity and the use of aggregation drums and application of Mirant was demonstrated. After the visit, a permit for minor use of fipronil on citrus was issued so the station could use the chemical on its citrus trees.

Collaborative research
Assistance was given to visiting termite researchers from CSIRO and Belgium on *Mastotermes* and other termites in the NT. CSIRO is conducting research into variation in the DNA and cuticular hydrocarbons in different colonies of *Mastotermes darwiniensis.* To assist in this work, collections of *Mastotermes* from various colonies were made at the southern part of their range (Elkedra Station and Ti Tree). New products are being tested for insecticide companies and representatives have visited Darwin for discussions.

PROJECT: Peanut Entomology

Project Officers: M. Connolly and G. R. Brown

Location: Katherine and Douglas Daly

Objective:

Sample and identify insect species found on peanut crops and determine their pest status.

Background:

Peanuts, *Arachis hypogaea* L. (Fabaceae), are a high value, high input legume crop. This is the third year of a three-year project where intensive insect sampling has taken place on peanut crops. In 2003 the Peanut Company of Australia set up several pivots at the old Hickey's Farm site on Florina Road, Katherine. Another peanut crop is located about 40 km south west of Katherine and the other is in the Douglas Daly Basin. The Douglas Daly grower has planted two pivots with peanuts for six years consecutively whilst the Katherine grower will make the third harvest at the end of the 2003 growing season.

Method:

During 2003 sampling of peanut crops was restricted to the Katherine area. Douglas Daly was only visited on two occasions. Beginning in April the sampling regime included weekly vacuum samples taken from 50 m of crop row from one Katherine pivot only. Visual sampling for arthropods occurred simultaneously at the two Katherine crops until peak flowering. Sampling continued at the property 40 km out of Katherine until late July when sampling progressed to fortnightly, digging of nuts to check for pod damage. Vacuum sampling data from this season will be added to that of previous years and analysed for trends. Any new insect pests or live specimens that were collected or reared were lodged in the NT Economic Insect Collection.

Results:

Complete results, together with consecutive years of data will be published as a Technical Report in late 2003. A peanut Agnote has been drafted covering common pest and beneficial insect species and further information will be made available on the newly developed Entomology website. A demonstration of peanut scouting techniques was presented to 27 primary producers and government staff at Douglas Daly Research Farm in June. The following is an overview of insect activity compared with the previous year's observations. Beneficial insects are not discussed.

Unlike in 2001, sucking bugs, including the green vegetable bug, *Nezara viridula* (Linnaeus) and the red-banded shield bug *Piezodorus oceanicus* (Montrouzieri) (Hemiptera: Pentatomidae), were almost completely absent from the crop canopy. One species of leafhopper *Austroasca alfalfae* (Evans) (Hemiptera: Cicadellidae) was again abundant, with the presence of nymphs indicating breeding activity. Despite high numbers of *A. alfalfae,* typical leaf feeding damage normally associated with leafhoppers was not observed.

The brown mirid, *Creontiades pacificus* (Stål) (Hemiptera: Miridae) and its nymphs were abundant on crops at early flowering and sprays were applied to reduce flower loss caused by mirid feeding. The source of high mirid populations may have originated from an infested Cavalcade crop growing on the same pivot area. Cavalcade is used as a wet season cover crop and for hay. The status of the brown mirid as a peanut pest is under review by QDPI.

An infestation of cowpea aphids *Aphis craccivora* Koch (Hemiptera: Aphididae) occurred at Douglas Daly in 2003, covering developing pegs with honeydew liquid and sooty mould. Through their feeding habits aphids may contribute to introduction of diseases. The aphids multiply rapidly once they have entered the crop; however the transverse ladybird beetle *Coccinella transversalis* Fabricius (Coleoptera: Coccinellidae) and hover flies (Diptera: Syrphidae) have played an important role in controlling these outbreaks.

Helicoverpa spp. (Lepidoptera: Noctuidae) larvae were present during most of the crop's cycle and have proven to be especially damaging at flowering when they tend to feed on flowers instead of foliage. *Spodoptera litura* L. (Lepidoptera: Noctuidae) larvae were again found at the Katherine site where they fed on developing peanut pegs before they reached the soil.

Lucerne seed web moths, *Etiella behrii* (Zeller) (Lepidoptera: Pyralidae) were abundant in small areas of the Katherine crop towards the end of the 2002 season. This pest appears to be extremely sporadic and occurs most often in stored peanuts.

To date a variety of other caterpillars have been found amongst the crop. Most appear to feed only on foliage whilst a few species fed on fresh peanut kernels when offered as a food source in the laboratory. Identifications of possible economically important species include *Athetis reclusa* (Walker) *and Leucania loreyimima* (Rungs) (Lepidoptera: Noctuidae).

No damage from any species of false wireworm (Coleoptera: Tenebrionidae) was noted in 2003.

Table 1. Major peanut insect pest monitoring summary

	Crop growth stage				
	Seedling	**Vegetative**	**Flowering**	**Pegging**	**Pod fill**
Monitoring frequency	Daily	1 / week	2 / week	1 / week	1 / week
Pest	False wire-worm	Leafhopper	*Helicoverpa*	*Spodoptera*	*Etiella*
	Army-worm	Other caterpillars	Brown mirid	Aphids	Other larvae

PROJECT: Pest Management in Tropical Vegetables

Project Officers: B. M. Thistleton and M. J. Neal

Location: Darwin area

Objective:

Advise on management of the major pests of tropical vegetables.

Background:

Poinsettia white fly, *Bemisia tabaci* Type B (Hemiptera: Aleyrodidae), melon thrips, *Thrips palmi* Karny (Thysanoptera: Thripidae), and two spotted mite (TSM), *Tetranychus urticae* Koch (Acarina: Tetranychidae), are the most serious pests of tropical vegetables in the Darwin area. All three species exhibit resistance to a greater or lesser extent to most of the currently commercially available pesticides and outbreaks are generally linked to the persistent use of chemicals. Other pests are more specific to particular crops (e.g. bean-fly *Ophiomyia phaseoli* (Tryon) (Diptera: Agromyzidae) on snake beans can be controlled with more specific pesticides (e.g. melon and cowpea aphid control with pirimicarb).

A range of natural parasites and predators are effective against these pests, provided that non-disruptive chemicals are used to prevent excessive mortality in natural enemies. In addition, the commercially produced Chilean predatory mite, *Phytoseiulus persimilis,* Athias-Henriot (Acarina: Phytoseiidae) can be introduced to bring TSM populations under control.

Results:

Several talks were given to Asian vegetable growers at their monthly meetings on control measures for various pests. These talks covered all methods of control including chemical, biological and cultural, with an emphasis on how they could be used together for IPM. Research on IPM methods for several vegetable pests has been reported in previous Technical Annual Reports and the results of this work were included in the talks. Full lists of all insecticide products registered for each crop were presented to the growers, but the use of soft chemicals and natural enemies was promoted.

Visits were also made to growers' properties to assess pest populations and advise on control measures. Advice was also given to enquiries made by telephone.

PROJECT: Pest Management in Ornamentals

Project Officers: **B. M. Thistleton, G. R. Brown, M. J. Neal, H. Brown and H. Wallace**

Location: Territory wide

Objective:

Advise on management of pests of ornamentals and carry out research on key pests.

Background:

The nursery industries in Darwin and Alice Springs requested assistance during the year. In Darwin significant damage has been reported to alpinias and other types of ginger by caterpillars of a stem-boring moth. In Alice Springs assistance was required with pest control strategies for nursery pests, particularly integrated pest management (IPM) methods.

Results:

This moth attacking alpinia was identified as *Conogethes pluto* (Butler) (Lepidoptera: Pyralidae), a species closely related to yellow peach moth, *Conogethes punctiferalis* (Guenee). Recent research by CSIRO, started as a response to submission of specimens from alpinias in the NT, has indicated that there is a complex of species under the name “yellow peach moth” within Australia and that taxonomic clarification is required.

Researchers have visited all growers of alpinias in the NT to determine caterpillar damage levels, local factors that act on populations and the potential losses in flower production. Work is concentrating on the ecology and management of the moth.

Insecticides have been recommended and successfully used on occasions. However both the growers and the Department prefer to integrate the use of insecticides with other options. Work is now concentrating on setting up a culture of the moths so that biological control methods, such as the release of egg parasites, can be investigated.

A workshop was conducted in Alice Springs in November 2002 for the Alice Springs Nursery and Garden Industry Association. This was funded jointly by DBIRD and the nursery industry, through Farmbiz. The workshop, at which there were 24 participants, was held at the Arid Zone Research Institute and dealt with various pests of nursery plants, emphasising biological and IPM control measures. Visits by Darwin based entomologists were also made to nurseries in the Alice Springs area in November 2002 and April 2003 to collect specimens of important pests and advise on their control.

SUBPROGRAM: Interstate Quarantine

PROJECT: Provide a Government Certification System as an Alternative to Interstate Certification Assurance (ICA) for Market Access of NT Produce

Project Officers: **J. Swan, P. Cawdrey, A. Mullins, J. Lindsay, S. Cross, B. Dilley, I. Haselgrove, C. Ellis, A. Jacks and S. Chester**

Location: Darwin, Katherine and Alice Springs

Objectives:

Provide access to markets in other States of Australia to NT produced plant material.

Provide plant health certificates specifying that entry conditions to those States have been met.

Background:

NT produce (fresh fruit and vegetables, cut-flowers, nursery stock) consigned to States, which have quarantine entry requirements, must be certified by either Plant Health Certification or ICA to confirm that those requirements have been met. Most producers have opted for ICA accreditation where an approved arrangement has been developed to enable certification. Where ICAs are not available for a particular product, consignments are irregular or few in number and making ICA uneconomic, DBIRD may provide a Plant Health Certificate based on inspection or other procedures.

Nationally agreed ICA arrangements for cut-flowers and nursery stock have not been developed, or are not yet approved. These industries require departmental inspection and government certification prior to consignment to States where entry restrictions exist.

Method:

To enable interstate movement of cut-flowers and nursery stock, the NT Quarantine Section (NTQS) staff are required to inspect each consignment and certify it if it meets the receiving State's entry requirements.

All nurseries and cut-flower suppliers consigning to Western Australia are monitored for melon thrips (*Thrips palmi*), spiraling white fly, western flower thrips and mango leafhoppers to meet this particular certification requirement.

Businesses accredited under ICA and consigning to some States must also have an inspection of their produce by NTQS, followed by official endorsement on their documents showing the produce to have been inspected and found free of a number of pests not covered by ICA arrangements.

Results:

A total of 841 Plant Health Certificates were issued during the financial year to 30 June 2003 and a total of 319 endorsements were made on ICA documents.

PROJECT:	**Market Access for NT Produce under Approved Interstate Certification Assurance (ICA) Arrangements**
Project Officers:	**J. Swan, P. Cawdrey, A. Mullins, S. Chester, J. Lindsay, C. Ellis and A. Jacks**
Location:	Darwin, Katherine and Alice Springs

Objective:

Maintain market access to NT horticultural produce within Australia under approved ICA arrangements.

Background:

ICA is a system of plant health certification based on quality management principles. ICA provides an alternative to traditional plant health certification involving DBIRD inspectors. Traditionally inspectors supervised treatment and/or inspected produce and issued Plant Health Certificates for the movement of produce intrastate or interstate.

Under ICA, a business can be accredited to issue Plant Health Assurance Certificates for its produce. To be accredited, a business must be able to demonstrate it has effective in-house procedures in place that ensure produce consigned to intra and interstate markets meets specified quarantine requirements.

Method:

ICA is based on documents. Operational procedures are developed by DBIRD in conjunction with industry and interstate quarantine authorities. Operational procedures describe the management system and process controls that must be implemented and maintained by a business to become accredited to certify that a specific quarantine treatment has been done.

Under an ICA arrangement, the accredited business assumes responsibility for specified treatments and/or inspections previously undertaken by DBIRD inspectors. DBIRD must ensure the ICA arrangement is in place and working effectively through a program of regular audits.

Once accredited, a business is able to issue documents known as Plant Health Assurance Certificates that are accepted by DBIRD and the plant quarantine authorities of other States as evidence of compliance to the specified quarantine requirements covered by that certificate.

Results*:*

Operational procedures have been developed for a range of treatment and condition requirements including:

- dipping
- flood spraying
- low volume non-recirculating spraying
- fumigation
- heat treatment (vapour heat and hot water)
- cold treatment
- hard green/mature green/unbroken skin condition
- pre harvest treatment and inspection
- splitting and reconsigning certified produce.

Over 900 arrangements are currently being utilised by over 500 businesses in the NT. Further operational procedures will be developed as needed.

PROJECT: Provide a Screening Process of Imported Plant Material for the Presence of Pests and Diseases

Project Officers: **J. Swan, I. Haselgrove, P. Cawdrey, B. Dilley, A. Mullins, J. Lindsay, C. Ellis and A. Jacks**

Location: Territory wide

Objective:

Ensure that any plant material entering the NT from other regions of Australia complies with movement conditions under NT legislation.

Background:

The local horticultural industries are advantaged by reduced production costs and better market opportunities where the NT is free from pests and diseases that occur in other regions of Australia.

Plant material (fresh fruit and vegetables, cut-flowers and nursery stock) entering the NT must comply with legislation and have accompanying certification that these requirements have been met.

The NT accepts Plant Health certificates and Interstate Certification Assurance (ICA) certificates.

Method:

An ongoing inspection program is maintained with NT florists, nurseries, and fresh fruit and vegetable importers to inspect product from risk areas of Australia.

Targeted pests include western flower thrips, spiralling white fly, Mediterranean fruit fly, banana fly, cucumber fly and red imported fire ant (RIFA).

The NT targets RIFA as a particularly serious environmental and agricultural pest and high-risk materials, which may harbour this pest, are routinely inspected on arrival by the RIFA surveillance officer.

Results:

The NT has maintained freedom from these targeted pests.

PROJECT: Dissemination of Information

Project Officers: **J. Swan, P. Cawdrey, A. Mullins, J. Lindsay, S. Cross, B. Dilley, I. Haselgrove, C. Ellis, A. Jacks and S. Chester**

Location: Territory Wide

Objective:

Provide relevant information and awareness to industry and the general public of movement conditions and methods of meeting certification requirements for the movement of plant material into and out of the NT.

Background:

The Section is responsible for keeping industry and the public well informed of quarantine movement requirements for plant material between different regions of Australia.

Various arrangements have been developed under an interstate certification assurance system, approved nationally for market access of plant material. Advice regarding this and the alternate Government certification methods are provided.

The Section provides advice to importers and brokers on procedures for prompt and efficient quarantine clearance and/or subsequent treatment of goods originating from the giant African snail (GAS) countries that have been identified under NT legislation.

Method:

- Staff respond to telephone enquiries from both industry and the general public on movement conditions of goods.

- Training packages are delivered to industry and staff on correct methods of meeting requirements.

- Meetings are attended locally and interstate to maintain up-to-date information and develop new access requirements. This information is also distributed to industry bodies after approval from interstate plant health regulatory working committees.

- Routine attendance at regional shows to highlight current issues and disseminate timely information.

- Production of timely reference documentation and distribution to industry through mail and personal visits when required.

- A website is being developed for the general public and industry on quarantine, ICA and plant health information.

Results:

- More than 2500 telephone enquiries from the general public and industry were processed during the year.

- Attendance at grower properties, nurseries, florists, fresh fruit and vegetable outlets on a routine basis to check compliance and advise of new conditions.

- In office enquiries/appointments for the general public and industry have been considerable. Currently 900 arrangements are utilised by over 500 businesses in the NT. All information is maintained on the *Plant Health Information System* database.

SUBPROGRAM: Surveillance and Eradication

PROJECT: Management of Surveillance and Eradication Programs

Project Officers: I. Kilduff and E. S. C. Smith

Location: Territory wide

Objective:

Develop strategies and operational procedures to detect exotic and established (in other States) plant pest and disease species that do not occur in the NT and if located, develop plans and procedures for their containment or eradication.

Background:

The Northern Territory has the potential to be the first place of entry for exotic plant pests and diseases that can affect the horticultural and agricultural industries and the community. Since 1997, more than 25 species that had not previously been recorded in Australia have been identified in the NT. These include five diseases, a weed and more than 20 arthropod species. The NT is free from many plant pests and diseases that occur in other parts of the country.

Method:

The Plant Health Branch conducts an array of surveillance programs to detect exotic plant pests and diseases. On detection of a potential pest or disease, it initiates incursion responses. The Divisional Director is the nominal incident manager for each incursion and response. A suspected detection normally triggers the involvement of a specialist to identify the potential new pest or disease and once confirmed, to promptly notify the relevant committees and the Commonwealth/State authorities. Team structures manage incidents and tasks are defined in the Departmental Response Plan.

The Plant Pathology, Entomology and NT Quarantine Sections generally have at least an early involvement in the investigation of incidents, determination of the identity of the organism, resource allocation and assistance with procedures to contain or eradicate the problem.

Results:

During the year, various programs were continued or developed in conjunction with the operational sections of the Plant Health Branch. Some of these are reported separately in this Subprogram.

The Branch developed the national Grapevine Leaf Rust Eradication Program and submitted it to interstate authorities for approval of the methodology, staffing, budget and the commencement.

A second eradication program was initiated following the detection by a commercial pest control operator of the drywood termite *Cryptotermes dudleyi* in a house in a Darwin suburb. Other local pest control industry personnel were notified. A presentation will be made to industry on detection of these cryptic pests. The remainder of the infected premises and neighbouring properties were inspected and damaged timber was removed.

Other developments in the surveillance and eradication areas in which the Branch was involved included:

- revision of the NT exotic incursion protocol in conjunction with industry representatives;
- development of a national 1800 telephone Hotline by Plant Health Australia to report suspicious or unknown plant pests or diseases and initiate possible responses;

- training in emergency response planning in the event of plant pest or disease incursions
- training in exercise management;
- involvement in the large emergency animal disease activity *Exercise Minatour*.

PROJECT: Inspections and Indexing of Plants in Post-entry Quarantine for Interception of Diseases

Project Officers: R. Pitkethley, B. Condé and A. Daly

Location: Darwin

Objective:

Detect exotic plant diseases in post-entry quarantine.

Background:

The Plant Pathology Unit provides the services of a quarantine plant pathologist under the AQIS Operational Science Program. These services include progressive and pre-release inspections of plants in the Berrimah post-entry quarantine facility. The quarantine plant pathologist inspects plants during their prescribed time in quarantine in order to intercept any exotic plant diseases. Depending on the nature of the plant material, special tests (indexing) may need to be performed, but usually visual examination is sufficient. Other duties of the quarantine plant pathologist include identification of suspected diseases in imported (legally or illegally) goods and preparation of impact statements.

The post-entry quarantine facility is owned by the NT Government and is operated by the Horticulture Division under a licence from AQIS.

Results:

The facility was closed in November 2001 pending a decision on its future. Following renovations and upgrading of building regulation and AQIS standards, it was reopened on 14 May 2003. No plants have been introduced through the facility since its reopening.

PROJECT: Provide Responses to Incursions of New Exotic Pests and Diseases

Project Officers: J. Swan, P. Cawdrey, A. Mullins, J. Lindsay, S. Cross, B. Dilley, I. Haselgrove, A. Jacks and C. Ellis

Location: Any area within the NT

Objective:

Provide a timely response to incursions or potential incursions of new exotic pests and diseases which would increase the feasibility of eradication and minimise the costs of the incursions.

Background:

The Northern Territory has the potential to be the first place of entry for both interstate and international exotic pests and diseases that can affect the horticulture and agricultural industries and the community. Experience has shown that early detection and rapid responses can increase the feasibility of eradication and greatly reduce the financial costs involved.

Method:

A situation report of an incident would trigger the involvement of a specialist who can identify a potential new pest or disease. The report must be confirmed and notification must be given to appropriate senior staff, legal officers, Ministerial staff, specialist interstate plant pest/disease committees, Commonwealth and State authorities before more work commences.

Management team structures and tasks are established and the incident is managed according to the Departmental Response Plan (November 2000) which is being currently revised.

The NT Quarantine Section generally has an early involvement in the investigation of incidents, containment operations, resourcing and assisting to develop procedures to maintain market access of plant material should this be affected.

Result:

The NT Quarantine Section was involved in three incidents relating to exotic pest and disease incursions during the year:

- South African citrus thrips - November 2003: A major pest of citrus, which was found in Brisbane on the host plant 'Mother of millions'. Searches throughout Darwin, Katherine and Alice Springs were initiated but no thrips were detected on these host plants.

- Grapevine Leaf Rust - June 2003: An incident occurred where a grapevine was moved out of the Darwin quarantine zone to Katherine. The incident was investigated and in response, the vine and neighbouring vines on the recipient property and on an adjoining property were destroyed.

- Drywood termite *Cryptotermes dudleyi*: Following the detection of this species by a commercial pest control operator in house timbers in a Darwin suburb, NTQS officers contacted neighbouring residents to obtain approval for inspections of their properties by a pest control officer.

- Surveillance programs that target fruit flies exotic to the NT and the red imported fire ant were continued throughout the year and are reported elsewhere.

PROJECT: Surveillance for Banana Leaf Spot Diseases

Project Officer: A. Daly

Location: Darwin

Objective:

Survey Sigatoka-like diseases in bananas and submit samples to QDPI for detection of black Sigatoka.

Background:

As part of the national surveys for detection of black Sigatoka, leaf samples showing Sigatoka-like symptoms are collected from commercial plantations and other sites and forwarded to QDPI Mareeba for identification of the pathogen. Yellow Sigatoka is not readily distinguishable from black Sigatoka in the field.

Results:

Samples were collected from two localities, the rural area and urban Darwin.

- Three types of leaf spots caused by the fungi *Mycosphaerella musae, Deightoniella torulosa* and *Mycosphaerella musicola* were identified by microscopic and PCR analysis.

- No black Sigatoka (*Mycosphaerella fijiensis*) was detected.

PROJECT: Quarantine Entomology

Project Officer: G. R. Brown and L. Zhang

Location: Darwin

Objectives:

Identify insects and other organisms intercepted by the Australian Quarantine Inspection Service.

Provide advice on the quarantine significance of these organisms and facilitate the recording of this information on a database.

Background:

AQIS provides partial funding to the quarantine entomologist to provide identifications of insects intercepted by Quarantine Inspectors in the Northern Territory.

Method:

Insects and other animal samples collected by Quarantine Inspectors are submitted with insect interception record sheets to Quarantine Entomology for identification and advice. Identification and advice are provided and the record sheets are completed. Identifications are remotely added to the Pest and Disease Interceptions (PDI) database in Canberra, and copies of both sheets are forwarded to the relevant inspectors, and to AQIS in Canberra.

Interceptions considered of quarantine significance were further investigated.

Results:

Due to alterations made in the database records by AQIS in Canberra, it is not possible to identify the number of insect interceptions for this year's TAR. Consequently, only an incomplete list of significant interceptions is provided below:

Interesting records:

Aranaea

Theridiidae
Latrodectus geometricus (C.L. Koch), egg sacs and adults from East Timor and Indonesia
unidentified species from Spain

Diptera

Culicidae
Aedes aegypti (Linnaeus), (x 11) from Indonesia or foreign fishing vessels
Culex spathifurca from a visiting yacht

Calliphoridae
Chrysomya spp. from a cattle ship insectecutors (not *C. bezziana*)

Hippoboscidae
Unidentified live fly in the cabin of an aircraft from India

Hemiptera

Coccidae
Unidentified species on the fruit and leaves of lime

Hymenoptera

Formicidae
Solenopsis geminata (Fabricius), from East Timor and Malaysia

Apidae
Apis mellifera Linnaeus, in air baggage from Brunei

Vespidae
Unidentified mud wasp nest on the engine of a fork-lift from East Timor

Isopoda
Unidentified marine isopod from rock ballast in a foreign fishing vessel from Indonesia

Isoptera

Rhinotermitidae
Coptotermes acinaciformis Froggatt, nest under Stokes Hill wharf and originally suspected of being exotic

Squamata

Gekkonidae
Hemidactylus frenatus Duméril and Bibron, from East Timor, Malaysia and Thailand

Gastropoda

Achatinidae
Giant African snail, *Achatina fulica* Bowdich, from a container from East Timor

Bradybaenidae
Bradybaena sp., from the exterior of a container from Taiwan

Camaenidae
Parglogenia sp., from East Timor

Ellobiidae
Ellobium aff. *Aurisjudae* (Linnaeus) associated with ballast of a foreign fishing vessel from Indonesia.

Helicidae
Helix aspersa (Muller), from New Zealand
Theba pisana (Muller), from Taiwan

Littorinidae
Littoraria undulata (Gray) from Indonesia

Mammalia

Microchiroptera
Unidentified bat on a vessel at Groote Eyrlandt

PROJECT: Exotic Fruit Fly Monitoring

Project Officers: **I. Haselgrove, B. Dilley, J. Peart, A. Jacks, C. Ellis, E. Conway, J. Starr and D. Salter**

Location: Territory Wide

Objective:

Detect and identify in a timely way exotic and interstate fruit flies which are not endemic to the NT.

Background:

Monitoring for pest species of fruit flies occurring interstate and overseas but not in the NT is carried out on a fortnightly basis during the dry season, or more frequently when conditions require it.

The strategic monitoring grids are located throughout the main urban areas and across the majority of horticultural production areas of the NT.

Early detection of pest species is extremely important both for the feasibility and cost of eradication.

Method:

Three lure types are used: ME (Methyl Eugenol), CUE (Cuelure H) and MED (Capilure R). The areas surveyed and number of traps in each are as follows:

Area	ME	CUE	MED
Darwin and Rural Darwin	50	9	20
Katherine	17	0	9
Tennant Creek	4	4	0
Borroloola	2	0	0
Ti Tree	4	19	4
Gove	4	7	4
Alice Springs and Rural Alice Springs	21	65	16

Lures are assembled in Darwin and dispatched to the regions monthly.

All specimens (except from Alice Springs) collected from traps are sent fortnightly to the Darwin office for identification. Procedures are in place to enable the Alice Springs Office to identify catches in Central Australia.

Results:

A single male specimen of the exotic fruit fly *Bactrocera neohumeralis* (lesser Queensland fruit fly) was detected at Nhulunbuy on a monitoring trap clearance on 5 July 2003. Although considered a major pest species, this fly is not endemic and has not previously been recorded in the NT.

PROJECT: Red Imported Fire Ant Monitoring

Project Officers: B. Dilley, C. Ellis, A. Jacks and J. Swan.

Location: Territory Wide

Objective:

Detect any possible red imported fire ant incursion in the Northern Territory by passive and active surveillance methods.

Background:

The red imported fire ant (RIFA) *Solenopsis invicta* is an exotic ant species that was first detected in Queensland in early 2001. This pest is currently undergoing an eradication program throughout the greater Brisbane area. RIFA is a serious agricultural and social pest that will affect our Territory lifestyle. These ants could adversely affect our agriculture and horticultural industries, tourism activities and develop into a severe nuisance for the general public. Native flora and fauna, infrastructure, equipment and machinery could also be affected.

Early detection is extremely beneficial, since it will reduce the cost associated with any potential eradication program against this pest.

All areas of the Northern Territory are at risk of an introduction of RIFA, but the three major urban centres of Darwin, Katherine and Alice Springs are of high risk and monitoring is concentrated in them.

Method:

Passive surveillance is conducted by alerting industry and the general public of the risks of transporting RIFA from Queensland to the Northern Territory. A specially prepared pamphlet, media releases, advertisements and attendance at displays at agricultural shows are some of the methods of disseminating information on prevention and advice.

Active surveillance is conducted by visiting sites where high-risk material is frequently moved from Queensland to the Northern Territory. These include nurseries, landscape dealers, wharves, airports and trucking depots where visual inspections are performed on a regular basis. Promotion of awareness of this pest is also carried out at these sites.

Medical centres throughout the Northern Territory have been alerted to the notification procedures should ants sting patients.

Results:

High-risk sites are checked on a monthly basis. A further 22 other sites have been physically checked, logged by GPS and samples taken for identification following public and industry advice. None of these sites have proved positive to RIFA. Although this ant is very similar to the local ginger ant, there have not been a large number of local enquiries about this pest.

PROJECT:	**Provide an Inspection Service for Shipping Containers from the Giant African Snail (GAS) Infested Countries under NT Legislation**
Project Officers:	**J. Swan, P. Cawdrey, A. Mullins, J. Lindsay, S. Cross and B. Dilley**
Location:	Darwin

Objective:

Provide prompt and efficient quarantine clearance and/or subsequent treatment of goods originating from GAS infested countries identified under NT legislation.

Background:

GAS is considered by most authorities to be the world's most damaging land snail. It is known to attack over 500 plant species including legumes, cucurbits and many other vegetables as well as a wide range of tropical ornamentals. GAS has long been a concern to the NT due to its presence in all countries in SE Asia and the ease of transfer of snail or eggs by shipping containers.

The Australian Quarantine Inspection Service (AQIS) does not include Indonesia (and some SE Asian countries) in the high -risk GAS areas on the basis that the risk of GAS in the few main ports of large cities is low.

The Territory however, has different shipping links with Indonesia when compared with other areas of Australia and may receive cargoes from minor ports where the risk of GAS being present is much greater.

GAS is identified on the NT notifiable pest list.

Method:

Containers identified as imported from GAS areas, which would be released by AQIS but are identified by NT legislation, are considered to be a Quarantine risk. The imported break-bulk cargo, containers and their contents may be contaminated with quarantine risk materials such as GAS and soil. Containers are unpacked under the supervision of an NT Quarantine Inspector. When quarantine risk material is detected during inspections, the cargo/container is referred back to AQIS.

Results:

NTQS with contract personnel inspected 215 containers for GAS during the year. Considerable break-bulk cargo was also inspected.

No infestations of GAS were detected. However 31 containers (15%) were referred to AQIS for quarantine action. This compares with a contamination rate of 21% from 306 containers inspected during 2001-02. Among quarantine risk items detected were soil, manure, contaminated seed, live insects, bark, bone and feathers.

PROJECT: Post-Barrier East Timor Surveys for Exotic Plant Pests and Diseases

Project Officers: S. Gall, E. L. Crowson and E. S. C. Smith

Location: Darwin and Katherine regions

Objective:

Conduct six-monthly surveys to detect incursions of exotic plant pests, diseases or weeds and exotic bees or their parasites in the main areas of military and refugee activity during the East Timor disturbance of late 1999.

Background:

As a result of the East Timor political disturbances in 1999, two initial surveys (NT surveys 1 and 2), were conducted by the (then) Department of Primary Industry and Fisheries. These were conducted in October-November 1999 and May-June 2000 and were reported in DPIF Technical Annual Report 1999-00. A further survey (NT survey 3) was carried out in May-June 2001 and reported in DPIF Technical Annual Report 2000-01. An additional survey was performed in December 2001-February 2002 (NT survey 4).

Following discussions with Agriculture Forestry and Fisheries – Australia, Biosecurity Australia requested that regular surveys be performed as part of an Australia-wide post-barrier exercise. The Commonwealth and the Northern Territory signed a consultancy agreement in April 2003 entitled *East Timor – Post Barrier Surveys in the Northern Territory* to conduct two surveys per year: one during the wet season and the other during the dry season.

Results:

Two surveys were conducted from 4 June to 21 August 2002 (NT survey 5), and from 10 February to 7 May 2003 (NT survey 6).

During the first survey, 183 samples were collected and submitted for identification. They were mainly weeds, insects and samples of fungal diseases. No target or exotic pests were found during this survey. However, several instances of insect or weed infestations were made and reported to the appropriate managers of the properties on which they were detected.

During the second survey, some sites, which had previously been examined during post-East Timor surveys could not be visited due to a heightened security alert at the time. Thus, access to parts of the Darwin and Tindal RAAF bases and the army training sites was not approved. Arrangements have been made to ensure that these areas are visited during the next survey, and preferably in company with a NAQS officer.

The resident NT quarantine officer in the town visited the Katherine areas and roads during June. In addition, the Katherine roadside verges were regularly travelled by specialist quarantine and plant health personnel who have, and will continue to, observe any suspect plants or symptoms of plant damage. Forty-seven samples were collected and submitted for identification during the survey period. These were mainly weeds, insects and samples of fungal diseases. Specialist staff has not identified some samples as yet. Once determined, Entomology and Plant Pathology staff will record and follow up new or interesting records if required.

No new or targeted insects or fungal diseases of economic importance were identified. However, one case of the giant sensitive weed, *Mimosa pigra* and two separate cases of the fringed spider flower, *Cleome rutidosperma* were recorded. The observations were reported to the authorities in the Department of Infrastructure, Planning and Environment, which are now responsible for weed management.

PROJECT:	**The National Grapevine Leaf Rust Eradication Program**
Project Officers:	**S. West, G. Schultz, K. Sharp, M. Black, K. Hann, S. Smith, S. Hornby, G. Hore, T. Edwards, B. Hitchins, C. Burnup and E. Tsangaris**
Location:	Berrimah Farm

Objectives:

Conduct a survey of all properties in Darwin and Palmerston for grapevines (Vitis spp.).

Conduct a selective survey of the greater Darwin rural area for grapevines

Assess vines for the presence or absence of grapevine leaf rust and eradicate all diseased grapevines by December 2003.

Background:

Grapevine leaf rust (GLR) is caused by the fungus *Phakopsora euvitis*. It was detected in a suburb of Darwin on 17 July 2001. The disease did not occur in Australia previously and is regarded as exotic. Climate modelling by CSIRO and consultation with a recognised expert indicates that the disease could potentially pose a problem in most commercial growing regions of Australia. If the disease were to spread to commercial growing regions, additional fungicide applications may be required in the growing season.

GLR threatens the Australian wine and table grape industries, which are worth $4.4 billion and employ more than 60,000 people. They include the Northern Territory's $20 million Ti Tree table grape industry.

A media campaign in Darwin, Palmerston and the greater Darwin rural area initiated a public response, which led to the destruction, cutting back or fungicide treatment of grapevines. The program located 233 grapevines, of which 45 (19 %) were infected.

Surveys for GLR were also performed in Katherine, Ti Tree (approximately 200 km north of Alice Springs), Alice Springs, Kununurra and North Queensland. Urban surveys were conducted and leaflets were distributed in all capital cities and in Rockhampton, Mackay and Cairns. The surveys did not detect any infected grapevines other than in Darwin. Feedback from industry suggests that southern production areas are free of GLR.

Although the route of entry of GLR to Australia is not defined, a potential pathway could be the illegal importation of plant material.

A resolution of the Primary Industries Ministerial Council on 10 October 2002 approved an initial budget of $1m for an eradication program with funding based on a cost sharing arrangement between the Commonwealth and State governments.

Results:

The national grapevine leaf rust eradication program (NGLREP) commenced in March 2003 and has implemented an eradication strategy based on the four-phase plan approved by the Consultative Committee for Exotic Plant Pests and Diseases in early February 2003.

Phase 1

Phase 1 of the program was completed by 30 June 2003. This phase included intensive surveying to detect all grapevines in Darwin and Bakewell, a suburb of Palmerston. Approximately 28,500 properties were surveyed. This figure is less than the anticipated 30,000 due to the large number of high rise units and flats, particularly in the Darwin CBD. A small number of properties are still to be inspected. A total of 475 grapevines were located on 449 properties, with a 50% disease infection

rate. To date 126 grapevines have been removed, including 78 positive and 48 negative for GLR. The latter were volunteered for removal.

A quarantine area (QA) for GLR was gazetted on 14 April 2003, under Section 11 of the *Plant Disease Control Act*. This prohibits the movement of all grapevine plant material into, within, or out of, an area of 50-km radius from Darwin. There are no restrictions on the movement of fruit or processed grapevine material.

A scientific advisory panel with members from State and Commonwealth governments and industry visited Darwin from 8 to 10 May 2003. The panel reviewed the scientific component of the eradication program and the research project funded by the Grape and Wine Research and Development Corporation on the pathology of GLR and identification of resistance.

A national review team also visited Darwin, from 26 to 30 May 2003 and provided 21 recommendations to fine-tune the program. Members praised the efforts of the NGLREP team and what had been achieved in the short time that the program had been operating in the community.

The Winemakers Federation of Australia, on behalf of Australian grape-growers and wine-makers has contributed to the communications program on an ongoing basis by providing information, promotional materials and high quality images, particularly for the television advertising campaign.

All nurseries within the QA have also been surveyed. Five grapevines were located in an old stock area on one very large wholesale nursery. These were volunteered for destruction and all returned a negative result for GLR. No other nurseries had grapevines growing on the properties or for sale.

The program has conducted a selective survey of Katherine as a strategic step. Katherine is the next major centre out of Darwin and the obvious route for the potential movement of GLR to either SA or WA. Other communities between Darwin and Katherine were also selectively surveyed and included Adelaide River, Batchelor, Corroboree and Pine Creek. All identified grapevines were negative for GLR.

One key to reducing the effect of future incursions would be to identify a resistant cultivar and replace all existing grapevines with that cultivar. Any grapevine located adjacent to a GLR positive grapevine, and not currently showing symptoms, is tested for disease resistance by inoculation in the laboratory. Once inoculated, all of them have become infected.

DBIRD will conduct ongoing surveys of known grapevines in Katherine and Ti Tree. Ongoing surveys for GLR in Borroloola, Groote Eylandt, Kununurra, Nhulunbuy and Bathurst and Melville Islands (located immediately north of Darwin) are included in the NAQS annual surveys of these regions.

Media and consultation

A key component of the program has been the media campaign, including the two-week television advertising campaign prior to the commencement of the surveys. The television advertisements, featuring the Greek-born Northern Territory Administrator, John Anictomatis, has been a critical connection point with members of the Greek community, who are the principal custodians of grapevines in the region.

There has been ongoing coverage of wide-ranging aspects of the program by local media through television, radio and newspapers. Stories on the program have also featured in national newspapers, including the *Australian* and grape and wine industry magazines.

All Members of the NT Legislative Assembly, local town and community councils and 40 community leaders within the QA have been briefed on the NGLREP through meetings, letters and newsletters.

Briefing sessions on the program were held with commercial grape-growers in the Ti Tree area and with the National Vine Health Steering Committee, a national committee made up of Commonwealth and State agencies and grape and wine industry representatives.

The NGLREP contributed with an information display at the Fred's Pass Show and the Katherine Show, as part of DBIRD extension activities.

Future directions

The 2003-04 financial year will see the completion of Phases 2 and 3 of the Work Plan. This is the critical lead up time to the required two-year disease free period, prior to declaring the region free from GLR in June 2006.

SUBPROGRAM: Technical Support Services

PROJECT: Plant Health Legislation and Reporting Requirements

Project Officers: I. Kilduff, I. Miller, J. Alcock and E. S. C. Smith

Location: Darwin

Objectives:

Facilitate appropriate legislation to enable the NT to maintain its relative freedom from incursions of plant pests and diseases.

Develop responses to potential incursions of plant pests and diseases.

Provide timely and appropriate reports on plant health policy and operations.

Background:

The Plant Health Branch has the prime responsibility for plant quarantine within the NT and to maintain interstate trade in plant products. To operate effectively, these functions require an appropriate framework for operational procedures and a reporting system to meet the Territory's national and international obligations.

Results:

Various members of the Branch are delegates on national committees to provide consultation and reporting functions necessary for the effective operation of the groups.

During the year, the Branch was represented on several technical committees, including:

- Plant Health Australia
- the Executive Committee for the Cooperative Research Centre for Tropical Plant Protection
- the Product Integrity and Security Committee
- the Signatories Working Group
- the Plant Health Committee
- the Interstate Plant Health Regulation Working Group
- the Registration Liaison Committee
- the Consultative Committee on Exotic Plant Pests and Diseases
- the Consultative Committee on Exotic Plant Incursions
- the North Australian Quarantine Strategy Stakeholders' Committee
- the North Australian Quarantine Strategy Technical Advisory Panel
- the North Australian Quarantine Strategy Joint Operational Group
- the Black Sigatoka Technical Working Group
- the National Diagnostics Network Steering Committee
- the National Vegetable Pathology Working Group
- the Torres Straits Fruit Fly Technical Advisory Panel
- the Scientific Advisory Panel for the National Grapevine Leaf Rust Eradication Program
- the National Monitoring Group for Imported Fire Ant Eradication Program, and
- the Mangoes to China Market Access Steering Committee.

Management staff also developed policy and liaised with other personnel in the preparation, consultation, review, amendment or revocation of relevant Territory Plant Health legislation.

PROJECT: Control of Use of Agricultural and Veterinary Chemicals Legislation

Project Officers: I. Kilduff and J. Alcock

Location: Darwin

Objective:

Develop new legislation for the control of use of agricultural and veterinary chemicals, fertilisers and stock feed.

Background:

The Australian Pesticides and Veterinary Medicines Authority registers agricultural and veterinary chemicals for use in States and Territories. Control over use is a State responsibility. Currently control of use legislation is included in the *Poisons and Dangerous Drugs Act* administered by the Department of Health and Community Services and is very limited in scope.

In addition the Territory has no legislation controlling the composition of fertiliser or stock feeds.

Results:

Cabinet approved the release of a discussion draft Bill that includes control of use of agricultural and veterinary chemicals, component control of fertilisers and a framework for controls over stock feeds. Discussions are almost complete.

PROJECT: Development of New Plant Health Legislation for the Northern Territory

Project Officers: I. Kilduff, I. Miller and E. S. C. Smith

Location: Darwin

Objective:

Develop new plant health legislation for the NT

Background:

The existing *Plant Diseases Control Act 1979* has deficiencies that were identified in a Northern Territory Quarantine Review in 1999. Occurrences of the exotic fruit fly and Panama disease have also tested the usefulness of the Act, while control of diseases such as grapevine leaf rust require legislative provisions that enable effective survey and eradication.

Method:

The process to seek approval to draft new plant health legislation for the NT began in November 2002. Stakeholders in the Territory's plant-based industries and related groups will be consulted as part of the drafting process.

As a result of public consultation, the examination of interstate legislation and consideration of the existing NT legislation, a Plant Health Bill will be drafted. Further public consultation will take place before recommending that the Bill be introduced to the Legislative Assembly.

Results:

In June 2003, Government approved drafting of a new Plant Health Bill and the release of a public discussion paper. The paper will create awareness of the need for new plant health legislation and the

type of changes being proposed. The paper will also invite public comments to assist in the preparation of drafting instructions.

PROJECT: Proposal to Eradicate the Queensland Fruit Fly from Central Australia

Project Officers: E.S.C. Smith and I. Kilduff

Location: Alice Springs and Tennant Creek

Objective:

Develop proposals for the eradication of the Queensland fruit fly from Alice Springs and Tennant Creek.

Background:

The Queensland fruit fly (QFF) established in Alice Springs in 1987 and is now found widely throughout the town and on hobby farms. The presence of this pest has dramatically affected backyard production of fruit and vegetables in the township and can reduce investor confidence for developing new horticultural industries or expand current horticultural enterprises in the region. Founder flies from the town were likely to have initiated the QFF outbreak in the Ti Tree area during 2001. The commercial grape farms at Ti Tree normally have an “area free status” to gain market access without costly de-infestation treatments.

The proposed program aims to eradicate this horticultural pest without using pesticides, by utilising the harsh Centralian winter to significantly reduce the number of flies. The small number of survivors would then be introduced to large numbers of sterile male flies. The mating between the surviving wild, fertile females and the released sterile males should drive the populations to extinction.

A successful outcome would reduce the risk of fruit fly outbreaks in commercial production areas. Such outbreaks increase production costs, can cause loss of market access, and decrease investor confidence in further horticultural development.

Results:

DBIRD, in collaboration with the horticulture industries and local government agencies in Central Australia, has commenced planning for the eradication of QFF. Industry has initiated the Central Australian Queensland Fruit Fly Eradication Steering Committee to lobby political, physical and financial support for the proposed project.

The Alice Springs Town Council has indicated that it would participate in, and contribute financially to, the ongoing awareness campaign. DBIRD’s quarantine officers will maintain fruit fly trapping grids as preliminary work for the proposed fruit fly eradication program.

A Cabinet Submission has been made to obtain necessary funding.

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