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INTRODUCTION

The primary industry and fisheries sectors in the Northern Territory are growing significantly and contribute substantially to the local economy. They also provide employment and investment opportunities to many Territorians. The Department of Primary Industry and Fisheries promotes the continued sustainable development, productivity and profitability of these sectors by providing useful and timely professional advice to stakeholders on a variety of problems that may constrain their progress. Such advice is based on results of locally conducted scientific research and development projects by departmental staff in collaboration with stakeholders, often on their properties. This Technical Annual Report presents a summary of those projects and the results for 2000/2001.

To support the primary industry sectors, officers of the Department conduct research in such areas as pastures, cattle and other livestock production, animal diseases, crops, fruits, vegetables, ornamentals, weeds, rangeland management and pests and diseases of economically important plants.

The fisheries sector benefits from research conducted to provide long term assessments of wild stocks in Territory waters to help set guidelines for the appropriate level of harvest of the various species in order to maintain a sustainable resource base. Aquaculture research aims to improve the commercial production of molluscs, crustacea. and finfish on aquaculture farms.

The pastoral sector had an excellent season in 2000/2001. There was good pasture and crop production in the Top End and excellent pasture production in all other parts of the Territory. Cattle prices reached record levels as a result of a high demand both in the domestic and overseas markets. Prices for young cattle exceeded $2.00 per kilogram liveweight. The gross value of pastoral production for 2000/2001 was about $190 million. Live exports continued to recover after the slump of 1998 and are improving almost back to the peak of 1997. Indonesia continues to be our major customer. Trade with the Middle East is growing satisfactorily and there are good prospects for the future. However, prospects for growth in the Philippines market have been disappointing.

There was continued interest in commercial production of peanuts in the Territory. The Peanut Company of Australia is about to be established. There was also an increasing interest in the market for locally produced sesame.

There was continued growth in horticulture in 2000 with the gross value of production estimated at $91.7 million, an increase of about 9% over the 1999 figure of $84 million. At an estimated value of $70.8 million, fruits contributed 77.2% of the total value of horticulture, followed by vegetables at $10.8 million or 11.8% and ornamentals at $10 million or 11%.

The gross value of the fruit sector increased by only 3.4% from $68.5 million in 1999 to $70.8 million in 2000. This reflected an increase of 4.5% in production from 23,579 tonnes to 24,641 tonnes. The most significant increases in terms of both production and value were in table grapes and rambutans. The gross value of mangoes decreased by 2.2% from $36.4 million in 1999 to $35.6 million in 2000, while production increased by 1.7% from 11,749 tonnes to 11,952 tonnes. The value of table grapes increased by 24.1% from $14.5 million in 1999 to $18 million in 2000 and production increased by 25% from 2,400 tonnes to 3,000 tonnes. The value of bananas decreased by 0.1% from $13.1 million in 1999 to $13.0 million in 2000 while production increased by 16.2% from 6,466 tonnes to 7,515 tonnes.

The trend in vegetable production has been variable with opportunistic cropping of a range of Asian vegetables. For example, okra production increased by 48.3% from 600 tonnes in 1999 to 890 tonnes in 2000. Other significant vegetable crops maintained their values. Overall the value of vegetables increased by 20.3% from $9 million in 1999 to $10.8 million in 2000 but production decreased by 2.6% from 4,321 tonnes to 4,207 tonnes.

Investment in aquaculture continued to increase and the flow from it is expected to continue in 2001/2002. The value of aquaculture production in 2000/2001 was about $60 million compared with $58 million in 1999/2000. The recreation and tour operator sectors contributed about $50 million over the same period compared with $40 million the previous year. The fishing tour operator sector is growing steadily at around 20% annually. A more realistic value of recreational fishing will be available in late 2001 with the completion of a national survey. Wild stock fisheries have grown rapidly in the last two years at around 20% annually.

The 2000/2001 value of wild stock commercial fisheries was $35 million, compared with $27 million in 1999/2000. The prawn catch was lower for 2000, valued at $61 million compared with $68 million in 1999.

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:

An expanded 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 - 2000/01

The 2000/2001 Wet season opened with a frontal system which brought rain to most of the Top End in October. This was followed by a dry spell which lasted until late November. The rainfall for the Wet season was about average. The mid Wet season in the Darwin District turned out to be a dry period punctuated by short, intense monsoonal periods and isolated storms. The intense monsoonal periods compensated for the intervening dry spells.

While March rainfall was good, there were few significant storms or rainfall events in the Darwin area after the end of March. Light, isolated showers continued through until mid May. The light showers kept pastures green until mid May, but the upland pastures dried out quickly when the rain stopped. Overall, the Wet season was below average for upland pastures.

As the floodplains did not dry out completely in the previous Dry season, water tables were high at the start of the Wet season. The floodplains generally flooded early and remained wet through until early June. Access to the floodplain by stock was four weeks later than usual.

Demand for extension/information on pastures and seeds continued at record levels during the year, similar to the previous year.

PROJECT: Increase of Early Generation Seed of Released Pasture Cultivars

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

Location: Paddocks 8 and 9 Berrimah Farm

Objective:

- ***To evaluate new lines in a confined non-grazed environment.***
- ***To bulk up seed from promising lines for further evaluation.***
- ***To bulk up early generation seed of pasture cultivars released in the NT.***

Project Period: 2001-2006

Method:

Intensively managed small areas of perennial cultivars are maintained in Paddocks 8 and 9. Seed is harvested as required to maintain fresh early generation seed.

Annual species are grown so seed is harvested as required.

Results:

No seed was harvested in 2000/01.

Weeds were controlled on the Arnhem pre-basic seed area. This cultivar appears susceptible to weed invasion between tussocks.

PROJECT: Assessment of Newly Released Australian Pasture Cultivars under NT Conditions

Project Officers: B. Ross and G. Hore

Location: Berrimah Farm (2000)

Objective:

To determine if forage cultivars released commercially elsewhere in Australia are suitable for use in the NT.

Project Period: 1999-2002

Background:

Many pasture, hay and forage cultivars released commercially in Queensland are suitable for use in the NT. Some are not, by virtue of their time to maturity, lack of Dry season drought tolerance or high soil nutrient requirements. As most are marketed widely throughout northern Australia, it is necessary that such new releases be evaluated under Northern Territory conditions. From time to time, industry interest in "old" cultivars requires evaluation or re-evaluation of such cultivars.

Method:

Newly received seed is grown in confined non-grazed areas for evaluation and to multiply seed for further trials.

The 1998/99 sowings included:
Bambatsi panic *(Panicum coloratum var. makarikariense)* cv Bambatsi (also known as Makarikari grass). Interest in Bambatsi panic has increased with experimental and commercial sowings as a component of the pasture rotation phase on grey clay cropping soils in 600 - 750 mm rainfall areas of Queensland. Bambatsi grew well but by June 2000 it appeared to have run out of nitrogen.

Paspalum atratum cv Hi Gane is the Australian release of the US cultivar "Suerte" which is used extensively in Florida. Hi Gane was released in Queensland in 1998 as a potential pasture grass for the coastal region. A similar *P. atratum* accession ATF1054 has persisted and grown well at Berrimah.

Paspalum nicorae cv Blue Dawn is being marketed in southeast Queensland as a turf/ground cover. Blue Dawn continues to grow well but has produced little seed.

Aeschynomene villosa cv Reid is the early maturity component of the commercial seed mix "Villomix". It is being evaluated in the NT as one of a number of legumes, which may have potential as pasture or ley legumes in newer intensive agricultural areas of the NT, such as the Sturt Plateau. Growth at Berrimah Farm has been only fair to good.

Urochloa mosambicensis cv Saraji was developed at Saraji mine in central Queensland as a ground cover species for revegetation but may also be a better grazing plant in lower rainfall areas than the existing Sabi grass cultivar, Nixon (U. *mosambicensis cv Nixon).* Saraji has shown poor ground cover and is less vigorous than Nixon at Berrimah Farm.

1999/2000 sowings included
Repeated sowing of Hi Gane because last year's sowing did not germinate. According to Murray Aitchison of Progressive Seeds, it is difficult to store this species. Hi Gane made considerable vegetative growth and did not flower this year because it was planted late.

Dicanthium aristatum cv Floren grew quickly and produced moderate amounts of dry matter.

Bothriochloa bladhii subsp glabrata cv Swann did not germinate.

Results 2000/2001:

Of those planted in 1998/99 (*Paspalum nicorae* cv Blue Dawn, *Aeschynomene villosa* cv Reid, *and Urochloa mosambicensis* cv Saraji), only Blue Dawn continues to be attractive. Saraji has spread slowly but produces little dry matter. Reid has re-established from seed but is not outstanding.

1994/95 Wet season sowing
Paspalum atratum and *P. guenoarum are* the only lines, which have persisted. Work on *P. guenoarum* will be terminated prior to the 2001-02 Wet season and *P. atratum* will be maintained.

Other current plantings
Plots of Jarra (*Digitaria milanjiana* cv Jarra) and Arnhem (*Digitaria swynnertonnii* cv. Arnhem) have been maintained.

PROJECT: Assessment of Pasture Cultivars on Pre-Release in Queensland

Project Officers: B. Ross and G. Hore

Location: Berrimah Farm (2000)

Objective:

To determine if forage cultivars intended for release commercially elsewhere are suitable for use in the NT.

Project Period: 1999-2002

Background:

Because of some similarities in climate and industry in parts of Queensland and the NT, the results of plant evaluation programs in Queensland may be of relevance to NT producers. By evaluating potential cultivars, which have reached the pre-release stage of evaluation elsewhere, we can gather sufficient information to determine whether these plants can have a role in the NT before they come on the market.

Method:

Newly received seed is grown in a confined non-grazed area for evaluation and to multiply seed for further evaluation.

The 1998/99 sowings included
Paspalum nicorae CPI 27707 along with CPI 21370 (now cv "Blue Dawn") which were placed on pre-release in Queensland in 1991. They are being considered in southeast Queensland as potential high use pastures with the ability to withstand competition from weeds and for amenity planting.

Arachis pintoi ATF 2320 is a high quality, high yielding forage peanut.

Results 1998/99:

Both *P. nicorae* lines established and grew well.

A. pintoi was not planted out due to difficulty in germination and subsequent late release from quarantine.

Results 1999/2000:

Both *P. nicorae* lines grew well but produced little seed.

A. pintoi was the only Arachis at Berrimah Farm to survive four weeks of continuous rain and saturated soil. It has grown and spread under dense grass cover of *Urochloa* spp.

Results 2000/20001:

As previously, both *P. nicorae* lines grew well but produced little or no seed, while *A. pintoi* continues to persist.

PROJECT: Evaluation of Short Season Legumes

Project Officers: B. Ross and G. Hore

Location: Berrimah Farm (2000)

Objective:

To evaluate a range of early maturing forage legumes for their potential use as pasture or ley cultivars in regions of the NT receiving less than 900 mm annual rainfall.

Project Period: 1999-2004

Background:

As more intensive agriculture extends into lower rainfall areas of the NT, there is a need for hay crops and ley legumes suitable for those areas. Cavalcade is the predominant hay crop in the NT but it is limited by its relatively late flowering to areas with a Wet season of at least five to six months. This makes its regeneration from seed in dryland areas south of Katherine unpredictable.

Method:

The first phase of the evaluation is multiplication of scarce seed to obtain enough seed for regional evaluation. At the same time accessions are screened under favourable conditions (irrigated and fertilised) to eliminate those which are unsuitable for further evaluation.

Small quantities of seed that were received from researchers in other States were germinated in a seedling mix in the shadehouse and transplanted to the field at four to six weeks of age as spaced plants. Out of 33 accessions received from the genera *Aeschynomene*, *Arachis*, *Centrosema*, and *Desmanthu* 30 made it to the field. The remaining three which were from the first sowings of *Arachis,* failed to germinate, probably because the seed was10 years old.

A series of records is taken monthly throughout the growing season. Seed is collected, cleaned and stored.

Results 1999/2000:

Arachis monticola CQ 990 again died back during the wettest month of the Wet season. As it did last Wet season, it has regrown or re-established from seed but growth has been only poor to fair.

All *Aeschynomene americana* lines grew well with the exception of 93,579 whose growth was only fair. A number of plants were destroyed by termites preflowering, and all suffered from powdery mildew in the late Wet and early Dry season.

The growth of *A. histrix* ranged from poor to very good (93595).

The growth of *A. villosa* ranged from poor to good (86,163, 91,082, and 90,897). The performance of cultivar Reid has been only fair.

All *C. pascuorum* lines had good or very good growth except 91318, which was only fair. CPI 65950 grew less vigorously than in 1998/99 and appeared to suffer nutrient deficiency. This line was promising in early evaluation of ley legumes in Queensland.

PROJECT: Drought Tolerant Grasses

Project Officers: B. Ross and G. Hore

Location: Berrimah Farm (2000)

Objective:

To evaluate a range of drought tolerant grasses for their potential use as pasture or ley cultivars in regions of the NT receiving less than 900 mm annual rainfall.

Project Period: 1999-2004

Background:

As more intensive agriculture extends into lower rainfall areas of the NT, there will be a tendency to run more cattle on smaller areas, which will require more productive and resilient grasses than are used at present. The use of a ley phase in cropping systems will require grasses, which can be established and become productive in a short space of time.

Method:

In addition to Saraji, Bambatsi and *Paspalum nicorae*, all of which may fit the objective of this evaluation, four other grass accessions from the genera *Chrysopogon, Panicum* and *Digitaria* were established in the 1998/99 Wet season as spaced plants to obtain seed for further evaluation.

Floren blue grass and HiGane paspalum were established in 1999/2000 and planted out in February 2000.

Results 1998/99:

All except *Chrysopogon*, which suffered from poor germination, grew well.

Results 1999/2000:

Saraji survived but grew relatively poorly. Both *Paspalum nicora*e accessions grew well but produced little seed. Bambatsi grew well early in the season but appeared to run out of fertiliser by the late Wet season. *Panicum* C1, Floren and both *Chrysopogon* spp grew well and produced seed, although the *Chrysopogon* seed is very light and has long awns making it exceptionally difficult to handle. *Digitaria natalensis* grew well, but produced no seed. Because of the late planting, HiGane did not flower this Wet season although vegetative growth was good.

Results 2000/20001:

Panicum C1 continues to grow well, as do *P. nicorae* accessions. C1 has shed seed and readily established new plants, whereas *P nicorae* has produced very little seed.

Hi Gane grew well and set seed this Wet season, but dries off quickly and plants appear to be poorly fixed in the ground.

Floren has persisted with moderate yield but appears that it will require relatively high fertiliser inputs for continued production.

The *Chrysopogon* and *Digitaria* accessions appear to have no prospect of commercialisation and will be terminated.

PROJECT: Gamba Grass Mapping

Project Officer: B. Ross

Location: Darwin and Katherine Regions

Objective:

To map the results of gamba grass surveys undertaken by Weeds Branch, Agriculture Branch, and Specialist Weed Control Pty Ltd.

Project Period: 1999-2001

Background:

In the last two years several groups have surveyed the occurrence of gamba grass along roadsides in parts of the Top End. Many individuals and organisations have expressed interest in the results of these surveys.

This small project was undertaken using ArcView 3.1 to see if the various surveys could be reconciled and to provide a visual record of the gamba grass survey and control demonstration project.

Progress:

A poster of preliminary results was presented at the NARGIS'99 Conference. Progressive results of the 1998 and 1999 surveys were presented at workshops in October 1999 and March 2000. A limited repeat survey was carried out during 2001 and maps will be updated to reflect these results.

PROJECT: Characteristics of Tropical Floodplain Grasses

Project Officers: G. Hore and B. Ross

Location: Darwin area

Objective:

To document growth and seed production of common native perennial floodplain grasses found in the Darwin region and provide a nursery of plant material for further research.

Project Period: 2001-2004

Background:

There is considerable interest in the potential use of native floodplain grasses for revegetation following the control of *Mimosa pigra* and for grazing as an alternative to establishing exotic grasses. For this to be possible, a ready supply of seed or vegetative planting material is necessary.

Method:

In December 2000, runners of *Hymenachne acutigluma*, *Pseudoraphis spinescens* and *Leersia hexandra* were collected in the field and transplanted on Paddock 1 at Berrimah Farm. Plants have been maintained throughout the year under drip irrigation. Seed of H. *acutigluma* is collected weekly. Seed of *L. hexandra* is collected opportunistically, while *P. spinescens* has not produced seed. All species continue to grow and spread vegetatively throughout the year.

PROJECT: Seed Testing Laboratory

Project Officer: A. Simonato

Location: Berrimah Farm

Objective:

To provide an accurate and reliable seed testing service to the pastoral industry in the NT.

During the year 293 consignments were submitted for testing. The number of quarantine lots submitted for identification was double that of the previous year. This may be due to the increased traffic to and from East Timor, with seed found on or stuck to equipment and vehicles. The following tests were carried out on the submitted samples:

Test	**No. of tests**
Certification	8
Purity	21
Germination	219
Bulk Search	16
Quarantine Inspection and Identification	523
Other	
Comparative Test	3
Tetrazolium Test	4
Export Examination	30
Seed Count	1
Identifications	3
Total	**828**

Seed Certification applications were made for 133 hectares during the 2000/01 Wet season.

SUBPROGRAM: Irrigation Development

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

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

Location: Douglas Daly Research Farm

Objective:

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

Background:

Irrigated maize is currently grown by a small number of producers in the Katherine district. While the demand for maize revolves around a small local market, the potential of the crop has not been fully exploited by producers. Past commercial yields have been disappointing. Maize has the potential to provide producers with moderate to good returns, provided high yields are achieved. Maize can also be used in rotation with other irrigated crops to help reduce weed, insect and disease pests in farming systems.

There is a need to evaluate the potential of irrigated maize in the Top End, to identify suitable varieties and develop specific agronomic recommendations for this area. The demand and returns for irrigated maize is likely to increase significantly if farmers can consistently produce high yielding crops. Irrigated maize production has been investigated at DDRF for the past three Dry seasons.

Method:

Selected maize varieties, provided by commercial seed companies are sown into a conventionally prepared seedbed between late Match and late April. Four replicates are sown in a randomised complete block design. The total area is approximately 5 hectares. Plot sizes are 150 m long by four rows. Hand and machine harvest samples are taken from each plot. Leaf samples are taken 35-40 days after sowing (DAS) and at silking to determine plant nutrient content.

Fertiliser is applied pre-plant, at planting (banded) and by fertigation. The trial receives approximately 280 kg N, 40 kg P, 150 kg K, 33 kg S, 64 kg Mg, 20 kg Zn and 1.5 kg B depending upon soil analysis. Zinc and Mg are applied at high rates initially to avoid deficiency. Subsequent Zn and Mg applications are reduced. Average population is between 75,000 and 84,000 plants per hectare.

An Environscan® soil moisture-monitoring system and Jet-Fill® Tensiometers monitor irrigation and soil moisture content. The crop receives about 4.8 ML of water. Primextra® (atrazine plus metolachlor) is used post-plant pre-emergent to controls weeds. When threshold populations of insects such as armyworm, *Helicoverpa* spp. and green vegetable bug (GVB) are reached, they are controlled by recommended insecticides.

1999 Results:

The crop showed early P and N deficiencies due to uneven banding of fertiliser at planting. This was caused by poor design of the fertiliser metering system. All varieties recovered shortly afterwards, as nutrients became available. Variety PAC338 had a significantly lower yield due to poor plant establishment (52,000 plants/ha), because of low seeding vigour. Pioneer 3237 was the highest yielding variety. The other seven varieties did not differ significantly in production.

Insect pressure was high in 1999. Leafhoppers, plant-sucking bugs and various lepidopterous larvae were at damaging levels at specific periods during the season.

Two chemical applications were carried out by helicopter to control the pest complex. High insect pressure and the need for control measures at critical times are important management considerations in irrigated maize in the Daly Basin.

Table 1. 1999 variety performance

Variety	Plot Yield		Yield t/ha*
PAC 338	179.9	a	6.02
Pioneer 1196K	269.9	b	9.06
PAC 269	275.2	b	9.11
Pioneer 3394	289.4	b	9.67
Pioneer 3158	289.7	b	9.63
DK 689	294.5	bc	9.74
Pioneer 31M10	306.7	bc	10.24
Hycorn 75	307.8	bc	10.28
Pioneer 3237	333.6	c	10.86
Hycorn 90	Observation only		Ob. only
LSD (p<0.05) 42.41, p-value < 0.001, CV(%) 8.0			

*Means with common letters are not significantly different.

2000 Results:

On 28 April 2000, 11 varieties were planted at DDRF. Planting was carried out using a Nodet Gougis precision vacuum planter. Nitrogen, phosphorus, sulphur and trace elements were banded beneath and to one side of the seed furrow at the rate 100 kg/ha (9 kg N, 19 kg P, 10 kg S, 2.5 kg Zn and 2.5 kg Cu). The varieties were established at a mean population of 86,000 plants per hectare. Banding of fertiliser at planting eliminated early nutrient deficiency that was evident in the 1999 crop.

Insect pressure was extremely high throughout the season. Insect control was carried out on five occasions. Dimethoate was applied three times between week three and week five to control leafhoppers, which transmit Wallaby Ear Virus. Armyworm, *Helicoverpa* spp. and GVB were present in high numbers at silking. Insecticide was aerially applied twice, once prior to silking and once during silking.

Rogor® and Lorsban® were mixed and applied by helicopter to control of GVB and *Helicoverpa* spp. and armyworm during pollination and early grain fill. After spraying it was apparent that plants were not effectively pollinating. A large percentage of plants in all varieties produced partially pollinated ears. Stems distortion was also evident in most plants. Some plants also produced as many as five barren cobs. Prior to spraying, the crop appeared in excellent health with no apparent nutritional disorders or phytotoxicity symptoms.

Days after spraying it was obvious that normal pollination was not occurring. Plants also exhibited bending of the nodes above the ear. It was initially assumed that the symptoms were caused by hormonal herbicide, possibly as a contaminant in the helicopter tanks. This was later discounted. At this point the cause of the poor pollination and stalk bending is unclear. It is uncertain whether the stalk bending is reducing yield or whether it is linked to incomplete pollination. Investigation is under way to determine the possible causes.

Table 2. 2000 variety performance

Variety	Name	t/ha
1	PAC 442	6.8
2	Hycorn 75	4.2
3	Hycorn 90	6.8
4	DK 689	7.2
5	PAC 269	4.2
6	Pioneer 3237	8.8
7	X32 J35	8.9
8	32 P75	8.0
9	Cracker Jack	6.9
10	Genex 2	7.1
11	PAC 5317	5.6

Machine harvested yields at 12% moisture.

Yields in 2000 were reduced because of incomplete pollination. In 1999 mean yield for the site was 9.4 t/ha. In 2000 it was only 6.8 t/ha, a 28% decline from the previous year. It is important to determine why pollination was affected in the 2000 trial and if the chemicals applied interfered with the pollen or silks.

Table 3. Insect pests on irrigated maize at DDRF, 2000

Insect pest	Growth period and damage
Leaf hoppers (various) *Cicadulina bimaculata.* Possibly also *Chiasmus* sp. *and Orosius* sp.	From emergence through to week five or six. Causes Wallaby Ear i.e. stunting, distortion and thickening of leaf and veins.
Armyworm, *Mythimna separata.*	Late vegetative stage to silking. Defoliate plants and damages flag leaf and silks.
GVB, *Nezara viirdula.*	Distortion of cobs and damage to individual kernels.
Heliothis, *Helicoverpa amrigera/punctigera.*	Damage to silks and cobs.

2001 Activity:

The trial plants were sown on 10 April using a Nodet Gougis precision vacuum planter. Land preparation, experimental design and general management were similar to previous years. Nine varieties were evaluated. Due to heavy infestations of leaf hopper, various lepidopterous larvae and GVB in the past, different insect management and application methods were used.

In an attempt to achieve effective control of leafhoppers, all trial seed was treated with Gaucho®, a systemic insecticidal seed dressing. Gaucho is one of the newly developed chloronicotinyl chemicals, which has been used in cotton for early season aphid and thrip control. A control area was established to compare the difference between treated and untreated seed.

Control of lepidopterous larvae and GVB was undertaken using an Agri-Inject Insectigator III® instead of using aerial application. The insectigator injects a precise amount of chemical into the centre pivot line during irrigation. Gemstar® (active constituent: Nuclear Polyhedrosis Virus) and DiPel Forte (active constituent: *Bacillus thuringienesis* var *kurstaki)* were used through the insectigator to assess the efficacy of these products on armyworm and *Helicoverpa* spp. when applied through irrigation water. One application of chlopyrifos and one synthetic pyrethroid was applied prior to silking and at early grain fill, respectively, principally to control GVB.

At the time of writing this report, only hand harvest yields had been completed.

Table 3. 2001 variety performance

Varieties	Yield kg/ha*
Pac 53IT	12.9
Hycorn 75	13.1
Pac 424	14.2
Pioneer 3335	12.1
Pioneer 3153	14.3
Q 81	9.9
Cracker Jack	11.9
Pioneer 3237	13.3
DK 689	12.9
Site Mean	12.7

*Yield is the average weight from ten hand-harvested plants from each replication converted to t/ha

Insect Management

Gaucho® provided control of leafhopper and protection against Wallaby Ear virus. The control area was infested with leafhopper and severely affected by Wallaby Ear. Affected plants were stunted with dramatically reduced stalk, leaf and root development. The treated area had lower leafhopper numbers and no visible disease symptoms. The use of Gaucho® as a seed treatment reduced the need to control leafhoppers and saved two to three insecticide applications.

Table 4. Effect of Gaucho® on leafhopper number and yield in maize

	Control	Gaucho treated
Leaf hopper No./10m row*	94	5
Yield	10.8**	12.7

*Average number from vacuum sample

** Estimated yields from non-replicated hand sample

Application of insecticides and biocides through an insectigator proved successful. Improved control was achieved compared to aerial application in previous years. This can probably be attributed to more optimum application times using an insectigator versus waiting for availability of aerial operators. The cost of using an insectigator will be lower than aerial methods over the medium to long term. Gemstar® appeared (observation only) to be more effective in reducing larvae numbers than Dipel®. However both products require further evaluation under local conditions. The improved insect control is reflected in improved yields in the 2001 season.

PROJECT: Industry Development and Extension (Agriculture and Irrigation)

Project Officers: F. O'Gara, C. Ham, D. Parker, S Bellgard and M. Connolly

Location: Douglas Daly/Katherine

Objective:

To improve learning and information flow within and between industry and DPIF and increase the performance of irrigated field crop enterprises in the Top End.

Background:

Irrigated field-crop production is a relatively new and high-input venture in the NT. Most of the producers involved are either new to the NT or new to irrigated production. There is limited expertise in the industry.

Lack of information and grower inexperience is often an impediment to achieving viable yields. Distance between growers also hinders the transfer of information and opportunities for learning.

The purpose of the program is to:

1. Allow industry to review and provide input on R&D activities.
2. Encourage growers to actively participate in identifying and addressing priority areas for R&D.
3. Encourage information flow and learning opportunities within the industry.
4. Enhance the productivity and viability of irrigated enterprises in the NT

Summary of Activities:

Regular producer meetings and field walks have been held since 1998. Growers have inspected DPIF research and commercial operations at Douglas Daly and Katherine. Growers identified important issues such as crop options and rotations for irrigation, agronomy and crop management advice, nutrition and weed control strategies and long term sustainability. Table 1 outlines some of the issues and outcomes achieved to date.

Table 1. Issues and outcomes identified

Issue	**Outcome and progress to date**
Crop Rotation and Options	Peanut and maize still provide the basis for a crop rotation. Wet season green manure crops are being evaluated. Some producers are now producing melons and pumpkin for higher returns. Other crops and market niches need to be evaluated.
Agronomy and Management	Trials have resulted in better varieties for commercial production, improved timing of crop operations, more accurate information on crop water use and insect and disease management. Growers are adopting timing, varietal and other management recommendations such as earlier planting and maize varieties.
Nutrition	Trials have indicated a more accurate picture of nutrient requirement and plant uptake, which is contributing to improved recommendations, e.g. role of native calcium in peanut nutrition and reduction in applied gypsum. Trace element nutrition on light soils has improved.
Pest Management	Monitoring and trials are resulting in improved knowledge and understanding of pest/crop interactions and leading to improved management e.g. improved management of peanut pod-rot disease complex.
Information and Learning	Improved understanding of the complexities of irrigated production in this environment. Better knowledge of natural resources in the area. Improved collaboration/cooperation between industry/DPIF/agribusiness.

PROJECT: Examination of Varying Rates of Three Macro Elements for Peanuts on Ruby Blain soil

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

Location: Douglas Daly Research Farm, Irrigation area, Circle 2

Objective:

To examine the effects of low, medium and high rates of Potassium (K), Magnesium (Mg) and Calcium (Ca) on kernel development, quality and yield.

Background:

Incomplete kernel development, initially observed during the shelling process, detrimentally affected the quality of the produce in the 1999 dry season trials. Whilst several causes could be surmised it is possible that this effect was either caused or exacerbated by:

1. Incorrect levels of nutrient applied.
2. Nutrient uptake was influenced by incorrect levels of other elements in the soil solution (possibly due to fertiliser placement).
3. Incorrect estimate of reserves in the sub soil resulting in inadequate levels of fertiliser applied.

P and Ca play major roles in kernel development formation; high levels of one can affect uptake of the other. High levels of Mg are believed to be antagonistic to Ca uptake; however evidence is scarce.

Peanuts are unique in that the developing pods actively adsorb nutrients from the surrounding soil solution (top 5 cm) rather than relying on translocation via the gynophore (peg). Hence nutrient imbalances at the surface are of concern.

Fertiliser placement has been identified as critical in Queensland. The processes by which the plant absorbs these elements are intertwined; excessive levels of one element can limit the others. Soil type influences retention and uptake of these elements.

It is important to note that the kernel blemish was not typical of Boron deficiency.

Method:

The trial is a complete randomised block design with four replicates. The data will be analysed by analysis of variance (ANOVA).

Treatments have been calculated so that there is a range of levels from critical to excessive levels in varying combinations. There is a nil fertiliser control (K, Ca and Mg only) and a maximum fertiliser control. The fertiliser was applied to the surface of the plot and incorporated by hand. Surface placement was deliberate to maximise the chance of creating imbalances. Other nutrients that were not under investigation were applied in adequate amounts.

Table 1. Current (prior to fertiliser application), critical and potentially desirable soil nutrient levels

	Nutrient level mg/kg			
Element	**Current**	**Critical**	**Desired**	**Excess**
P	12.0	20.0	30.0	
S	6.4	10.0	10.0	
K	51.7	110.0	190.0	220.0
Ca	233.3	220.0	500.0	750.0
Mg	31.7	40.0	70.0	80.0
Mn	38.0	30.0	50.0	
Cu	0.3	1.5	1.5	
Zn	2.8	1.5	1.5	
B	0.2	1.4	1.5	

Table 1 displays the current status of the soil before fertiliser was applied, the critical levels considered necessary for peanut production and the "desired" optimal level. Table 1 also suggests levels, which would be considered to be excessive (K, Ca and Mg only). The excessive levels have been calculated. In reality it is likely that our cation exchange capacity (CEC) is so low (1.8 mEq/100g) that it would not be possible to achieve these actual levels in the soil for any length of time.

The pH of the soil ranges from 7.0 (at 0-15 cm) to 5.6 (at a depth of 30-40 cm).

Table 2. Quantity of elements required (kg/ha)

Element	**Critical**	**Desired**	**Excess**
K	43.7	103.7	126.2
Ca	0.0	200.3	387.8
Mg	6.2	28.7	36.2

Table 2 displays the amount of each element (kg/ha) required to attain the levels specified in Table 1. The aim is to vary the level considered "critical", "desired" or "excessive". This has been calculated allowing for the current levels in the soil and taking into account the bulk density of the surface layer. The calculations are based on the volume of soil occupying a 5 cm deep layer.

Table 3. Levels of fertiliser applied (kg/ha)

Fertiliser used	**Critical**	**Desired**	**Excess**
MOP (50% K)	87.5	207.5	252.5
GYPSUM (18.7% Ca)	0.0	992.0	1907.0
GRANOMAG (50% Mg)	12.5	57.5	72.5

MOP =Muriate of Potash

Table 4. Treatment description

	Treatment Number							
Element	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
K	current	critical	excess	critical	critical	critical	critical	excess
Ca	current	current	critical	desired	excess	current	current	excess
Mg	current	current	current	current	current	critical	desired	excess

Planting was on 24/3/2000.

Measurements:

- The trial area was sampled prior to fertiliser application by taking five random soil samples over the entire area at three depths 0-15 cm, 25-30 cm and 40-50 cm.
- At 40 days after emergence the plots were sampled using youngest mature blade and petiole. It was sampled again at eighty days after emergence. The foliar samples were submitted to the DPIF Chemistry Laboratory for analysis.
- At harvest time a 1-metre sample was taken to determine total biomass and the population.
- A 5-metre sample was thrashed, shelled and graded for yield and quality. The population was measured.

Irrigation and rainfall:

The crop received 5.75 ML of water coupled with an additional 240 mm of rain, which fell between 23/3 to 2/5. Irrigation was scheduled according to soil moisture data provided by Enviroscan™ software.

Results:

Table 5. Yield per treatment and average yield for both total biomass (pod and bush not including roots) and pod yields (hand harvested)

Treatment	Total biomass (t/ha)	Nut in a shell (t/ha)
1	10.0	5.4
2	9.8	5.8
3	10.8	5.6
4	10.0	5.4
5	9.1	5.3
6	10.6	5.3
7	9.9	6.0
8	10.0	5.8
Average of all plots	10.0	5.6

Table 6. ANOVA results for pod yield

SOURCE	DF	SS	MS	F	Tabular F (5%)
Rep	3	1.891	0.630	2 ns	3.07
Treatment	7	1.865	0.266	0.844 ns	2.49
Error	21	6.615	0.315		
Total	31	10.371			

ns = not significant

The ANOVA shown in Table 6 demonstrates no significant differences between the treatment and the replication variation.

Table 7. ANOVA results for total biomass, pod and bush, not including roots

SOURCE	DF	SS	MS	F	Tabular F (5%)
Rep	3	12.54	4.18	1.96 *ns*	3.07
Treatment	7	6.91	0.99	0.46 *ns*	2.49
Error	21	44.68	2.13		
Total	31	64.13			

ns = not significant

Equation 1, base saturation levels in the trial plot

Formula for deriving base saturation

$$\frac{\Sigma \text{ exchangeable bases (mEq/100g)}}{\text{Total CEC (mEq/100g)}} \text{ multiply by } 100\%$$

Total CEC = 1.8 mEq/100g
The base saturation levels based on soil samples from the trial area equal 99%.
This essentially means that although the quantity of ions held by the soil is small they are readily exchanged.

Table 8. Breakdown of soil CEC measured within the trial area

Calcium	72.8%
Potassium	8.3%
Magnesium	16.5%
Sodium	2.4%

Conclusion and recommendations:

Cation exchange capacity (CEC) affects the ability of soils to retain adsorbed ions. The low clay content and the type of clay present in Ruby Blain soils results in a limited ability to retain fertiliser in the upper layers of the soil. The calculation of our base saturation indicates that the cations that are adsorbed are readily available to the plant. Ca (60–75%) and Mg (10-15%) dominate cation exchange ratios. K comprises approximately 7% of ions on the exchange complex.

Uptake by roots occurs through two main processes, passive and active. Ca is likely to be taken up by passive processes whereas K and Mg are taken up by active mechanisms. Mass flow (passive adsorption) ensures adequate supplies of Ca. Active adsorption relies on high concentrations within the soil solution and constant replenishment from the exchange complex. If there is little exchange available from the soil complex then it must be supplied by frequent fertiliser application.

Due to the low CEC, more mobile cations are not retained at the surface where most of the active uptake by plants is occurring. The dissolved mobile cations will shift to the lower levels of the irrigation zone. There is a large amount of uptake via the soil solution rather than the soil exchange complex. Monovalent cations are less attracted to the weakly charged clays. Therefore the cations that dominate the soil solution are likely to be the less mobile, more chemically attractive ions, such as Ca^{++} and Mg^{++}. Dissolved cations that have shifted to deeper profiles will be available to plants with extensive root systems and mychorrizal associations. As the mobile cations are more uniformly distributed throughout the soil profile they are unlikely to affect uptake of other nutrients at the surface.

The higher levels of fertiliser present in this trial were most likely shifted through excessive rain and irrigation, therefore unable to dominate the soil solution. The lower rates were able to adequately supply the plant needs, providing some base levels from which we can derive fertiliser recommendations.

Despite concern that high levels of K could induce Ca deficiency in peanuts, the results of this trial indicate it is relatively difficult to achieve, given the properties of Blain soils.

The kernel disorder that was seen in 1999 was not observed in any treatment. Whilst an explanation for this symptom has not been identified in this trial there have been positive outcomes from this work that further our understanding of nutritional management on the sandy surfaced Blain soils of the Top End.

Short term strategies
- Use more frequent, smaller applications of mobile fertiliser, particularly K, S and N.
- Use fertigation where possible.
- Avoid excessively heavy irrigations when plants are small.
- Adjust timing of planting to avoid large rainfall events where possible.

Long term strategy
- Use low input green manure crops to build up soil structure and assist with fertiliser retention.

SUBPROGRAM: Cotton Industry Development

PROJECT: Research of Dry Season Cotton Production

Project Officers: **C. Martin, A. Ward, G. Schultz, S. Bellgard, M. Kahl, N. Hartley, F. Adams K. Shrimp, C. Ham, S. Lucas and S. Yeates**

Location: Katherine Research Station (KRS)

Objective:

- ***To develop an agronomic package for efficient and sustainable field production systems for cotton.***
- ***To identify the most appropriate varieties of cotton in terms of yield, quality and maturity.***
- ***To develop suitable irrigation systems for commercial scale cotton production.***

Introduction:

Since 1993 DPIF has been involved in a joint project with CSIRO and Agriculture WA to investigate the possibility of establishing a viable cotton industry in northern Australia. This work intensified with DPIF becoming a core partner of the Australian Cotton CRC in 2000.

The project is based on the use of transgenic cotton grown in the Dry season to minimise insect problems that caused the failure of cotton in the Ord region in the 1970's.

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.

Progress in 2000:

Cotton was sown on 14 ha at the Katherine Research Station. Of this 10 ha was watered by a lateral move irrigator (LMI) and 4 ha by subsurface drip irrigation (SDI). Approximately 2 ha were sown to experiments, and the remainder divided between 2 ha of Sicot 189, as an unsprayed refuge, and 6 ha of Sicot 289i.

Field operations and data

Operation	Time and/or quantity
Sowing	24/3/00 to 13/4/00
Pre-planting herbicide	Roundup, 2 to 4 L/ha
Post-plant, pre-emergence herbicide	Stomp, 4 L/ha
Post emergence herbicide	Staple, 120 g/ha; 0 to 2 sprays of Verdict at 0.6 L/ha
Weather	Cooler than normal, 38 cold shock days
Yields	6.5 to 9.5 bales/ha
Harvesting	Mid October 2000
Fertilizer	N, 138 to 216 kg/ha; P30 to 50 kg/ha; K,25 to 50 kg/ha
Water used, excluding rainfall	SDI, 6.8 to 7.2 ML/ha; LMI, 7.8 to 9.3 ML/ha
Insecticide sprays	Total of five including 1 for *Heliothis* spp.

Experiments:

Variety trial: 12 entries with yields from 5.9 to 9 bales/ha.

Compensation trial: Tipping plants at five or nine nodes reduced yields from 9.3 to 7.9 and 7 bales/ha respectively whereas removal of squares had no effect.

Pix trial: Pix treatments at node 9, at flowering, or a combination of the two had no effect on machine-harvested yield which was approximately 7 bales/ha.

Weed survey on irrigated farms in the Katherine and Douglas Daly districts: The major weeds were grasses, mainly *Brachiaria* and *Digitaria* spp. The volunteer crops, peanuts and sorghum, were a problem on some farms. Of the broadleaf weeds, *Senna obtusifolia* would appear to be the most troublesome.

PROJECT: Chemical Control of Zamia Palm

Project Officers: G. Schultz and B. Beumer

Location: Marrakai Station

Objective:

To determine herbicide formulations for the effective control of Zamia Palm.

Background:

Zamia palm, *Cycas armstrongii* (Family Cycadaceae) is a native palm-like tree growing 1-4 metres high with a tall slender trunk and fern-like green leaves on top. This plant can form dense stands and the leaves and fruit are toxic to stock. It is especially a problem when cattle are hungry or moved from clean country to areas infested with zamia. The effect on the animal is cycad staggers from posterior paresis and ataxia.

Method:

A trial was conducted using 75 g/L Picloram plus 300 g/L 2,4-D (Tordon 75D®), 100 g/L Picloram plus 300 g/L Triclopyr (Grazon DS®) and 600 g/L Metsulfuron methyl (Brush-off®) at two heights of injection for Tordon 75D and Grazon DS and an overall spray for Brush-off. The application was carried out in August 1999 and February 2000.

The treatments for Tordon 75D and Grazon DS involved cutting off the plant crown or at ground level and injecting the herbicide on the freshly cut surface. The Brush-off was applied with a low-pressure knapsack.

Table 1. Herbicides, site and rate of application on Zamia at Marrakai Station

Time of Application	Herbicide	Site of Application	Range of plant size		Application rate
			Height (cm)	Diameter at cut (cm)	
17 August 1999	Tordon 75D	below crown	670-2,230	60-100	1 to 3 in water at 1 mL/2.5 cm dia
17 August 1999	Tordon 75D	at base	900-2,000	90-130	1 to 3 in water at 1 mL/2.5 cm dia
17 August 1999	Grazon DS	below crown	410-1,450	40-90	1 to 3 in water at 1 mL/2.5 cm dia
17 August 1999	Grazon DS	at base	50-1,300	70-120	1 to 3 in water at 1 mL/2.5 cm dia
17 August 1999	Brush-off	overall spray	30-430	20-80	30 g/100 L plus 0.1% wetter
8 February 2000	Tordon 75D	below crown	800-2,300	70-90	1 to 3 in water at 1 mL/2.5 cm dia
8 February 2000	Tordon 75D	at base	900-1,450	100-140	1 to 3 in water at 1 mL/2.5 cm dia
8 February 2000	Grazon DS	below crown	750-1,700	60-100	1 to 3 in water at 1 mL/2.5 cm dia
8 February 2000	Grazon DS	at base	900-2,500	90-130	1 to 3 in water at 1 mL/2.5 cm dia
8 February 2000	Brush-off	overall spray	13-1,900	10-160	30 g/100 L plus 0.1% wetter

Results:

For a mid Dry season treatment and final assessment after 12 months, the application of Tordon 75D and Grazon DS gave a significantly better kill from a basal treatment than crown. Brushoff gave a 30% kill rate for the same time period. Wet season treatment gave similar results but Brush-off increased its kill to 40%. No significant difference was found for time of application.

Discussion:

Over a two year assessment the best control was achieved using either Tordon 75D or Grazon DS on a freshly cut base of zamia. The use of Tordon 75D is the preferred product due to current registration of these herbicides.

PROJECT: Identification of Weed Species Developing under Pivot Irrigation Systems

Project Officers: G. Schultz. N. Hill* and N. Hartley

Location: Larramah, Katherine and Douglas Daly Regions

Objective:

With landholder involvement, to:

- ***Determine the weed species which pose a threat to intensive crop production.***
- ***Develop an integrated weed management package for their control.***

Background:

Low weed density populations can still have a significant effect on both the cost and quality of the final product under intensive systems. There is a limit to the number of herbicide options available and a range of environmental issues to consider. A more strategic approach to weed control will reduce the need for herbicides and reduce the chance of resistance by plants to herbicides. This is of particular interest for developing peanut and cotton industries.

Method:

Seven irrigation systems were selected within an area from Larramah, Katherine and Douglas Daly regions. These were assessed for plant composition at three different times. These were:

- Before any land preparation.
- After planting and after herbicide application would have had an effect.
- End of the Wet season when weeds would be reproducing.

The method involved the use of a modified GRASS Check® system to assess each paddock. This has now been carried out for two consecutive seasons. Table 1 shows the range of species in these areas reflecting the plant species identified and their incidence for two years. The data selected is for the March assessment. Other data is available for September and May.

Discussion:

Relatively few plants have the characteristics to be true weeds but under intensive irrigation systems plants which are not usually known for their weedy nature can become difficult to control. They also harbour pests and diseases for many crop species. It will require several years to study the importance of these species. Similar surveys are being carried out in other states with similar irrigation uses so that a more complete picture of the weed spectrum can be developed.

* N. Hill is now employed by Agriculture, WA.

Table 1. Plant species and their incidence on seven irrigation sites in March 2000, 2001

Botanical Name	**Site**													
	1		**2**		**3**		**4**		**5**		**6**		**7**	
	Mar-00	**Mar-01**	**Mar-00**	**Mar-01**	**Mar-00**	**Mar-01**	**Mar-00**	**Mar-01**	**Mar-00**	**Mar-01**	**Mar-00**	**Mar-01**	**Mar-00**	**Mar-01**
Alysicarpus vaginalis	5	17	62		6			1		6	1	1		
Amaranthus hybridus					1									
Arachis hypogaea	90	91											73	68
Aristida												87		
Bidens pilosa													24	
Boerrhavia dominii												1		
Brachiaria sp.					77		60		83	8			81	20
Cayratia trifolia											1	2		
Cenchrus ciliaris														7
Centrosema pascuorum		13			1	4	1	2		4				
Chloris barbata					1									
Chrysopogan fallax											55			
Citrullus lanatus													12	
Corchorus olitorius		3												
Crotolaria sp.	3	23	3					1			1	7	6	8
Cyperus rotundus									2					
Dactyloctenium sp.		1			8	9	6	17	16				3	
Digitaria sp.	99	90			7		16	3	78			2	9	53
Echinochloa sp.					8	48		24	11					
Eleusine Indica							1							
Eragrostis								2						
Euphorbia vachellii												1		
Gossypium hirsutum							1							
Indigofera sp.			2								1	2	4	42
Ipomea eriocarpa		1										14	11	2
Lablab purpureus						4								
Macroptilium sp.	4	3	1											
Medicago sativa					1									
Melochia								1						

Botanical Name	Site													
	1		2		3		4		5		6		7	
	Mar-00	Mar-01	Mar-00	Mar-01	Mar-00	Mar-01	Mar-00	Mar-01	Mar-00	Mar-01	Mar-00	Mar-01	Mar-00	Mar-01
Mitrocarpus								1						
Oryza sativa	31				79	99	46	100					1	
Panicum maximum									2					
Passiflora foetida		1	6											
Pennisetum sp.	1	1					1						18	62
Physalis minima		1					6						1	
Portulaca oleracea		5												
Rhynchosia minima											2	2		
Rottboellia formosa											12			
Senna obtusifolia	31	10	65			1			27	20				
Setaria apiculata													4	
Sesbania cannabina									5					
Sida acuta		5	5			1			8	2			1	
Sida cordifolia		2			1					2		1		6
Sida rhombifolia			4											
Solanaceae physalis		4												
Sorghum sp.													1	
Sorghum bicolour	2					1			86	98	98	89		
Sporobolus australasicus													1	
Stylosanthes hamata											1			
Tridax procumbens						1	10							12
Triumfetta rhomboidea					1	6	9							
Urachloa sp.			100				56							
Vigna sp.		4	25				1	1	2				28	24

PROJECT: Evaluation of the Herbicide Metsulfuron methyl for the Control of Senna obtusifolia

Project Officers: G. Schultz and N. Hartley

Location: Beatrice Hill Farm

Objective:

To test the suitability of Metsulfuron methyl for the control of Senna obtusifolia in a rangeland situation.

Background:

Senna obtusifolia (sicklepod) is a significant weed on the fringes of floodplains around many river systems. This weed often grows in combination with similar or related species and then competes for resources on these valuable grazing areas during the Wet season. They also hide feral animals and are problem weeds in natural ecosystems. They are generally dispersed by water, in mud on machinery and by stock movement. When senna is combined with *Calopogonium mucunoides* (calopo) they are capable of forming a dense impenetrable cover. Senna does not have any beneficial attributes but calopo is considered a desirable grazing plant in the late Wet/early Dry season. Senna is difficult to control except as seedlings and can react differently to control methods in different areas.

Method:

A trial was conducted using different rates of Metsulfuron methyl (Brush-off®) on slashed old growth senna at Beatrice Hill farm in 2001. The rates applied were 0,5,10,15,20 gm of Brush-off per hectare mixed with 0.01% wetter and applied at 133 L/ha by a precision sprayer.

Results:

Efficacy of Metsulfuron methyl was measured on eight different species in the period January to April 2001. Table 1 shows a summary of the data for three test dates.

Discussion:

Metsulfuron methyl is a suitable herbicide for the control of a range of weed species provided it is applied at a sufficient rate and on new growth. The herbicide does not have any residual control on these weeds, gives good initial control but dormant seed of the weeds can develop a new stand later in the Wet season. This means that at least two applications are needed to give a season-long control. This product has limited effect on grass production where plants like senna and calopo quickly produce a dense cover, which has the capacity to smother any grass growing underneath.

Table 1. Summary of the data for three test dates for use of Metsulfuron methyl

Herbicide rate g/ha	Date of assessment	Ground cover %	Species							
			Calopo	Ipomoea	Crotalaria	Sedge	Senna	Sida	Hyptis	Grass
0	11/01/2001	52.5	25.3	9.3	0.0	1.1	5.6	2.9	0.0	8.8
	8/02/2001	67.5	21.2	4.4	3.7	6.9	9.4	4.4	0.0	17.5
	6/04/2001	86.3	44.3	6.9	0.7	1.9	3.8	4.4	0.0	26.9
5	11/01/2001	52.5	37.0	0.6	0.0	0.0	14.6	0.3	0.6	0.0
	8/02/2001	63.7	34.0	0.0	0.0	2.9	17.1	3.8	4.1	0.0
	6/04/2001	88.8	51.3	0.9	0.0	13.8	19.4	2.9	0.0	7.5
10	11/01/2001	55.0	35.3	0.0	4.1	0.6	10.6	1.9	0.3	2.1
	8/02/2001	70.0	27.5	1.3	5.0	2.5	25.0	1.3	5.0	8.8
	6/04/2001	88.8	38.8	2.5	3.8	0.0	25.0	0.7	5.0	13.1
15	11/01/2001	13.5	7.5	0.0	0.6	0.0	5.3	0.0	0.0	0.0
	8/02/2001	45.0	14.1	0.9	8.8	2.9	15.6	2.5	0.0	0.0
	6/04/2001	80.0	26.9	10.0	22.5	0.8	16.3	0.0	0.0	3.1
20	11/01/2001	33.7	10.3	0.8	7.5	0.0	11.1	2.0	0.8	0.3
	8/02/2001	62.5	16.3	0.0	10.0	0.0	30.0	5.0	2.5	0.0
	6/04/2001	85.0	36.3	5.0	10.6	0.0	25.6	0.6	2.5	4.4

PROJECT: Insect Dynamics of the Cotton Ecosystem in the NT

Project Officers: A. Ward, K. Shrimp and M. Connolly

Location: Katherine Research Station

Objective:

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

Background:

An essential component of any cotton production system in the Northern Territory is a sustainable insect management package based on an understanding of the ecology of both pest and beneficial insects. To complete this research, funding has been obtained from the Australian Cotton Cooperative Research Centre. Research commenced in April 2001 with the planting of the 2001 cotton crop.

Progress:

To meet the project objectives studies are being undertaken in three key areas. These are population dynamics, resistance management and the assessment of preliminary components of potential IPM systems for NT cotton. The following activities are being undertaken to complete these tasks:

Population dynamics

- Twice weekly monitoring of crops grown using both permanent trickle tape and overhead irrigation to assess the abundance and bio-diversity of the pest and beneficial insects in each system. Included in the overhead irrigation area are small blocks of Twingard® cotton and unsprayed conventional cotton.

- Weekly monitoring of the seasonal abundance of Lepidopterous pests at eight sites including both bush and established cropping areas using pheromone traps. Species being examined are *Helicoverpa armigera* (8) *H. punctigera* (8) *Spodoptera litura* (5) *Pectinophora gossypiella* (5) and *Spodoptera exigua* (2).

- Two weekly monitoring of egg and larval parasitism in *Helicoverpa* and how this changes over time. Andrew Davies (University of Queensland) will identify *Trichogramma* sp.

- Two weekly monitoring of *Helicoverpa* populations using Lepton test kits to identify how the species mix changes throughout the season.

- Regular monitoring of the broader environment to determine the sources of both pest and beneficial insects outside the cotton ecosystem.

Resistance monitoring

- Baseline susceptibility of *H. armigera* and *H. punctigera* to BT at Katherine is being assessed in collaboration with Dr Hoe Dang at ACRI. *Helicoverpa* spp. resistance to other insecticides is being assessed in collaboration with Dr Robin Gunning from NSW Agriculture in Tamworth.

Assessment of components of potential IPM systems for NT cotton

- Assessment of the suitability of various trap crops for both sucking insects (green vegetable bugs and brown mirids) and *Helicoverpa*. The crops being assessed are niger, chickpea, sesame, lablab, kenaf and pigeon pea.

- Preliminary assessment of the insecticides applied both at planting and as a side dressing at first square to control early-season sucking insects.

SUBPROGRAM: Agroforestry

PROJECT: Agroforestry

Project Officers: D. Reilly and B. Robertson

Location: Berrimah Agricultural Research Centre (BARC) and Douglas Daly Research Farm (DDRF)

Objective:

- ***To conduct species evaluation trials on various sites which address a number of criteria to meet industry requirements for both long and short rotation timber crops.***

A number of trials have been implemented over the past few years to evaluate production levels of various tree species on various soil types at sites across the Top End of the NT. The main focus of the trials has been to assess the success of establishment and subsequent growth rates, monitored by measuring height and stem diameters. Sites were established at two DPIF research farms in the mid-1990s for both research and demonstration purposes.

The first trial was established at BARC in August 1995, (not the most appropriate time for planting), but served the purpose of gaining publicity and bringing together a number of community groups interested in tree growing and the research staff of DPIF and Greening Australia. As there is very little rainfall in August in the Top end, trees in the trial were irrigated for the first two years. Table 1 outlines the species planted and the progress made over the last six years.

Table 1. Tree planting at 3 m x 3 m spacing at BARC in August 1995

Species	Survival % 1997	Average height (cm)				
		1996	1997	1998	1999	2001
Blepharcarya involucrigera	42	177.0	273.3	370.0	449.0	-
Cedrela odorata	96	273.8	443.1	620.0	720.0	940.0
Eucalyptus pellita	96*	233.0*	370.4	355.0*	235.0*	-
Flindersia australis	80	202.0	275.0	385.0	467.0	610.0
Pleioginium timorense	90	267.0	436.1	615.0	698.0	890.0
Syzygium nervosum	90	149.0	231.0	310.0	362.0	470.0
Syzygium forte	96	158.6	256.5	380.0	346.0	650.0

* Dead plants replaced with new seedlings

- Indicates that most trees have died and not enough numbers left for an average

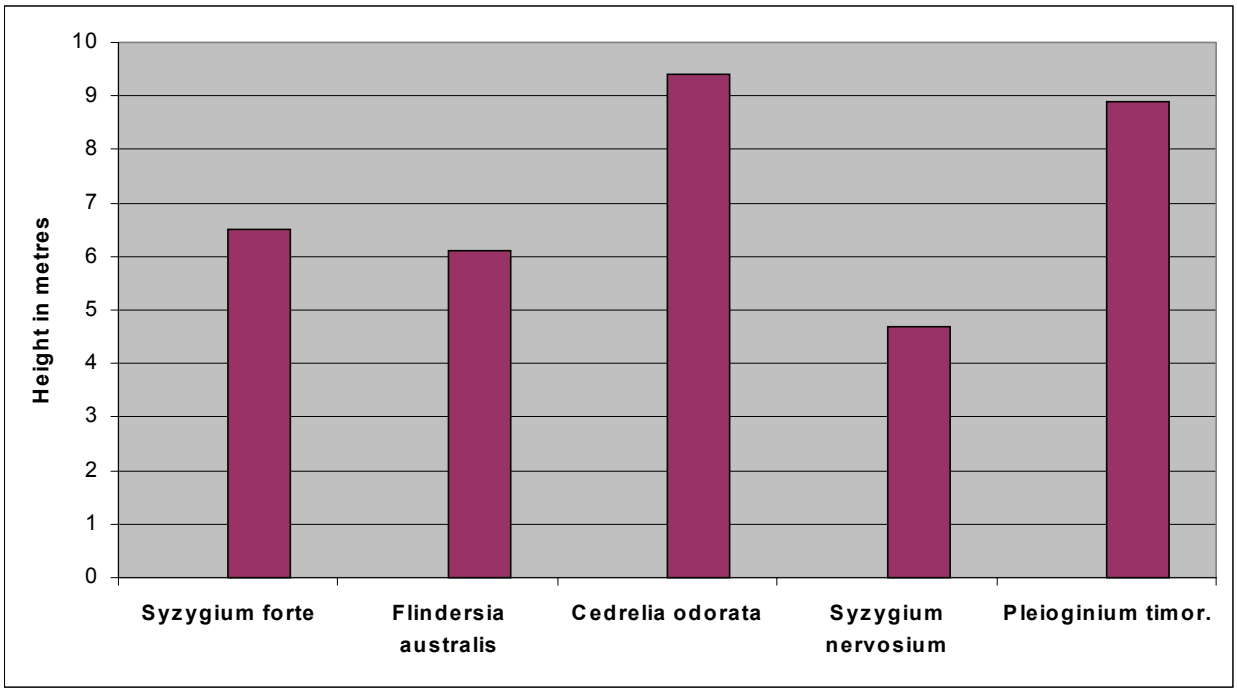


Figure 1. August 1995 planting at BARC

In December 1996, the BARC tree trial was expanded to evaluate another 12 species and provenances of high value tropical hardwoods to produce saw logs for timber. A number of spacing treatments were incorporated into the establishment to determine which were most appropriate for timber species in the NT environment. The results will only be realised many years down the track when other management practices are applied such as pruning and thinning. It is anticipated that closely planted trees will force each other upward to be tall and straight with minimal branching whereas the widely spaced trees will spread out. Also closely planted trees will compete for light, nutrients and water sooner than widely spaced trees and will therefore require thinning earlier to maintain growth.

The spacings were:

3.0 m x 1.5 m 2,222 stems per ha
3.0 m x 2.5 m 1,333 stems per ha
3.0 m x 3.0 m 1,111 stems per ha

Table 2. Measurements of mixed timber species planted at BARC in December 1996

Species	Survival %	Average height (cm)			
	1998	1997	1998	1999	2001
Gmelina schlechteri	98.5	240.3	365.2	430	510
Eucalyptus maculata	45.8	163.0	269.0	0*	0
Swietenia humilis(chol)	83.3	124.0	310.1	390	500
Samanea saman	100	206.0	358.5	360	490
Acacia aulacocarpa	93.1	292.0	433.2	580	780
Eneterolobium cyclocarpum	91.7	261.0	382.8	476	600
Acacia mangium	84.7	367.0	589.4	727	1160
Flindersia brayleana	60.9	93.3	218.6	0*	0
Acacia auriculiformis	98.6	352.0	506.4	657	790
Swietenia macrophylla	84.7	114.0	277.0	300	460
Swieteria humilis (coma)	80.6	116.0	284.2	347	540
Castanospermum australe	48.6	81.3	162.7	0*	0

*Indicates survival and growth in 1999 were poor and continued measurements were not warranted. Where such spaces occurred in the field, other high value timber species that prefer growing through a canopy were planted.

Table 2 shows survival and subsequent growth rates. It can be seen that some of the species performed poorly, indicating their unsuitability to conditions in Darwin. *F. brayleana* is a rainforest species more suited to the wet tropics of north Queensland and *E. maculata*, or spotted gum is better suited to the more temperate conditions of central NSW and southern Queensland. The other species are performing very well, particularly *A. mangium*, averaging over 7.2 m across all spacing treatments.

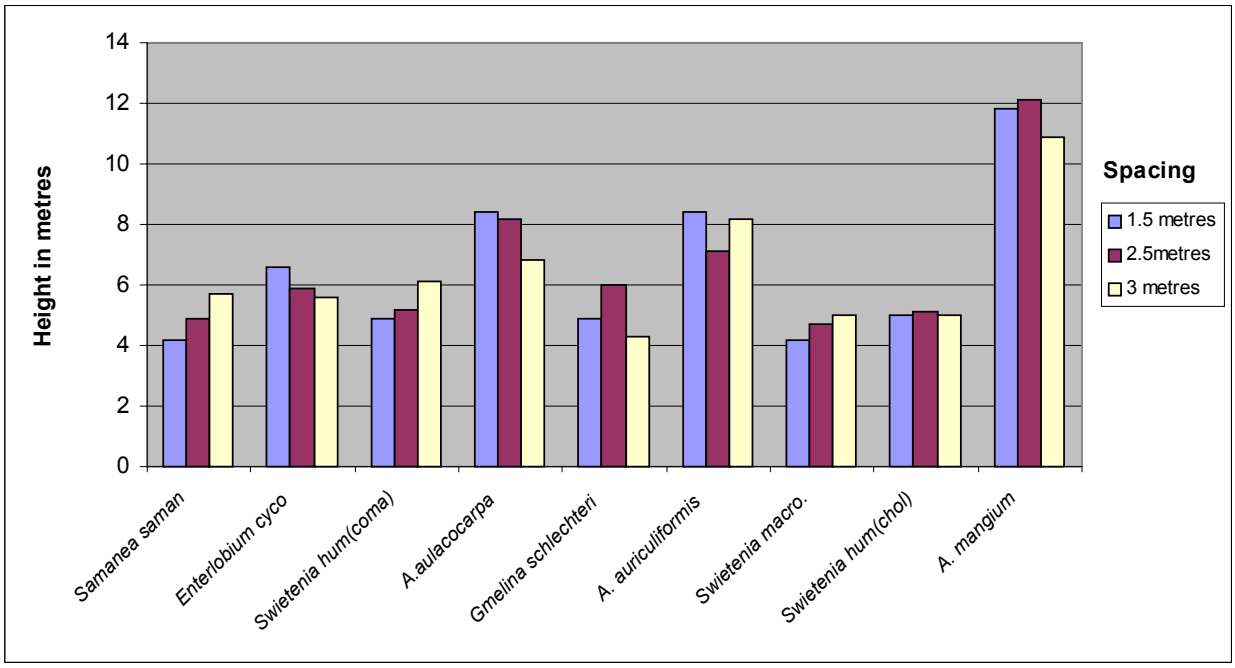


Figure 2. December 1996 planting at BARC

Figure 2 shows the nine best performing species in the trial and the growth rates across the three spacing treatments. A trend is beginning to emerge where the 1.5 m and 2.5 m spaced trees are gaining greater height than the 3.0 m spaced trees, as would be expected.

In December 1997 a small tropical hardwood trial was established at Ranku on Bathurst Island in co-operation with Sylvatech which has an agreement with the Tiwi people to plant a 200 hectare pilot project. The Sylvatech project is concerned mainly with the fast growing Acacia mangium species for wood chip production. The DPIF trial is looking at high value hardwoods on the same site and has used species already in trials at DDRF and BARC. These include *Cedrela odorata, Swietenia humilis (coma), Flindersia australis, Eucalyptus brassiana, Eucalyptus pellita, Eucalyptus camaldulensis, Swietenia macrophylla* and *Swietenia humilis (chol)*. The trees have been planted in three randomly allocated replications and spaced at 3 m x 3 m, giving a planting density of 1,111 stems per hectare. Data on this trial was taken only once, when it was six months old. The best performing species at that time were the three eucalypts.

In December 1998, a trial similar to that described above was planted at Rolla Plains on Melville Island. The planting design was similar to that at Ranku the previous year, except that *E. brassiana* was unavailable and was replaced by *Khaya senegalensis*, (African mahogany).

A teak (*Tectona grandis*) trial was established at DDRF to determine the success of the species on Blain soil, which was thought to be the most suitable for teak in the Top End.

The trees were planted into ripped rows, 3 m apart in blocks of 5 x 5 at 2 m intervals, in three different treatments. The treatments were:

- Open root/shoots cut and roots trimmed (Stumped).
- Grown in 1-litre bags.
- Grown in *Plantek* trays 35.

A two-row buffer was planted around the outside of the trial area using the same seed. The area had previously been sprayed with herbicide for pre-planting weed control. Trees were planted on two occasions, 17 December and 28 January because some seedlings were too small on the first planting date. Mixed fertiliser at 200 g/tree with trace was applied on 3/2/99. During the first recording in August 1999 minor form pruning was undertaken to remove any multiple leaders so as to encourage good straight growth of a single stem. Measurements have been taken on four occasions and the results are shown in Table 3.

Table 3. Survival and growth rates of Tectona grandis planted at DDRF in December 98 and January 99

Treatment	Survival % 1999	Average height (cm)			
		August 1999	December 1999	August 2000	March 2001
Stumps	81*	24.45	32.00	48.70	135.13
1 L bags	100	101.43	109.92	136.36	226.94
Plantek trays	95	78.17	88.42	117.94	209.06

* The lower survival rates and the lower growth rates for the 'stump' treatment is due to the poorer quality planting material that was used to make up numbers. Many of the stumps were far too small to be planted out, but as the Wet season progressed, time was running out to establish a rain-fed trial. The growth spike that occurred leading up to the last measurement in March 2001 should also be noted. Some trees grew over 2 m in the eight-month period between the third and fourth recording. This can be explained by the fact that these trees had sunk their roots down far enough to access moisture in the well-drained sandy soil, which enabled them to grow faster.

SUBPROGRAM: Livestock Management

PROJECT: TenderBuff Development and Supply Project

Project Officers: B Lemcke, E Cox and L Huth

Location: Beatrice Hill Farm

Objective:

To 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. DPIF runs the project in conjunction with the NT Buffalo Industry Council and provides the personnel to do the QA and branding of carcases at the abattoir. The price remains at $3.10 per kg hot standard carcase weight (HSCW) paid to the producer. There are five specifications to comply with to enable the carcase to receive the TenderBuff strip brand.

With the destocking of the Coastal Plains Research Station, supplies are now sourced mainly from commercial properties and agisted at Beatrice Hill Farm to maintain a steady supply. Beatrice Hill Farm with its extensive floodplain and ponded pastures is able to fatten stock all year round and is only a 45 minute drive from the Litchfield abattoir, well placed to supply the market. Few producers are yet able to turnoff directly into this market without using agistment to improve quality.

From November 1999 to January 2001 Beatrice Hill farm has supplied the Brunei supermarket trade to help keep up supplies. From March 2001 onwards, Beatrice Hill Farm will concentrate on producing TenderBuff, and will send only non-conforming stock to the Brunei trade.

TenderBuff has lower cholesterol and fat content than beef, both of which can be used as positive marketing factors.

Method:

The current specifications are:

- 150-300 kg HSCW
- 3-12 mm fat at p8 site
- No permanent teeth
- Electrically stimulated carcase
- pH of muscle after 18 hours < 5.8

DPIF staff monitor the TenderBuff animals through the abattoir on slaughter day and also carry out the chiller assessment the following day.

The producer pays the abattoir a kill fee of $65. The discount grid determines the sale price to the wholesaler of animals, which do not comply with the five specifications.

There have been only six Riverine ¾ bulls in the market over this 12 months. Significant numbers of agisted swamp buffalo have been put into the TenderBuff system. This is mainly due to the younger age at marketing (better tenderness) and better muscling and yield. Excess fat can be a problem with the higher Riverine content, particularly in females and may require better monitoring of fat depth and selling at a lower liveweight. Sufficient fat in Swamp males from agistment sources for the July to November period has been a

slight problem in supply; however the effects of castration will be tried in new groups to see if extra fat can be produced at this critical time.

Results:

Table 1. Parameters for TenderBuff

Carcase and production parameters for TenderBuff				
	July-December 1999	**January-June 2000**	**July-December 2000**	**January-June 2001**
No. of head	29	33	10	26
Mean HSCW	206.4	216.9	163.9	193.6
Mean eye muscle area	53.9	56.2	46.2	53.7
Mean pH	5.69	5.57	5.57	5.63
Mean carcase length	104.7	101.8	96.5	99.4
Mean gross $	599.68	662.37	503.55	578.91
Mean grid $/kg	2.93	3.05	3.07	3.00
Mean p8 fat (mm)	3.8	5.1	4.6	8.3
Mean dressing %	47.7	49.8		
River Cross %	$(^{3}/_{29})$=10.3	$(^{1}/_{29})$=3.4	$^{2}/_{10}$ = 20	$^{4}/_{26}$ = 15.4

All the six River crosses this year were ¾ culls due to temperament or lack of sale as breeder bulls. The comparative statistics are shown in Table 2.

Table 2. Comparison between Swamp and Riverine animals

For period July 2000 – June 2001			
	Swamp 30	**¾ River**	**% Difference from Swamp of ¾ River**
No. of head	30	6	
Mean HSCW (kg)	187.4	224.7	+19.9
Muscle area (cm^2)	51.9	62.5	+20.4
Mean pH	5.63	5.64	+0.15
Mean carcase length (cm)	98.9	102.2	+3.34
Mean grid $/kg	3.04	2.79	-8.3
Mean p8 fat (mm)	7.2	13.5	+87.5
Mean dressing %	48.9	51.8	2.9 higher
Mean price $	569.96	623.64	+9.4

The reduced price received for the ¾ crosses was due to two over-fat older carcases and a poor temperament bull (high pH). The price received was still 10% higher. Age comparisons are not possible due to the unknown origins of the majority of swamp; buffalo.

The very low numbers of TenderBuff that went to market in 2000-01 compared with the previous year, are more related to the lack of suitable supplies, particularly with the emphasis of Beatrice Hill Farm to supply the Brunei supermarket trade. This policy has now been reversed to concentrate on the local TenderBuff specifications. Better quality for TenderBuff will occur as producers refine stocking rates and use fertiliser and improved pastures. Segregation (weaning) from the main herd for young growing stock is an important issue, which many producers are currently not practising.

PROJECT: Riverine and Crossbreeding Buffalo

Project Officers: **B. Lemcke, E. Cox, G. Jayawardhana, T. Olm and BARC and BHF Staff**

Location: Beatrice Hill Farm and Berrimah Farm

Objective:

- ***To determine the merits of crossbreeding and upgrading to Riverine buffalo for the NT buffalo industry.***
- ***To distribute suitable progeny from the program to industry for breeding or for TenderBuff supply.***
- ***To 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 with the import of two bulls, followed over the next three years by a further four heifers and two more bulls. A crossbreeding program was started and progeny performance was monitored. Progeny were also put through the TenderBuff system. The purebred group has increased now to 26 head. Two of the imported bulls died, one accidentally and the other from TB three years ago. Also one calf died shortly after birth because the heifer did not have sufficient milk.

Method:

Purebred animals are held at both Beatrice Hill Farm and Berrimah Farm. Crossbreds are at Beatrice Hill Farm. Half bred cows and heifers are mated to the bull OJ and swamp cows are mated to the bull Hillary. The bull Bill who was exposed to TB infected cows, was trained to an artificial vagina and subsequently about 1,200 straws of semen were collected from it and frozen in liquid nitrogen for later use. Some semen of Italian milking buffalo has also been imported into Australia. 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 at Beatrice Hill Farm, July 2001

	Imported bulls	Local bulls	Cows	Yearling bulls	Yearling heifers	Male calves	Female calves
Purebred Riverine	2	4***	9	0	4	1	6
Swamp Group		-	28	-	-	-	-
F1		-	28	-	-	10	14
3/4		1+6*	28	7**	12	11	14
7/8		2*			1	1	2
Total	2	5	93	7	17	23	36

* Sold as breeder bulls during 2000/01
** For sale 2001/02
*** Three for sale 2001/02

It is significant to note that 61% of all calves were females. This has helped to increase the number of purebred females but not the number of bulls for commercial producers.

The productivity of F1 cows continues to be consistently high (always above 80%) since their first calves.

Eight crossbred bulls (6 x ¾ and 2 x $^{7}/_{8}$) were sold during 2000/01 with five going interstate to Western Australia and South Australia.

Artificial insemination success rates have been disappointing. Brazil reports a 50% success on single inseminations using a different drug and timing protocol, which will be investigated. So far six AI calves have been produced from pure and ¾ cows with semen from Italy and from the bull Bill. Only one Italian blood bull calf so far from the six is required to service cows at $^{7}/_{8}$ level. Two ¾ bulls and two purebred bulls were lent to four herds this year

This year one purebred heifer was weaned at 12 months of age weighing 420 kg. This is the highest weight so far for a 12 month-old purebred. It was from one of the two larger imported cows that had weighed 800 kg when pregnant. Standard cattle races have caused problems for these large cows because they are too narrow. As a result weight data recording has been restricted.

A $^{3}/_{8}$ heifer also performed well at Taminmin high school with a weight of 335 kg at 12 months of age. This is the first record of progeny from a ¾ bull and bodes well for their early use by industry.

SUBPROGRAM: Farming Systems

PROJECT: Ley Farming Systems Trial

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

Location: DDRF

Objective:

To evaluate a sustainable farming system which integrates pasture, crop and cattle production.

Background:

An integrated farming system allows flexibility in the use of resources such as machinery and labour, spreads risk for commodity price changes and a crop/pasture rotation provides options for weed control and grazing management. This project incorporates a two-year pasture production phase (either cavalcade only or mixed sabi/cavalcade), grown in rotation with a one-year sorghum crop. In any season, there is a phase with sorghum stubble, a phase of first year newly establishing pasture, and a phase of second year established pasture. Weaners are introduced onto either the improved pasture or the sorghum stubble and weight gains are recorded over the Dry season, aiming to reach a turn-off weight by the Wet season. This grazing management and the crop/pasture rotation influences the plant population dynamics of the paddocks. Vegetation monitoring assesses these changes. In recent years, Wet season utilisation of the mixed pasture paddocks has also been monitored in the belief that significant pasture productivity was being lost due to shading. Shading is likely to increase the proportion of low-quality dry understorey material in the sward saved for Dry season utilisation.

The trial evaluates pasture and crop establishment, production and grazing management under no-till farming practices.

Method:

The 2000/2001 season weaner steers and the 38 smallest of the previous year's group (yearlings) were allocated into their treatment paddocks on 22 June 2000. Cattle were weighed monthly. Phase 1 (paddocks 1-6) stock were grazing sorghum stubble after mixed pasture (paddocks 1-3) and sorghum stubble after cavalcade only (paddocks 4-6).

Phase II (paddocks 7-12) stock was introduced to cavalcade only (10-12) and sabi/cavalcade (7-9) second year pastures and destocked in November in readiness for sorghum establishment.

Phase III (paddocks 13-18) contained first year self-resown mixed sabi/cavalcade pasture (paddocks 16-18) or cavalcade only (paddocks 13-15) and were stocked until November. Paddock 19 is the yearly-cropped sorghum paddock (half no-till and half under conventional cultivation).

Vegetation is assessed twice yearly; May (at the end of the Wet season prior to cattle being introduced) and November (at the start of the Wet season). Botanal ® is used to record species presence (percentage of weed and desirable species) and yield. Only mixed sabi/cavalcade paddocks are stocked during the Wet season.

The final cattle recording was on 28 March 2001 after which all paddocks were rested until the smallest of the previous season's yearlings were restocked on 21 May 2001. The new batch of weaner steers (ex-Tipperary) was introduced to paddocks on 5 June 2001.

Results:

Cattle weight gains in the Dry season and Wet season are given in Table 1.

Vegetation:

Sabi and cavalcade again regenerated well from the seed bank after the sorghum phase; however, resowing costs were incurred in the cavalcade (paddocks 10-15) because of a weed problem. The sorghum crop this year was better established than in previous years with much less growth of companion species (pasture and weeds). Birds are clearly a problem during establishment. The spraying of annual grasses in the cavalcade paddocks at the optimum time - at the break of the season - was complicated by dry weather. This necessitated a complete glyphosate spraying in order to get an entirely new germination of cavalcade. This was because annual grasses could not be adequately controlled by Spinnaker® herbicide as they were too advanced.

Weight gain results:

There is a trend toward increased liveweight gains per head in those paddocks, which have low stocking rates or sorghum stubble. Animals in cavalcade paddocks tend to gain weight well up until August but lose it quickly after that as feed quality and quantity deteriorate with increased temperatures, dew and early rains.

Table 1. Weight gain (kg/head) for 22 June 2000 to 12 October 2000 for yearlings and weaners, weaner weight gains from 12 October to 28 March 2001, and total yields before commencement of grazing (kg/ha) for each paddock for May 2000

Paddock No.	Pasture treatment	Stocking rate	Cattle weight gain (kg/head) yearlings/weaners	Weaner wet season gains kg/head	Mean quadrat yields (kg/ha)
1	Sorg/Mixed	Medium	10.0/16.1	Ns	9192
2	Sorg/Mixed	Low	14.0/22.4	105.8	8488
3	Sorg/Mixed	High	12.0/20.6	114.5	9262
4	Sorg/Cav	Low	48.0/41.4	Ns	7573
5	Sorg/Cav	High	37.5/44.4	Ns	6084
6	Sorg/Cav	Medium	38.0/42.4	Ns	8128
7	Mixed 2nd year	Medium	26.5/28.4	Ns	8636
8	Mixed 2nd year	Low	32.5/32.4	Ns	11,404
9	Mixed 2nd year	High	15.0/23.0	Ns	7274
10	Cav 2nd year	Low	69.5/50.7	Ns	5759
11	Cav 2nd year	High	43.5/36.3	Ns	7350
12	Cav 2nd year	Medium	48.0/45.0	Ns	7048
13	Cav 1st year	Low	67.0/58.0	Ns	7615
14	Cav 1st year	Medium	29.0/59.0	Ns	6159
15	Cav 1st year	High	32.5/37.0	Ns	7390
16	Mixed 1st year	Medium	56.5/34.6	94.3	9439
17	Mixed 1st year	High	28.0/25.4	95.5	9037
18	Mixed 1st year	Low	34.0/43.6	99.5	10639
19	Sorghum continuous	Low	63.0/55.0	Ns	11085
Mean all cattle			36.3/34.1		

Ns = not stocked in wet

Sabi and cavalcade again regenerated well from the seed bank after the sorghum phase in paddocks 1-6, however, weeds were not well controlled in paddocks 4-6.

Groups on mixed Sabi pastures are grazed continuously on into the Wet season while other groups were destocked and used as mulch removers in paddocks that needed to be sown to sorghum. This generally reduced weight gains in cattle where mainly summer grass was grazed at heavy stocking rates. We still have difficulties in sowing sorghum into Sabi-based paddocks in the early wet. This is due to the toughness of the crowns of established plants and the lack of penetration by the planting coulters.

Cattle were turned off during March to go for export. However the 38 lightest cattle were retained for restocking during the 2001 Dry season. This will give us further data on getting heavier growing cattle up to higher turn-off market weights over a second Dry season.

Sorghum Yield:

During the 2001 Wet season, sorghum was grown zero-till on paddocks 10-12 following cavalcade pastures for two years and paddocks 2-9, which were mixed sabi/cavalcade for two years. Machine harvest yields are given in Table 2. Paddock 19 is continuous sorghum cropping with 50% conventionally tilled and 50% zero-tilled.

Table 2. Sorghum yields

Paddock	Sorghum yield kg/ha
7	2,100
8	1,900
9	2,000
10	1,900
11	1,900
12	1,400
19 Conventional	1,500
19 Zero-till	1,600*

*This was despite a huge difference in pennisetum content (higher in the no till plot)

Yields were significantly higher this year compared with most previous years. This was due to the use of the Mason planter to give a better crop establishment initially. Bird damage to grain late in the season was still heavy prior to harvesting.

The mean sorghum yield for all paddocks was 1,788 kg/ha compared with 1,490 kg/ha the previous year. Bird consumption of grain would have accounted for at least 50% of the total yield of the crop by the time of harvesting.

This tends to be a problem when only small areas of sorghum are planted in the whole district and the birds are not shared around over a large crop area, to reduce their impact per hectare.

PROJECT: Pasture Species Evaluation under Grazing at DDRF

Project Officers: B. Lemcke, P. Shotton, N. Hill, L. Huth and DDRF staff

Location: Douglas Daly Research Farm

Objective:

- ***To evaluate pasture species and mixtures under a continuous grazing regime on Blain soil at DDRF.***
- ***To determine their persistence, productivity and contribution to cattle performance.***

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 Brahman weaner steers at one head/ha year round. Steers are allotted to paddocks in June/July (post weaning) and remain in the grazing trial until the following June. The exception is Paddock 49, which had four extra animals to increase the stocking rate to utilise the large amount of grass.

Paddocks are top-dressed annually with a phosphorus-based fertiliser. This year Goldphos 20® 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/Arhnem was sprayed to control Sida, but Oolloo was eliminated as well. A single application of 100 kg/ha urea was applied to paddock 45 (Pangola) and paddock 46 (Sabi) because they had shown symptoms of 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 is recorded monthly.

Cattle were weighed monthly, given a condition score and P8 (rump) fat was measured, starting in late December and continued till the end of the grazing year in June 2001.

Pasture composition and yield were assessed twice during the year, in early Wet season and during December 2000. A post-Wet season assessment was made during May 2001.

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).

First grazing of re-established Paddocks 48 and 50commenced 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. Each row is half the paddock in length. Paddock 50 contains four blocks of multiple plots of five legumes sown into buffel grass during December 1999. It was grazed continuously throughout July 2000 – June 2001.

Table 1. Mean cattle liveweight gains (kg/head)

Paddock No.	Pasture type	July 00 - Oct 00 late Dry	Oct 00 - April 01 Wet season	April 01 - June 01 early Dry	Total July 00 - June 01
43	Higane (P. atratum)	+6.35	+132.8	+45	+184
44	Leucaena/Pangola	+27.5	+125.8	+29.5	+182.8
45	Pangola/+ 100 kg urea	-5.5	+138.8	+27	+160.3
46	Sabi/+ 100 kg urea	+8.0	+124.8	+20.3	+153.0
47	Jarra	+6.8	+121.8	+31.8	+160.3
48	Kaz setaria/Sabi/Leucaena	+18.7	+128.5	+39.8	+188.9
49	Buffel/Blue pea	+8.0	+131.6	+35.3	+174.9
50	Buffel/Legumes	+27.0	+140.5	+40.5	+208.0
51	Strickland	+15.3	+147.8	+34.5	+197.5
52	Arnhem/Oolloo	0	+124.8	+25.3	+150.0
531	Buffel/Sabi/Blocks	+20.5	+131.5	+38.5	+190.5
532	Buffel/Sabi	+10.3	+114.3	+27.3	+151.8
533	Buffel/Sabi/Wynn	+14.0	+132.5	+34.5	+181.0
534	Leucaena/Buffel/Sabi	+24.3	+134.8	+26.7	+184.0
	Mean liveweight change				+176.1

Mean cattle liveweight change for 98-99 was 190.4 kg/head. Mean for 99-00 was 187.7kg/head. This year the mean cattle liveweight is down a further 6.2% after last year's 4.6% decrease.

The leucaena paddocks did not perform as well as in previous years in comparison with the mean performance of all groups i.e. 8.3% higher in 99/00 whilst only 4.1% higher this season. This may reflect on management where half the rows were bulldozed to reduce canopy height and ground cover. Poor performance by some groups was due to individual steers with disease problems, notably ephemeral fever and pestivirus, post weaning. The Buffel/legume group (Paddock 50) performed very well this year but it must be noted that this followed Wet season destocking of the paddock to establish the legumes. This will need yearly monitoring to follow changes under grazing over three to four years. With the attempted elimination of weeds from the Arnhem paddock (Paddock 52) and the consequent elimination of Ooloo entirely, there has been a significant decline in the productivity of the stock on that paddock. An attempt will be made to reintroduce Ooloo back into the system early in the next Wet season, if it does not establish from residual seed supplies.

Block Consumption

In the Dry season, Uramol® was fed from 4 July to 25 October 2000 and in the Wet season, Phosrite® was fed from 25 October 2000 to 6 June 2001.

Table 2. Dry and Wet season daily consumption rates of supplement

Paddock	Dry season consumption (Uramol) g/day/head	Wet season consumption (Phosrite) g/day/head
Period	**113 DAYS**	**224 DAYS**
43	66	87
44	86	30
45	84	56
46	88	105
47	86	99
48	46	46
49	68	74
50	71	98
51	92	82
52	91	78
531	97	105
532	116	160
533	46	96
534	46	74
mean 00/01	78.0 g/day	85 g/day
mean 99/00	81.8 g/day	75.5 g/day
mean 98/99	102.0 g/day	89.3 g/day
mean for 1997/98	134.3 g/day	119.3 g

Consumption rates per head for Uramol® were consistently lower than for the previous three years, whilst for Phosrite® there was a minor increase from last year's intake.

Block Comparisons

This year an attempt was made to compare blocks from different manufacturers. The Four Seasons Company supplied Wet and Dry season formulations to compare with Uramol® and Phosrite® previously used over a long term in this trial.

"Pro90®" was used in the Dry season for the group having 532 eartags, whilst the Wet season block was "HighP®". The HighP® blocks did not have sufficient Wet season weather resistance and were not replaced after 23 January 2001. The Pro90® Dry season block group produced only half the weight gain of the Uramol group (10.3 kg liveweight gain vs 20.5 kg liveweight gain for the total period) despite a higher level of block consumption.

Wet season consumption of Phosrite® was slightly higher than last year but with one month less at the start of the Dry when consumption rates tend to drop off in June. Uramol® consumption rates were marginally lower than the previous year but with a lot less paddock variation in consumption between groups.

Consumption rates on Pangola grass were well under the average in the Wet season – reflecting possibly the higher sodium content of Pangola grass. The average block costs for the year at the average consumption rates per head are as follows:

Wet season	$19.04	7 months
Dry season	$7.53	4 months
Total	$36.57	11 months

Based on prices per tonne of:

- Phosrite® $961.00
- Uramol® $925.00

The HighP® block has apparently been reformulated for better Wet season stability. It will be tested together with Pro90® in 2001/02.

PROJECT: Soil to Plant Uptake of Radioactivity

Project Officers: **P. Shotton (DPIF), J. Twining (ANSTO*) and P. Hausler (DPIF)**

Location: Douglas Daly Research Farm

Objective:

The aim of the trial is to determine the amount of radioactivity that may be taken up by cultivated plants used for animal and human consumption.

Background:

Nuclear power will have a role in the rapid industrial development occurring in the tropics, particularly given the need to reduce global greenhouse gas emissions and the increasing need for electricity. Hence, accurate and precise predictive models of radiological dose in tropical and sub-tropical regions of the planet are required should there be any atmospheric release of radioactive material. From ANSTO's perspective this is particularly relevant for the northern areas of Australia and across South East Asia. The data from this study will contribute significantly to the current low-level of knowledge that we have of the behaviour of these materials in tropical regions, particularly as the soil types being used are representative of large areas of agricultural regions within the tropics. The overall aim is to provide better emergency response planning but the study will also contribute to our understanding of general elemental biokinetics in crops.

Method:

The trial is located on two soil types (Tippera and Blain) at DDRF. The location was selected and the site was prepared in 1999. Fences and enclosures were completed in October 1999 and the areas pre-watered and the first treatments applied on 15/10/99.The area consists of:

Actual treated areas	$30m^2$
Enclosed area	$110m^2$
Quarantine areas	$2,500m^2$

Each year, sorghum and mungbeans are planted at each site with each crop alternating locations yearly.

All areas were applied with recommended fertilisers, planting rates, weed control herbicides and insecticides when required. Water was applied to the areas to assist with establishment. Strontium (85 Sr) is applied to both sites each year in October.

Both sites are hand harvested, taking grain and plant material from both treated and non-treated areas.

Results:

These results come from the analyses performed over the first year of the study. Radioactivity (Caesium-134, Strontium-85 and Zinc-65) was added in October 99. Sorghum and mungbeans were sown at the beginning of the Wet season and harvested in March and April. Additional Sr-85 was added in October 2000 (This isotope decays away each year) and the second season of crops was grown for harvest in April 2001.

Safety at the site has been well maintained as determined from dosimeters placed at the sites and at the community centre. The exclusion fences, distance from the community and the limited time spent at the site have ensured that no member of the community or public was exposed to radiation above background levels.

The radioactivity was strongly bound to the soil surface and is migrating into the soil very slowly. More than 90% remained in the top 5 cm (probably within the top few millimetres) at the end of the Wet season. No substantial differences in radionuclide retention between the two soils have been observed. Very little of the radioactivity has moved across the soil surface. (Table 1)

Table 1. Average specific activity in each soil by depth (Bq/kg DW) a) at time of labelling (Oct. 99) and b) at time of harvest (Apr. 00)

		Soil Type					
		Blain			Tippera		
Sample	Depth	^{85}Sr	^{134}Cs	^{65}Zn	^{85}Sr	^{134}Cs	^{65}Zn
A							
At label	0 - 5 cm	2,330	3,843	4,940	2,093	3,597	4,477
	5 - 10 cm	86	200	184	105	185	210
	> 10 cm	22	47	35	37	66	69
	Unlabelled	3	4	4	2	1	1
B							
At harvest	0 - 5 cm	3,595	2,340	4,860	1,858	1,198	2,138
	5 - 10 cm	440	84	150	195	61	101
	> 10 cm	33	14	21	95	46	110
	Unlabelled	17	9	20	16	3	6

Activity is corrected for decay to 1 October 1999.

Only the crop seeds have been analysed for radioactivity so far (Table 2). These show that plants close to the labelled area (within 2 metres) do take up some of the activity, probably by root penetration into the active area. This season, crops were sown further away from the activity to get a better background value. For the plants growing in the active areas, mungbeans generally accumulated more radioactivity than the sorghum. Both crops took up slightly more radioactivity from Blain than from Tippera.

Table 2. Average specific activity (Bq/kg DW) in each crop type, from labelled and unlabelled areas, by soil

	Soil Type					
	Blain			Tippera		
Crop	^{85}Sr	^{134}Cs	^{65}Zn	^{85}Sr	^{134}Cs	^{65}Zn
Mungbean						
Labelled	2,040	186	2,2400	1,810	86	16,500
Unlabelled	<6	<0.4	107	<3	4	360
Sorghum						
Labelled	404	68	18,700	343	74	10,500
Unlabelled	26	2	1300	5	1	54

Activity is corrected for decay to 1 October 1999.

The results for Cs and Sr are typical for these elements. The uptake of Zn, however, is about 10 – 20 times higher than expected. Additional chemical analyses are being conducted on the soil and the plants to try to understand this result. Analyses on other plant parts, such as leaves are also being made. The study will

extend over at least one more growing season (2001-2002) to look at the effect of soil adsorption on plant uptake as well as the other factors (pH, moisture content, nutrient status, etc) that are likely to influence bioaccumulation.

A background to the study and more detailed results are available at Berrimah Agricultural Research Centre in an ANSTO report number REPP-TR-01.DPIF file number 99/0365.

*ANSTO: Australian Nuclear Science and Technology Organisation

PROJECT: Weed Management Strategy Demonstration Site

Project Officers: N. Hill, P. Shotton, B. Lemcke, and DDRF staff

Location: Douglas Daly Research Farm

Objective:

To demonstrate a 'best bet' pasture rehabilitation/weed management strategy on a badly weed infested Cavalcade paddock

The area had been established as a cavalcade pasture for a number of years prior to the start of this project. It had become infested with weeds resulting in poor productivity. This project aimed to demonstrate a strategic weed management plan involving a five-year crop/pasture rotation. This will evaluate the increase in productivity of the pasture each year, and ultimately enable the area to be re-sown to Cavalcade. The total paddock area is approx 6 ha.

Method:

1995/96
The area was under cavalcade with large amounts of weeds, particularly sida senna and hyptis.

1996/97
The area was cultivated, sown to Jumbo sorghum, atrazine pre- and post- emergent applied; fertiliser applied (200 kg/ha of 0-18-0-10) and eventually harvested in early April. No nitrogen fertiliser was required. Yields of 12 t/ha of hay were achieved.

1997/98
The area was cultivated and sown to sabi (6 kg/ha of hulled seed) in mid-January, and fertiliser applied @ 37 kg/ha Pasture Gold ® 0-14-0-17 + trace. Sabi established well. Broadleaf weeds also emerged, so the area was sprayed with Diuron ® at 41/ha in mid March.

1998/99
Cattle were introduced on 17 June 1998 (5 head-1head/ha) and grazed continuously except for a two-week period in January (6-20) when the pasture was fertilised with 100 kg Pasture Gold 0-14-0-17 and sprayed with 2 L/ha Diuron and 2 L/ha 2,4D Amine (to control broadleaf weeds). On 28/1/99 two extra steers were put in Bay 11 (both at 234 kg, raising the stock numbers to 7 head/ 5 ha).

1999/2000
Cattle were replaced on 10 August 1999 with five weaner heifers, which were continuously grazed on the paddock through to 30/6/00 except when destocked for spraying. Cattle weights were recorded every two months. Cattle received ad lib access to Wet and Dry season supplement blocks. A group of 30 bulls was used to crash graze the paddock in January 2000 whilst heifers were removed prior to spraying with 2 L each of Diuron and 24D on 8/2/00. Heifers were brought back to the paddock on 17/2/2000. They continued in the paddock until November 2000, when they were removed for cultivation.

The paddock was pasture surveyed using Botanal in May 1997 (after harvest), November 1997 (to monitor emerging weeds with the start of the Wet), February 1998 (to record sabi establishment and weeds

emerging) and June 1998 (to record pasture species population before cattle were introduced). Botanal pasture surveys were also carried out in November/December 1998, 1999, 2000, and also in May 1999, 2000 and 2001.

November 2000
Two 1.2 ha plots were pegged and given the following treatments:

Plot 1 (No till plot)

Glyphosate 4 L/ha on 19 December 2000
Fertilised with 100 kg/ha of Goldphos 20® preplanting
Planted with 10 kg/ha Cavalcade seed (Buffalo Planter)
Pre-emergent application of Spinnaker® 0.4 L/ha on 19 December 2000

Plot 2 (Conventional tillage plot)

Glyphosate 4 L/ha on 19 December 2000
Ploughed 12 December and again on 16 December 2000
Planted with 10kg/ha of Goldphos 20®
Pre-emergent application of Spinnaker® 0.4 L/ha on 19 December 2000
Herbicide rolling using Glyphosate 1:7 mixture with water on 7 March 2001, pasture topping using slasher at 0.4 m height

Results:

Despite such a long weed-free period (five years of treatment) a considerable amount of *Senna obtusifolia* and *Corchorus aestuans* emerged along with Buffalo clover and some annual grasses.

Transects were scored on 15 February 2001 for estimated percentages of species present in quadrats using two observers.

Table 1. Species proportions of approximately 70 quadrats/observer

	Cavalcade	Senna	Corchorus	Buffel Clover	Grasses Other
No till	97%	-	1%	0.5%	1.5%
Conventional tillage	72%	5%	9%	11%	3%

There were very significant differences in weed content between the no till (NT) and conventional till (CT) plots. The NT plot was very clear of weed except where there were areas dug up by pigs. Where this disturbance occurred weeds were present. The rest of the plot was pleasingly clean.

The CT plot showed significant weed seedling establishment, which became increasingly obvious during the season, particularly as individual Senna plants became large. The two plots were remarkably different in weed content in favour of the NT plot.

This shows the effect of cultivation in enhancing the germination of residual seeds in soil profile despite the long weed free period. The areas were not baled for hay; however significant resources went into slashing and herbicide rolling to control the emerged weeds in the CT plot.

It is obvious that five years is not long enough to stop the Senna and Corchorus from re-establishing if conventional tillage is used.

PROJECT: Systems Research

Project Officer: P. Shotton

Location: Douglas Daly Research Farm

Objective:

To trial, monitor and record the short and long term effectiveness of weed control methods in pastures using herbicide rolling and slashing techniques.

Background:

The control of grass and broad leaf weeds in pastures is an ongoing concern, particularly where selective herbicides are not available or are uneconomical. 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 currently available at reasonable prices.

Herbicide wipers are one method being used for managing taller weeds in crops and pastures world-wide with varying success depending on location, weed species, application methods and chemicals used. The benefit of herbicide rollers is that the chemical is only applied to the target weed so wastage is minimal and spray drift is eliminated. Mechanical means for weed management, such as slashing, is a commonly used practice to reduce plant biomass and damage the plants to reduce competition, whilst also reducing weed seed production.

The effectiveness of using mechanical methods (slashing) on different weed species at different stages of plant growth and the reduction of weed species will be monitored over time. Different chemicals, surfactants, application rates and timing of application will be trialled using a herbicide roller and its effectiveness on a wide range of broad leaf and grass weeds will be monitored. The effectiveness of both methods will be evaluated using botanical surveys to determine weed reduction and other changes in the areas over time.

Method:

A replicated herbicide wiping trial was conducted at DDRF in February 2001 using three different chemicals and two surfactants on Sida *(Sida acuta)*, Flannel weed *(Sida cordifolia)*, Hyptis *(Hyptis sauveolens)*, Gooseberry *(Physalis minima)*, Sickle pod *(Senna obtusifolia)* and Pennisetum *(Pennisetum pedicellatum).*

Treatments:

1. Glyphosate® @ 3 L/ha with LI700® surfactant
2. Glyphosate® @ 3 L/ha with Uptake® wetter
3. Glyphosate® @ 2 L/ha with LI700® surfactant
4. Glyphosate® @ 2 L/ha with Uptake® wetter
5. Brush Off® @ 20 g/ha with LI700® surfactant
6. Brush Off® @ 20 g/ha with Uptake® wetter
7. Brush Off® @ 30 g/ha with LI700® surfactant
8. Brush Off® @ 30 g/ha with Uptake® wetter
9. Glyphosate® @ 3 L/ha and Brush Off® @ 20 g/ha with LI700® surfactant
10. Glyphosate® @ 2 L/ha and Brush Off® @ 30 g/ha with Uptake® wetter
11. Tordon 75D® @ 1 L/ha
12. Control No chemical applied

Note: Application rate is only approximate.

Results:

The 11 treatments used had varying degrees of success depending on the weed species. To date, the most universal chemical has been Glyphosate® with 0.1% LI700® and 0.25% Uptake® wetter. The major contributing factor has been the height and density of the weed mass. Generally taller weeds are better affected due to greater chemical contact.

Senna was the most difficult plant to kill with only Tordon 75D® producing an 80% success rate. Glyphosate® at 10 to 1 with both surfactants produced a 100% kill on *S. acuta* and S. *cordifolia;* however, all other treatments gave a 33% to 80% kill on both weeds. Gooseberry was controlled by all treatments. All chemicals used affected hyptis with six of the treatments giving 100% kill; however, the higher rates of Glyphosate® and Brush Off® were less effective. *Pennisetum* was only affected by treatments containing Glyphosate®, with all Glyphosate® treatments reducing plant growth; however only Treatment 3 was 100% effective. See Figures 1 and 2.

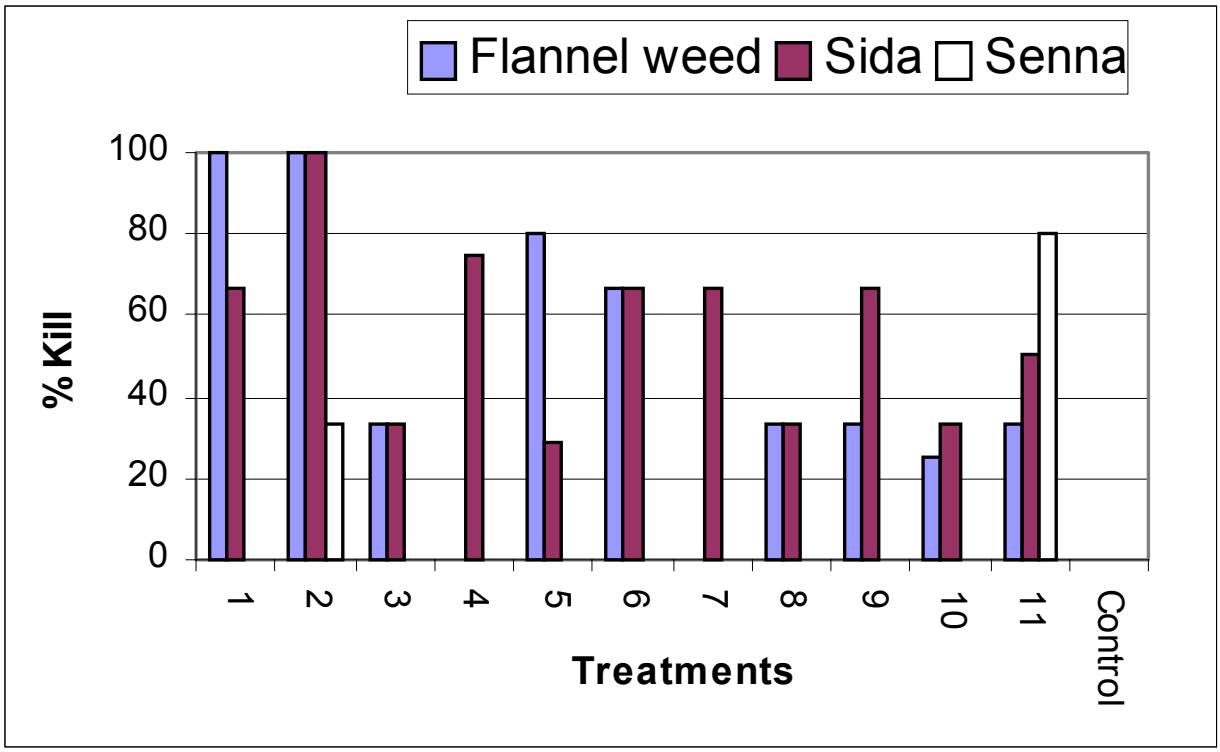


Figure 1. Effect of chemicals on Flannel weed, Sida and Senna

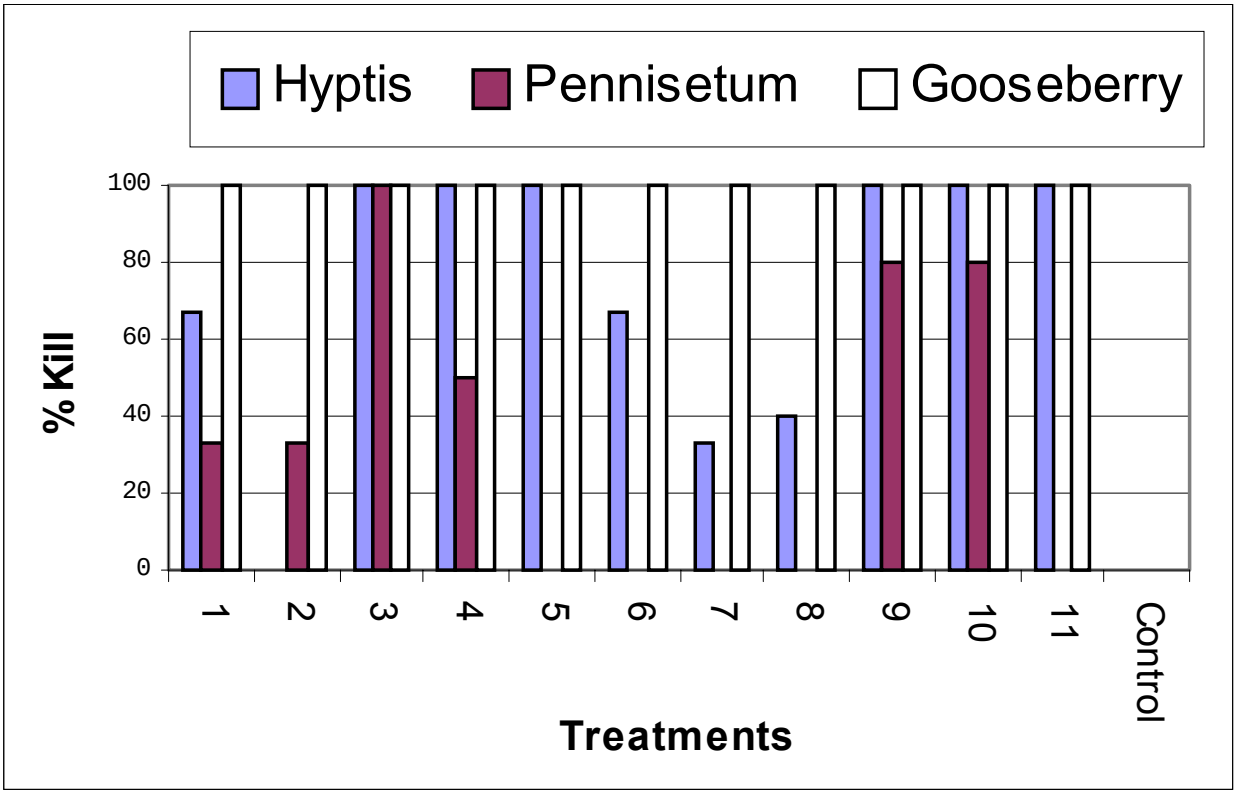


Figure 2. Effect of chemicals on Hyptis, Pennisetum and Gooseberry

PROJECT: Pasture Species Evaluation under Grazing at DDRF

Project Officers: P. Shotton and B. Lemcke

Location: Paddock 50, Douglas Daly Research Farm

Objective:

To 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 from DDRF south. 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.

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 in paddock 50 at DDRF. The area was lightly disturbed using a trash worker cultivator to encourage seed to contact soil after crash grazing.

Trial area:	**4 ha total**
Treatments:	Control - buffel only (Cenchrus ciliaris) Wynn cassia (Chamaechrista rotundifolia) Verano stylo (Stylosanthes hamata) Oolloo (Centrosema brasilianum) Maldonado (Macroptilium gracile) Milgara Blue pea (Clitoria ternatea)
Plot layout:	4 replicates, each randomised.
Plot size:	130 m x 12 m
Fertiliser:	50 kg/ha Goldphos 20 – December 1999 45 kg/ha 0-11-0-14 applied at seeding.
Weed control:	Broad leaf weeds were controlled by using Starane® as a post planting/pre-emergent herbicide.
Grazing:	No grazing during establishment in the first Wet season to allow legumes to set seed.
Recordings:	Botanal –In each plot botanal was used to determine plants present, the percentage of each and pasture yield. (November and May each year)
Plant samples	Taken from each plot to estimate the yield of buffel grass and legume and the proportion of each. Plant samples were also prepared and submitted to the Chemistry Section to be analysed for nutrient content.
Soil samples:	A single sample was taken from each plot to compare the differences in soil nutrient levels for the six treatments.

Results:

During the first season, all legumes established well, the most prolific ones being Milgara Blue pea, Oolloo and Maldonado. Wynn cassia and Verano stylo were less prolific than the twinning legumes. Verano, Wynn and Blue pea all seeded well although Oolloo and Maldonado seeded poorly. During the second season, all legumes again established and grew well. Results from the April 2001 harvest yields showed that the greater the legume content, the higher was the overall yield, but grass yield was lower. Oolloo mix had the highest overall yield and the control had the lowest overall yield. Results are given in Table 1.

Table 1. Plant yields

Treatments	Mean overall yield (kg/ha)	Mean legume yield (kg/ha)	Mean grass yield (kg/ha)	Buffel % nitrogen
Oolloo/Buffel	10,103	8,128	1,975	0.975
Wynn/Buffel	9,364	6,461	2,903	0.633
Maldonado/Buffel	9,154	5,661	3,493	0.670
Milgara/Buffel	5,555	1,784	3,771	0.558
Verano/Buffel	4,251	364	3,886	0.533
Buffel only	4,070		4,070	0.590

Grazing:

Steers were grazed between July 2000 and June 2001 at 1 head/hectare. Results from the species evaluation trial show the buffel – legume mixed pasture in Pdk 50 produced the highest overall steer liveweight gain over the 12 months and 9.2% higher than a pasture mix of buffel/Sabi only.

Plant samples harvested in April 2001 showed the percentage of nitrogen in the buffel grass was significantly higher in the Oolloo treatments. No significant differences however, were found in the December and May 2000 plant samples between treatments or replications.

PROJECT: Evaluate the Long Term Effects of No-Tillage and Conventional Tillage on Grain Yield and the Long Term Effects on Soil Properties

Project Officers: P. Shotton and B. Lemcke

Location: Douglas Daly Research Farm

Objective:

To monitor and evaluate the effects of tillage versus no-tillage practices on Tippera soil in the Douglas-Daly region in terms of soil properties, weed infestation, grain yields and insect activity.

Background:

The project was started in the 1984-85 Wet season with a maize/soybean rotation and tillage treatment. The original objectives were completed in 1988. Long-term soil changes were evaluated between 1984 to 1993 using maize/soybean and sorghum/mungbean rotations. In the 1996-97 Wet season *Centrosema pascuorum* cv Cavalcade was planted and harvested as a hay crop and the two tillage treatments were compared for yields. Forage sorghum was also used as a hay crop in the 1999 - 2000 season.

Method:

Total trial area:	2 ha.
Tillage plot size:	0.33 ha.
Fertiliser:	Depending on crop type and soil analysis.
Weed control:	Depending on crop type and weeds. Glyphosate® was used as a pre-planting knock down herbicide. For legumes, Spinnaker® @ 400 mL/ha pre-emergent was used and when necessary a grass selector was used post emergent. For maize and sorghum, Dual® and Atrazine® were used pre-emergent and Atrazine®, 24D® or Starane® was used post emergent.

Results:

K. Thiagalingham, J. Sturtz, N. Gould and T. McNamara found that between 1984 and 1993 there were different long-term effects on crop yield and soil nutrients under no-till and conventional till treatments. In their report, *Tillage Studies for Sustainable Crop Production in the Semi-Arid Tropics of northern Australia* (1996*),* they found that the five maize, five soybean and one sorghum crop yields under no till were 12% higher than under conventional till. Organic carbon, total nitrogen, available calcium, magnesium, zinc, copper and phosphorus were 7% higher under no-till than under conventional till in the surface soil (0 to 5 cm).

Further studies of the same trial area by Thiagalingham, Shotton, and Parker between 1994 and 1999 found grain yields of maize, sorghum, soybeans and mungbeans were all higher in the no-till areas than in the conventional till areas. In the 1996-1997 season a legume hay crop (*Centrosema pascuorum*) was grown. When compared, the no-till area produced a considerably greater yield than the conventional till area.

A study by Carole Wright of DPIF from1996 to 1999 found that soil organic carbon was higher in no-till areas but pH was not. Other soil nutrients such as N, Ca, Mg, Zn, Cu, and P are being currently evaluated.

The Entomology Section, DPIF conducted an insect study during the 1995/96 and 1996/97 seasons. The 1995/96 season results showed the proportion of insect damage to sorghum plants was higher in the no-till plots at 20.1% compared with 3.8% in the conventional till. The 1996/97 season showed similar results of insect damage in cavalcade when no-till areas suffered a 16.4% damage compared with 5.4% in conventional till areas. From this study Young and Smith concluded that reduced/no-till plots suffered more insect damage than the conventionally tilled plots.

Observations:

After 15 years, the no till areas had visibly less weed infestation than the conventional till areas. However, there were some problems emerging in the no till areas, such as soil surface compaction over time resulting in poor plant establishment and growth.

The conventional till areas became increasingly weedy, particularly with nutgrass, summer grasses, Senna, Sida and buffalo clover.

Crops in both treatment areas experienced different problems. The no-till areas required adequate moisture for the planter to work correctly. The conventional till areas required much less moisture, otherwise they became muddy and untrafficable.

PROJECT: Grain Sorghum Varieties for the Douglas - Daly District

Project Officer: P. Shotton

Location: Douglas Daly Research Farm

Objective:

To produce and compare new and commercially available grain sorghum varieties at the Douglas Daly Research Farm and determine which may be suitable for the area.

Background:

Over the past seven years replicated sorghum variety trials have been undertaken at the Douglas Daly Research Farm. During the past four years, sorghum seed has been used from the Pioneer and Pacific Seed companies. Varieties evaluated are those that have shown promise in past years and new lines that may suit the Top End conditions. Trial results will provide information and guidance for Top End sorghum producers to choose the most suitable commercially available seed varieties.

Method:

Trial location:	Paddock 10A, DDRF
Trial area:	3.5 ha
Number of varieties:	12
Trial design:	Randomised block with four replications
Weed control:	Glyphosate® 2 L/ha
	Atrazine® 2 L/ha
	Dual® 2 L/ha
	Post emergent application of Starane® at 300 mL/ha
Fertiliser:	200 kg/ha 19-13-0-10
	100 kg/ha urea
	75 kg/ha Muriate of potash

Each plot is monitored and evaluated for plant population, insect and pest occurrence, plant height, head type, resistance to head mould and leaf disease, plant lodging, hand and machine harvest yields, flowering and maturing dates.

Results:

During this season the wet conditions in March and April caused some problems with head moulds, leaf disease and insect problems, with some of the early-maturing varieties sprouting prior to harvest. Soil diseases and birds also affected plant population and establishment. Details are shown in Table 1.

Table 1. Sorghum variety trial 2000 - 2001

Paddock 10A. Douglas Daly Research Station												
Variety	**First Flower** DAP	**50% Flower** DAP	**Head type** (o,so, sc,c)	**Height** cm	**Head mould**	**Head exert**	**Lodging** 1 to 5	**Leaf disease**	**Hand harvest yield** At 13% kg/ha	**Plant pop** pph	**Machine harvest yield** At 13% kg/ha	**Krondomic weight**
Bonus	62	69	SC	130	3	3	5	3	3626	87,200	1880	68.5
Graze n Sile	62	68	SC	205	4	3	4.5	4	5312	90,700	1785	76
Jackpot	59	63	SC	135	3	3	5	3	3339	91,300	1499	65
MR Maxi	57	61	SC	125	3	2	5	3	3607	66,200	1802	66.5
XS 683	58	62	SC	135	3	3	5	2	3741	89,800	1982	67
GS 2412	54	57	SC	127.5	3	3	5	3	3415	99,800	1524	65.5
MR Buster	56	60	SO	120	3	3	5	2	4277	90,000	1878	62
MR 43	57	62	O	125	3	3	5	2	3913	87,300	2218	67
GS 2404	56	61	SO	127.5	3	3	5	2	3952	94,500	1847	62.5
8118	59	67	SC	157.5	4	4	5	3	4737	97,800	3265	76.5
MR 31	55	58	SO	127.5	2	4	5	3	3013	72,800	1484	56
8586	56	60	C	150	3	2	5	2	4010	97,200	2045	71.5

Head Type

O = Open
SO = Semi Open
SC = Semi Closed
C = Closed

Lodge

1 = Severe Lodging
5 = No Lodging
DAP = days after planting

Head Exertion

1 = Poor Exertion
5 = Good Exertion

Leaf Disease

1 = Severe Leaf Disease
5 = No Leaf Disease

PROJECT: Douglas Daly Research Farm Weather Recording

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

Location: Douglas Daly Research Farm

Objective:

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

Method:

Meteorological observations include a 9 a.m. cloud type and amount, visibility, evaporation, wind run, wet and dry bulb temperatures, minimum and maximum temperatures, past and present conditions and rainfall.

Every 10 minutes hourly and three hourly the automatic weather station records the following: wind run, wind speed and direction, dew point, wet and dry bulb temperatures, minimum and maximum temperatures, rainfall and barometric 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.

PROGRAM: Meat and Livestock

Introduction:

The Meat and Livestock Program consists of two components:

1. Beef Cattle Production and Marketing, and
2. Animal Health

Beef Cattle Production and Marketing

Objective:

To identify by the year 2005, cost-effective production systems and techniques that enable a sustainable 50% increase in the number of young NT-bred feeder cattle that reach SE Asian or Australian feedlot specifications within 12 months of weaning.

This component consists of two subprograms:

- Meeting Market Specifications
- Improving Breeder Herd Efficiency

SUBPROGRAM: Meeting Market Specifications

PROJECT: Effects of Genotype (4) and Weaning Weight Range (2) on Post-Weaning Growth and Final Fatness (P8, mm)

Project Officers: P. Ridley and T.J. Schatz

Location: Mt Sanford Station Research Site

Objective:

To measure and report on the effects of genotype and weaning weight range on:
- ***growth to the end of the first post-weaning Wet***
- ***final P8 (ultrasonic) fat depth.***

Background

The genotypes being compared are Queensland-derived purebred Brahmans, Droughtmasters and ¼ Charolais from the Kidman genotype comparison project and commercial Brahmans from Mt Sanford Station.

This is one of several projects receiving financial support from Meat and Livestock Australia (MLA), to evaluate:

- Two options (crossbred steers and single breed bulls) to optimise the value-adding potential of feeder cattle for the live export trade to South-East Asia.
- An alternative structure for the beef industry in the northern half of the NT capable of doubling the number of weaners (and thus the number of feeder cattle) available for the live export trade from the Katherine Region.

Method:

This was described in some detail in the Technical Annual Report for 1998/99 and will not be repeated here.

Two replicate blocks (Finch and Quail) stocked at 120 animals/6 km2 provided the experimental data; the cattle in this analysis were a subset of those present in each block.

The Hi weight range animals weighed more than 160 kg at weaning and the Lo weight range weaners weighed 100 – 160 kg.

All weaners were from the first weaning round (June).

The average weaning weights and the weaning weight ranges of the Kidman and the Mt Sanford derived weaners were similar.

Experimental animals grazed from weaning until the end of their first post-weaning Wet.

Results 1999/2000, 2000/2001:

Table 1. The property of origin of the weaners, their genotype and the numbers involved in this analysis

Genotype	Number	Weaner growth (kg/head)	P8 mm
Kidman			
Droughtmaster	29	122.6[a]	3.8[ab]
Brahman (k)	37	116.2[b]	3.1[a]
¼ Charolais	31	127.5[a]	2.7[a]
Mt Sanford			
Lo weight range	73	120.8[ab]	2.8[a]
Hi weight range	65	108.7[c]	4.2[a]

Within columns, groups with different superscripts were significantly different.

For growth:

- The difference between the Kidman and Mt Sanford Brahmans was negligibly small.
- The Droughtmasters and the ¼ Charolais grew 6.4 kg/head (5.5%) and 11.3 kg/head (9.7%) respectively, more than the Kidman Brahmans.
- Hi weight range weaners grew 12.1 kg/head (10.0%) less than the Lo weight range weaners.

These differences between the Kidman weaner genotypes are very similar to those recorded in the experimental feedlot at Katherine Research Station and in the grow-out phase genotype comparison on improved pasture (buffel) at Douglas Daly Research Farm.

For P8 Fat Depth:

- The Droughtmasters were fatter than both sources of Brahman.
- The ¼ Charolais were leaner (and larger) than all other genotypes.
- The Hi weight range was fatter than the Lo weight range (4.5 mm vs 2.8 mm).

The optimum fat depth for slaughter for Indonesian wet markets is about 3 mm.

Conclusions:

- The differences in growth and fatness between the two Brahman samples (Kidman and Mt Sanford) was negligibly small (i.e. they were of very similar mature size).

- Nearly all weaners which met export feeder live weight specifications were equal to or more than 160 kg at weaning and exceeded the optimal slaughter fat specification for Indonesian wet markets at the end of their first post weaning Wet. As a consequence they also had very low value-adding potential for either the supermarket or Philippines wet market trades.

- While Droughtmasters grew faster than the Brahmans, they were fatter and did not solve the Brahman's problem of low value-adding potential.

- The ¼ Charolais grew significantly faster than Brahmans (9.7%, 11.3 kg, p<. 01) and were leaner (P8 = 2.7 mm vs P8 = 3.1 mm for Kidman Brahmans and P8 = 3.5 mm for Mt Sanford Brahmans, ns). While this difference was small and not statistically significant at the end of their first post-weaning Wet, the feedlot data from Katherine Research Station has shown ¼ Charolais steers were 60 kg (15%) heavier than Brahman steers at the same fatness (P8 = 10 mm) at two years of age (i.e. they had 60 kg more value-adding potential),

- The use of ¼ Charolais steers to replace Brahman steers effectively solves the overfatness or low value-adding potential problem for both the Indonesian wet markets and the Philippines supermarket trade.

Value-adding potential equals the weight gain that is possible before either carcase weight or carcase fatness (P8 mm) exceeds market requirements.

Infusion of 25% late maturing genes from a number of late maturing *Bos taurus* breeds (e.g. Limousin, Blond d'Aquitaine) will provide a similar effect to that of Charolais.

SUBPROGRAM: Improving Breeder Herd Efficiency

PROJECT: Breeding Herd Efficiency of Alternative Breeder Genotypes

Project Officer: M. Cobiac

Location: Victoria River Research Station (VRRS)

Objective:

- ***To compare the breeding herd efficiency of three genotypes of cows (Brahman, Droughtmaster and F1 Brahman x Charolais.***
- ***To produce progeny (Brahman, Droughtmaster and $^{3/4}$ Brahman x $^{1/4}$ Charolais) that are tested for growth and their ability to meet future market specifications.***

Background:

The original 500 Droughtmaster cows on VRRS were reduced in late 1995 to 130 (randomly selected), and new breeders were purchased: 260 high grade commercial Brahmans (split into two equal herds) from a number of properties in Queensland; and 130 first-cross (F_1) Brahman x Charolais cows from Newcastle Waters Station. The Droughtmasters are an example of a simple two-breed (British *Bos taurus* x *Bos indicus*) composite and provide a link to past breeder research at VRRS. The Brahman (pure *Bos indicus*) cows represent the current breeding objective of the majority of district herds (currently about 80% Brahman) and are highly adapted to the tropics. Both Droughtmasters and Brahmans are considered to be medium sized mature animals.

As the live export trade to South-East Asian countries expanded in the early 1990's (particularly to Indonesia and the Philippines) a problem emerged with overfatness of NT-sourced cattle when turned off from feedlots in their destination country. This was a result of improved post-weaning management in the NT resulting in better weight-for-age at the time of exporting. The introduction of later maturing genes from European *Bos taurus* cattle was seen as one option to address this issue, and the F_1 Brahman x Charolais cattle provide a source of these genes. The 50% of European genes has always been considered as extreme for our environment, however when crossed back to Brahman, the progeny contain a high level of tropical adaptation (75% *Bos indicus*) as well as some (25% European *Bos taurus*) later maturing characteristics. There are two sources of these 25% Charolais animals: the progeny of the F_1 cows with Brahman bulls, and the progeny of Brahman cows with F_1 bulls. Future work is likely to involve evaluating the breeding efficiency of herds containing other proportions (e.g. 17% and 33% Charolais) of late maturing genes.

All breeders are run under the Department's Best Bet Management System, the basics of which are outlined in the 'Best Bet Breeding Herd' project report.

Some Results:

The current phase of breeder research at VRRS finished in May 2001. Herd structures are currently being modified to accommodate the new focus for breeder work, including the 'criss-cross' crossbreeding system for evaluating other proportions of late maturing genes and modifications to the standard Best Bet system. Data from 1995 – 2001 is presently being collated, checked for errors and prepared for analysis. Some preliminary results are presented here, with full analysis and reporting presently under way.

Table 1. Productivity results from VRRS breeder herds 1997 – May 2001

Cow genotype	Calf genotype	Weaning weight (kg)	Weaning rate (%)	Breeder efficiency (kg weaner/100kg breeder)
Brahman 1	Brahman	183	75.8	31.3
Droughtmaster	Droughtmaster	181	83.9	35.7
Brahman 2	¼ Charolais, ¾ Brahman	186	80.2	34.3
F_1 (½Brahman, ½ Charolais)	¼ Charolais, ¾ Brahman	185	82.1	31.6

Similar groups of young mixed steers are run with each adult breeder herd for 12 months and their relative performance (weight gain) over 12 months used as an indicator of grazing conditions available within that paddock. Table 2 shows the average steer performance over the period 1997 – 2001 from each herd.

Table 2. Weight gain of young steers run in adult breeder paddocks 1997 – 2001

	Brahman 1	Droughtmaster	Brahman 2	F_1 (½Brahman, ½ Charolais)
Average annual weight gain (1997/98 - 2000/2001) (kg)	133	134	123	128

Genotype in column headings refers to adult breeder herd and NOT the steers.

Translating relative steer weight gains into probable impacts on breeder productivity is not well understood. Table 1 shows that the Droughtmaster herd has consistently outperformed the other herds in terms of weaning rate (83.9%) and breeding efficiency (35.7 kg weaned per 100 kg breeder mated), and the Brahman 1 herd has returned the lowest values for these two performance indicators (75.8% and 31.3 kg, respectively). Table 2, however reveals that grazing conditions in the Droughtmaster paddock have been similar to the Brahman 1 paddock, thus it is reasonable to assume that in pure herds, Droughtmasters show superior productivity to Brahmans under similar conditions.

For crossbred herds, the Brahman 2 herd produced a lower weaning rate than the F_1 herd (80.2% versus 82.1%) but a higher breeding herd efficiency (34.3 kg versus 31.6 kg per 100 kg breeder mated). Data presented in the 1999/2000 Technical Annual Report show a mature weight and consequent stocking rate difference of 15% between Brahmans and F_1's with the F_1's having a higher mature weight and therefore lower stocking rate to achieve similar total mature weight per paddock. Table 1 reveals that even though the stocking rate of the F_1's is 15% lower, weaning rate in only 2% higher and weaning weight is virtually identical. For this reason, the Brahman 2 herd has the highest breeding efficiency of the herds producing crossbred progeny. This has been achieved despite the grazing conditions, as indicated by steer performance, being lowest in the Brahman 2 paddock.

Summarising, pure Droughtmasters have performed best of all herds, closely followed by the Brahman herd producing crossbred progeny. Pure Brahmans have lowest performance indicators and the F_1 herd does not produce sufficient extra weaners of heavier weight to compensate for the lower number of breeders in this herd. Full analysis and reporting of results is a major task for 2001/2002.

PROJECT: Best Bet Breeding Herd

Project Officers: M. Cobiac and N. MacDonald

Location: Victoria River Research Station (VRRS)

Objective:

- ***To refine DPIF recommendations for running breeders on semi-arid native pastures.***
- ***To ensure that these recommendations are sustainable.***
- ***To write up a comprehensive account of the Best Bet system and its results at Kidman Springs.***

Background:

The current Best Bet system was introduced into the Kidman Springs breeder herd in 1990 and resulted in much lower mortalities (12% down to 3%) and higher weaning rates (50% up to 80%) in the following years. These results were maintained until 1995 when the original herd was reduced and incorporated into the breeder genotypes trial. The new herds also run under the management system and have returned similar productivity figures. The main components of the Best Bet management system are tropically adapted breeders run on native pastures at 6-7 head per km^2, receiving year-round N, P, and S mineral supplementation and weaning calves 100 kg or heavier twice a year. Heifers are run separately until they wean a calf, bulls are in the herd continuously at a rate of 5%, and cows are culled for age, poor reproductive performance, and structural or mental unsoundness.

Breeding herd productivity improvements as a result of the Best Bet system result in healthier, bigger cows producing more and heavier calves. This in turn leads to an increase in grazing pressure if stocking rates remain constant (at 6-7 head per km^2.) Unsure whether this increase is sustainable in the long term, 13 pasture monitoring points, on two soil types and at varying distances from water in the Droughtmaster paddock, were established in 1997 and have been measured twice per year since then. Clear results are not expected for some years yet as fluctuations in seasonal conditions from year to year make it difficult in the short term to distinguish true changes in pasture condition from seasonal variation of pasture composition and growth.

Developments during 2000/2001:

During 2000/2001all field-work deadlines were met. Some preliminary analysis of the pasture data collected so far has been done. Pasture condition does not appear to be declining at this early stage of monitoring. Actual carrying capacity of the Droughtmaster paddock will be calculated and compared to a theoretical carrying capacity derived from land unit mapping and models of pasture growth.

PROJECT: Breeding Herd Efficiency on Commercial Stations

Project Officers: M. Cobiac, D. La Fontaine and N. MacDonald

Location: Mt Sanford, Elsey and Rosewood Stations

Objective:

To measure and record the breeding herd efficiency of a number of commercial herds in the district as a guide to current regional productivity.

Background:

There are about 200 000 breeding cows in the Katherine region with average annual weaning rates varying from 65% to over 80%. Sophistication and intensity of management vary greatly between properties. Measuring and recording the current base levels of efficiency in the regional herds will provide both an

overall picture of breeding efficiency under commercial conditions, and allow quantification of improvements in this measure of productivity in the future.

Developments during 1999/2000:

Cattle camp Paddock, Rosewood Station
A herd of about 300 high grade Brahman breeders is run in Cattle Camp paddock and range from maiden heifers to older breeders. Data collection began in July 2001 with initial weight, body condition and pregnancy status of breeders and weight of weaners measured. These data are due to be collected again in November 2001. Regular measurements (three times per year) will be taken from this herd over the next two years. Facilities are good at the station and present management is positive towards the project.

PROJECT: Breeding Herd Efficiency

Project Officer: D. Savage

Location: Alexandria Station, Barkly Tableland

Objective:

To measure and report on the breeding herd efficiency, rangeland conditions, supplementation regime in four herds of Alexandria composite breed cows.

Background:

The experimental cattle were mated in December-March inclusive each year and grazed native pasture on Alexandria Station.

Breeding herd efficiency can be defined as the kg of calf weaned/100 kg cow mated. Improved breeder nutrition (weaning/paddock management/supplementation) is a key contributor to improving breeding herd efficiency.

One or more of the following strategies can achieve improved breeder herd nutrition:

- Lower stocking rates.
- Appropriate supplementation.
- Early weaning (e.g. two weaning rounds per year and weaning calves greater than 100 kg).

No published information is available on current levels of breeding herd efficiency in the Barkly region. Such information is required if a measure of change in this variable is to be calculated as required in the sub-program objective.

This information will provide some insights into herd dynamics and concurrent:

- Rainfall levels and patterns.
- Supplement intake.
- Pasture and faecal characteristics.
- Cow physiological status.
- Weaning pattern, minimum weaning weights and calf weight distribution.

Results:

Table 1. Ranges in average annual animal performance for 1998 to 2001

Herd	Pregnancy % (4 month joining)	Weaning weight (kg)	Age @ wean (days)	Cow weight (kg)	kg calf weaned per cow	kg calf weaned per 100 kg cow
1	89 - 95	191 - 205	162 - 237	415 - 570	145.5 – 166.6	31.7 – 38.4
2	79 - 95	188 - 203	181 - 251	439 - 530	120 - 164	27.3 – 33.6
3	78 - 93	160 - 233	174 - 208	423 - 543	99 – 173.5	23.4 – 31.8

Herd 1 received the Rumevite Cattle block over the Dry season. Herd 2 received Rumevite Maxi-Breed over the Wet season and Fosforlic 45 over the Dry season. Herd 3 received Fosforlic 45 for the first half of the Dry season and Rumevite Cattleblock for the second half of the Dry season.

Figure 1 shows that average condition scores of the herds has ranged between 4.6 and 6.4, and these relatively high values reflect the better than average rainfall that has occurred, as shown in Figure 2.

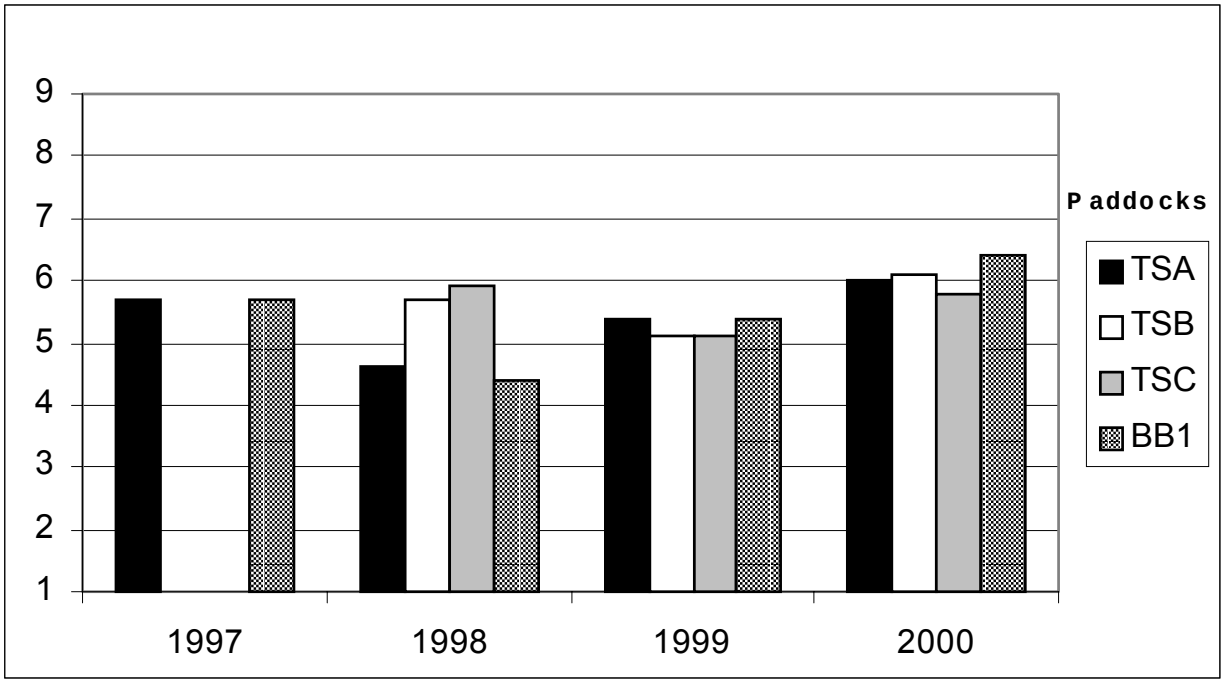


Figure 1. Cow body condition scores

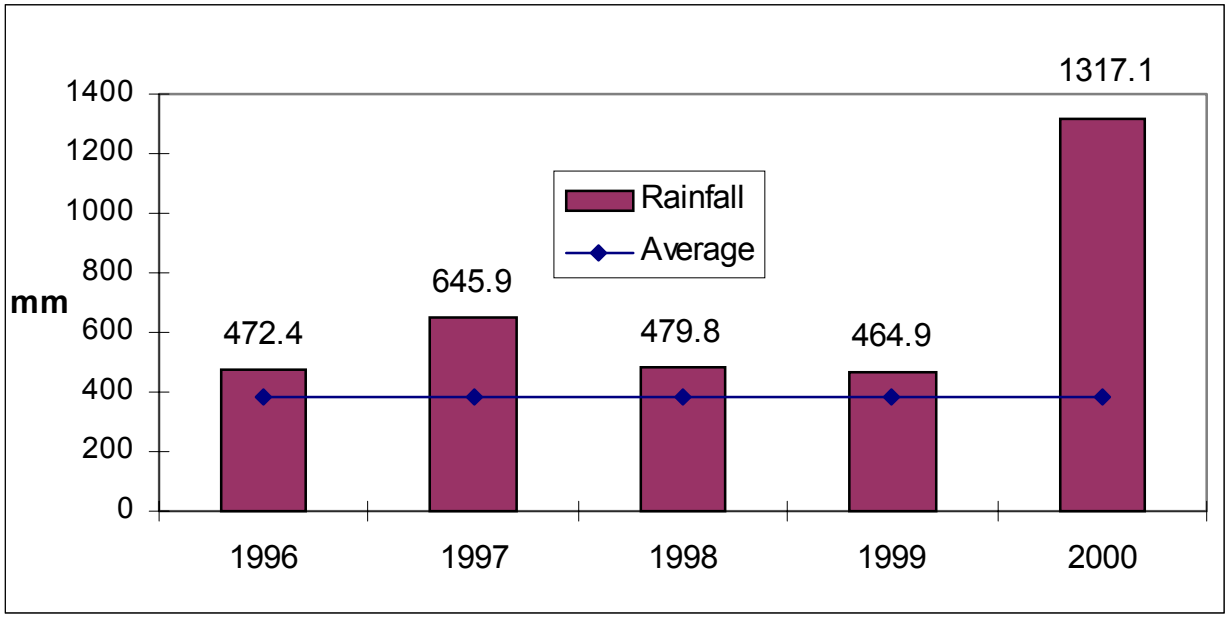


Figure 2. Average rainfall

Composition of lick blocks used

BLOCK NAME	pack wt. kg	Estimated daily intake (grams)	urea %	protein equiv. %	P %	Ca %	S %	Mg %	salt %	molas. %	Cu %	Co %	I %	Zn %	Fe %	Mn %	Se %
Maxibreed	20/100	85 / 150	10.5	30	6	8	0.5	3.5	10	40	0.004	0.0004	0.0004	0.014	0.0102	0.0032	0.0002
Cattleblock	18	150	8	30	4	8	2	0.2	25	0	0.03	0.003	0.003	0.05			
Fosforlic 45	20	85	15.7	40	5	7.5	3	0	48.4	0.5	0.03	0.003	0.003	0.05	0.0051	0.0001	0.00025

The final data collection was completed on August 24, 2001. Statistical analysis of results is underway and scientific papers will be prepared and submitted for publication in early 2002.

PROJECT: Seasonal Calving Study

Project Officers: A. Doust and D. Savage

Location: Avon Downs Station, Barkly Tableland

Objective:

To measure and report on the kilograms of calf weaned per 100 kg of cow mated, the reproductive performance and some associated variables in a group of breeders at Avon Downs Station, Barkly Tableland.

Background:

There is little information on the reproductive performance of breeders on the Barkly Tableland. This project will serve to produce information on current levels of performance and what effect breeder age, month of conception and body reserves may have on the overall level of weight of calf weaned.

The breeder phase of beef production is particularly important in the financial performance of a breeding enterprise, because of its low inherent efficiency (kg calf weaned/100 kg of female inventory). One or more of the following strategies may improve efficiency:

- Appropriate supplementation.
- Appropriate stocking rates.
- Rangeland management.
- Heifer selection.
- Breeder management.

Method:

A herd of approximately 850 Santa Gertrudis breeders is mustered twice yearly. Live weights, condition scores, pregnancy status and lactation status are recorded twice a year.

All weaners are weighed, aged and have their sex noted.

Developments in 2000-2001:

An early Wet season at the end of 2000 prevented the performance of a second round on these breeders.

Results of 2001 first round:

PTIC(%)	63	No. of calves weaned	703
Wet cows(%)	76	Calves branded	177
PTIC and wet(%)	45	Average weaner weight (kg)	258.7
Average cow weight(kg)	508	Minimum weight (kg)	90
Average condition score(1-9)	6	Maximum weight (kg)	450

PROJECT: Austral Downs Indicator Herd

Project Officers: A. Doust and D. Savage

Location: Austral Downs Station, Barkly Tableland

Objective:

To measure and report on breeding herd efficiency (kg calf weaned/100 kg cow mated) in one paddock for three successive years at Austral Downs Station, Barkly Tableland by January 2003).

Background:

No published information is available in the literature on current levels of breeding herd efficiency in the Barkly region. Such information is required if a measure of change in this variable is to be calculated.

Information from this project will provide some insights into herd dynamics and concurrent:

- rainfall levels and patterns;
- pasture and faecal characteristics;
- cow physiological status;
- weaning pattern and calf weight distribution;
- breeder body reserves.

Outcomes/Benefit:

1. Identify specific areas of the production cycle where improvements may be possible.

2. Evaluate and compare the financial contribution of the first and second round weaners.

3. Estimate the financial benefit of reducing calving spread and therefore increasing/decreasing the percentage of the weaning crop weaned at first round.

4. Improve knowledge of pasture condition and the relationship with herd performance and rainfall patterns

Method:

A herd of approximately 850 Santa Gertrudis breeders is mustered twice yearly. Live weights, condition scores, pregnancy status and lactation status are recorded twice a year.

All weaners are weighed, aged and have their sex noted.

Developments in 2000-2001:

An early Wet season at the end of 2000 prevented recording a second round on these breeders.

Because this project is very much in the early stages there is a lack of sufficient data from which trends may be drawn.

The 2000/2001 Wet season recorded the highest rainfall ever. The trial herd has been pregnancy tested, weighed and condition scored. Lactation status was recorded and all calves and weaners were weighed (Table 1). The percentage of pregnant and wet cows has increased from last year (12.8% to 22%). With time we may determine if this result is due to seasonal conditions alone or as a response to other factors such as delayed weaning. It is interesting to note that cow weight has not increased in response to the exceptional seasonal conditions with average weights changing from 497 kg in April 2000 to 491 kg in April 2001. This slight reduction in weight has been associated with a slight increase in average body condition score from 5.5 to 6.2. As a general observation, the condition score is high which is often typical with the seasonal conditions being experienced.

Table 1. Results to date

	As at 15/4/00	**As at 7/4/01**
No. of cows tested for pregnancy	641	656
Average cow weight (kg)	497	491
Average condition score (1 to 9)	5.5	6.2
Pregnant and wet (%)	12.8	22
Pregnant and dry (%)	27.5	23
Non pregnant and wet (%)	50.5	13
Non pregnant and dry (%)	9.2	42
Average calf weight (kg)	108	106
Average weaner weight (kg)	NA	339

PROJECT: Available Soil Phosphorus in the Alice Springs District

Project Officer: C. Hill

Location: Alice Springs District Stations

Objective:

- ***To sample the soil from DLPE land units under cattle grazing in the Alice Springs sub-districts for available soil P levels, by June 30, 2001.***
- ***To categorise the DLPE land units sampled in terms of the following available soil P categories by October 30, 2001.***
- ***To summarise the land units sampled into a broader land classification titled "land types" based on their available soil phosphorous levels for pastoralist use, by April 30, 2002.***
- ***To develop a map of available soil phosphorous categories for the Alice Springs district, by June 30, 2002.***
- ***To promote the use of cost effective and efficient phosphorus supplementation in Central Australia by supplying information on available soil phosphorous levels during the length of the project i.e. till December 30, 2002.***
- ***To produce a booklet for producers titled "A guide to phosphorous supplementation in Central Australia" using the project results by December 30, 2002.***

Table 1. Available soil phosphorus level

Adequate	Marginal	Deficient
> 8 ppm	7-8 ppm	< 6 ppm

Summary of results to date:

In addition to the completed map of the available soil phosphorus levels for Narwietooma Station (pilot study), two other stations have been successfully mapped. These are Amburla Station, north west of Alice Springs, and New Crown Station, in the south-eastern district. Two other stations have been sampled, and will be mapped when the results are complete. These stations are Erldunda and Curtin Springs, both in the south-western district of Central Australia. It is planned that the next property sampled and subsequently mapped will be in the north-eastern district.

There has also been some discussion in regards to extending the project to the Barkly Tableland, with Brunette Downs and Mittiebah Stations being considered first. This will depend on the timetable of Tennant Creek DPIF staff, and weather conditions.

This project did not achieve the original objectives set for June 30, 2001, and will not achieve those set for October 30, 2001. This is a result of changes in staff coordinating the project and exceptional rainfall seasons in the district, impeding soil sampling.

PROJECT: Breeder Herd Performance Recording

Project Officer: C. Hill

Location: Alice Springs District Stations

Objective:

- ***Develop a database of reproductive performance records from commercial breeders in the Alice Springs district by taking "snapshots" as opportunities arise until December 31, 2001.***
- ***Model the Alice Springs district herd on the best available information and produce an "average herd" that producers relate to by June 30, 2001 for use as a focal point in discussions on breeder performance.***
- ***In conjunction with Primelink staff, extend knowledge of management for improved reproductive performance to Alice Springs district producers emphasising the benefits of recording the performance of individual breeders for the duration of the project.***

In conjunction with other Meat and Livestock and Primelink projects, develop management recommendations for producers for improved breeder performance by June 30, 2002

Background:

This project has used records from the earlier project, other Meat and Livestock and Primelink projects and records collected during Primelink Officers' activities of pregnancy testing and spaying. The information obtained is a 'snapshot' of breeders' performance on stations throughout the district. The information is entered into the Access database. The results from the database will provide average herd information from stations to a regional level.

Summary of results to date:

Currently there are 6,735 entries in the database. Current database results are shown in table 1. There has been a reduction in the number of records obtained for this year, chiefly as a result of Primelink staff pregnancy-testing fewer animals. This is partly due to a new private veterinary surgeon in Alice Springs, who now pregnancy tests cattle on sale.

A model for the Alice Springs district herd to use the Breeder Herd Performance Recording database has not yet been achieved yet. It was decided to wait until adequate records (~10,000) were available in the database before modelling starts.

Table 1. Portion of pregnant cows at each condition score and the total number of animals in each group

Condition score	Percentage of wet cows pregnant	Percentage of dry cows pregnant
1	*	*
2	24	54
3	29	67
4	47	75
5	68	87
6	*	*

* Insufficient sample numbers (<20 animals)

PROJECT: Nutrition Laboratory Service

Project Officer: D. Wilson

Location: All NT Districts

Objective:

- ***To provide a nutrition laboratory service to DPIF staff and clients from all NT regions.***
- ***To provide information required for the prediction of the nutritional status of cattle and the pastures they graze.***

Background:

For over 25 years the laboratory has been analysing pastures for nitrogen and phosphorus content and dry matter digestibility and faecal content. These analyses provide information on the nutritional status of cattle and pastures, and have been used in many DPIF projects for evaluation purposes. The majority of samples are received from DPIF staff in Alice Springs, Tennant Creek and Katherine regions. Laboratory results are placed in the Australian Feeds Information Centre (AFIC) database. The Alice Springs AFIC database has the capacity to provide easy to read and access summaries and reports on individual species of plants, individual NT pastoral properties and NT pastoral regions. The AFIC database now contains over 15,000 records.

Table 1 shows the number of samples analysed in 2000/2001 and Table 2 shows the regions from which these samples were collected.

Table 1. Samples analysed in the Alice Springs nutrition laboratory in 2000/2001

2000-2001 Samples	% Pepsin/ cellulase solubilities	% Crude protein	% Nitrogen	% Phosphorus	% Dry matter
Faecal	1,032	656	254	254	254
Pasture	1,032	656	656	504	254
TOTAL			910	758	

Table 2. Regional breakdown of samples received for analysis

Region	Number of samples
Alice Springs	678
Tennant Creek	277
Katherine	398
Darwin	204
Other	5

PROJECT: Cograzing Cattle and Camels for Commercial Production

Project Officers: A. Phillips, C.Hill and G. Crawford

Location: Waite River Station, via Alice Springs

Objective:

- ***To quantify the expected production benefit per unit area of land from co-grazing cattle and camels compared to grazing cattle only.***
- ***To determine the impact camels have on native topfeed species when introduced to a new area.***
- ***To determine the impact camels have on woody weed species when introduced to a new area.***
- ***To estimate the composition and amount of pasture consumed by cattle and camel co-grazing compared to cattle grazing only.***
- ***To increase understanding of practical handling and management issues associated with co-grazing (such as important animal behaviour).***
- ***To develop recommendations for co-grazing cattle and camels for profitable commercial production.***

Background:

This project began in July 1997 and was completed in 2001. The project investigated the differences between grazing cattle only and cograzing cattle and camels in two paddocks on Waite River Station, 250 km north-east of Alice Springs. The project was partially funded by the Rural Industries Research and Development Corporation (RIRDC).

The project had four components:

1. tree and shrub impact monitoring;
2. pasture utilisation monitoring;
3. animal production measurements;
4. camel feeding and behavioural observations;

Summary of findings:

The project and a RIRDC report have been completed, meeting all objectives. Also, a condensed scientific paper has been prepared for presentation at the North Australian Beef Industry Conference in November 2001, to be held in Kununurra. Main results and conclusions are detailed below.

Pasture plants, utilisation and ground cover
During the drought conditions of late 1999, the cograzed paddock had only half the pasture (32 kg/ha) of the DPI (cattle-only) paddock and only 20% of what was available in the control (ungrazed) paddock. However, after rain periods, both treatment paddocks recorded similar yields of 400 – 460 kg/ha in February 2000 and 930 – 940 kg/ha in May 2000.

On all occasions the cograzed paddock had significantly less quantity of total forbs, and that was the only consistent impact attributable to cograzing during the trial. However, there was no consistent impact for any forb species in terms of percentage frequency of occurrence. Camels were suppressing forb production but this did not translate to an impact on the number of plants per unit area during the trial period.

On no occasion did cograzing have any additional impact on perennial or annual pasture grass species, when compared with cattle grazing only, both in terms of quantity available or frequency of occurrence.

Cograzing did lead to a significantly greater number of bare ground plots being recorded during drought conditions, but this ground cover was quickly restored when good rains returned.

Tree and shrub impact, and feeding observations
Tree and shrub cover (Table 1) was largely driven by seasonal conditions. In 1998, good autumn rain and subsequent herbage availability enabled the camels to graze more ground storey species. In 1999, the decrease in canopy cover was a result of cattle browsing on preferred topfeed species during the dry conditions. In 2000, extraordinary herbage availability enabled the camels to predominantly graze forbs. Only minor browsing impact on the trees and shrubs in the cograzed paddock was recorded. From August 2000 to May 2001, canopy cover increased everywhere in response to excellent seasonal conditions.

Table 1. Percentage changes in canopy cover inside the cograzed paddock and comparative transects in the control paddock and paddock with cattle only

Year	Control (%)	Cograzed (%)	Cattle only (%)
1997	+22.4	-15.5	
1998	+4.7	no change	
1999	-9.5	-8.8	
2000	+33	+30	
2001	+9.1	+11.8	+19.4

This project did not demonstrate impacts on vegetation that would be attributable to cograzing, however it did not run long enough to ascertain long term differences. Despite camels being generally perceived as browsing animals, they can preferentially graze forbs when they are available. They also graze fresh grass growth after the first rains following a dry period, until forbs become available. Therefore some dietary overlaps occur between cattle and camels for preferred tree, shrub and herbage species and for grass at certain times.

Cattle and camel production
Steer growth patterns reflected seasonal conditions and were therefore completely different during the first two periods, yet annual weight gain and overall growth rates were very similar (Table 2).

Table 2. Average weight gains (kg) and average daily gains (kg/day) of steers and camels

Period	Species	Average daily gain (kg/day)	Annual weight gains (kg)
Mar 1998 - May 2000	Steers	0.41 – 0.45	150 - 165
Mar 1999 – May 2000	Young bull camels	0.16	64
Aug 2000 – May 2001*	Steers	0.58 – 0.63	145 - 160
	Young bull camels	0.26	109

*This was a period of exceptionally high rainfall.

Average steer weight gains were consistently slightly higher in Muller paddock. Average daily gains of steers were 38 g/day higher between March 1998 and March 1999, 30 g/day higher between March 1999 and April 2000 and 54 g/day higher between August 2000 and May 2001. These differences were not statistically significant during the first two periods, but were significantly different during the final period. This finding is believed to have been due to the combination of excellent seasonal conditions and different land types, rather than any impact from reversing the grazing regimes.

Cograzing with camels was not shown to limit steer performance during the two years in Muller paddock, presumably because they were not in competition for feed resources and did not have any other detrimental interactions. Although steer growth information cannot be directly compared between years because of different seasonal conditions, if cograzing reduced steer growth rates, the maximum possible difference was 10 grams per day.

In 1998 when the camel-breeding herd was in Muller paddock, all camel weights (except calves) fell in autumn when the bull was in rut. Cow and weaner weights recovered three months later. In April 2000 several of the nine young bulls removed from Muller paddock showed signs of rut, and their weights had fallen by an average of 58 kg since January. Rut is thought to have been stimulated by the presence of one camel cow that was injured and not removed from the paddock with the rest of the breeder herd. In May 2001 none of the young bull camels were showing signs of rut. Their average weight gain, and average daily

gain over this eight-month period, is illustrated in Table 2. It seems necessary to avoid rutting behaviour to optimise camel production. Importantly however, camel-rutting behaviour did not affect cattle weight gains.

Cograzing camels with cattle substantially increased the weight of livestock grazed per km^2. In the three periods that camels were cograzed with steers, they accounted for 52%, 28% and 26% of the total livestock weight maintained per km^2 in the cograzed paddocks. Equivalent increases in the cattle stocking rate per km^2 would be expected to cause their production to suffer under most seasonal conditions. Running young bull camels at stocking rates of approximately one camel per km^2 with steers resulted in camel weight gains accounting for 10% (after being affected by rutting behaviour) of the total livestock weight produced per km^2 in 1999/2000 and 16% in 2000/01.

Conclusion:

If markets for camels continue to expand and it becomes economically viable to domesticate significant numbers of camels, this trial has shown that they can be successfully cograzed with cattle. Under careful management, a successful outcome of unchanged cattle production, plus additional camel production could be achieved without negative impact on pasture resources. Cograzing however may increase variable and capital costs somewhat when compared with grazing cattle only.

Cograzing may be even more applicable to the large areas of marginal land in Central Australia (such as spinifex and mulga country) than in the more productive land types used in this trial. The proportional contribution that camels could make to total livestock production would be expected to be higher on land types more marginal for cattle grazing and where there are long distances between water points.

Animal Health

Objective:

To deliver projects to protect and enhance the health and marketability of commercial livestock in the Northern Territory.

This component consists of two sub-programs:

- Livestock Market Access
- TB Freedom Assurance Program

The Livestock Market Access program of the Pastoral Division delivers projects to protect and enhance the health and marketability of Northern Territory livestock and livestock products. The program's projects are reported in the following pages.

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 Northern Territory livestock by investigating disease incidents and through 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 Northern Territory livestock.

The TB Freedom Assurance Program (TFAP) has been funded for five years from 1998 to 2002. The TFAP follows the conclusion of the Brucellosis and Tuberculosis Eradication Campaign (BTEC) at the end of 1997, when Australia was declared a TB free area. The purpose of TFAP is to monitor for five years to confirm the absence of TB and to be able to respond with an eradication program if a TB case is found.

The Division maintains preparedness to deal with outbreaks of animal diseases not normally found in Australia, and carries out surveillance to detect these 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 and also to help protect the community from zoonoses (diseases transmitted from animals to people).

The programs depend on a team of professional and dedicated Stock Inspectors, Veterinary Officers and clerical support staff, and close collaboration with BVL staff.

SUBPROGRAM: Livestock Market Access

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.

The animal welfare committee met for the fifth time since its inception. A major business item has been the national review of caged layer hen housing and the revision of the Poultry Model Code of Practice. Codes of practice under revision or being drafted include those for poultry and cattle, and livestock and poultry at slaughtering establishments, land transport of sheep, goats, ostriches, deer, and destruction or capture, handling and marketing of feral animals. These codes are at various stages of completion and some will be available soon.

The national consultative committee on animal welfare met for the 26th and 27th time in 2000/2001. The following issues are of notable relevance to the NT.

Position Statements: These serve as policy guidelines. Position statements were adopted on *tail docking of dogs* and *the welfare of animals at abattoirs*. The topics under discussion include rodeos, tail docking of cattle, calving induction in dairy cattle, Bobby calves, and export of puppies. This material is available at www.affa.gov.au/docs/animalplanthealth/animal_welfare/nccaw

Livestock Export: Agriculture Fisheries and Forestry Australia (AFFA) is conducting a reconciliation of relevant codes and welfare standards in the live export accreditation program. Some codes are out of date, but there is no support for Livecorp to abandon the process and create their own standards. AFFA is also working to ensure that the recommendations of the independent reference group are implemented.

A live export research and development technical forum was held in Fremantle in June 2001 to discuss progress with Meat and Livestock Australia and Livecorp funded research relevant to the industry. A study of comprehensive on board ship ventilation is likely to result in changes to regulations and ship design for the benefit of animals. A best practice study has captured useful industry knowledge. Other studies on stress, nutrition, mortalities and post delivery management will yield useful results in the future.

AusVetPlan: A review of AusVetPlan was conducted with a focus on the animal welfare suitability of its content. A number of recommendations were made which will lead to an improvement in the welfare of animals involved in an emergency animal disease situation.

National Animal Welfare Strategy: A workshop was conducted to seek endorsement of the components and direction of this strategy.

Other issues within the NT included the following activities. An animal welfare advisory committee was formed under the Animal Welfare Act to advise the Minister for Local Government on relevant issues. DPIF veterinarians and stock inspectors have been gazetted as Officers or Inspectors respectively, under the Animal Welfare Act. The intention is that DPIF employees are primarily responsible for the welfare of livestock.

In relation to the “code of practice for the care of animals for scientific purposes”, steps have been taken within the department to apply the animal welfare approval and reporting requirements of this code. The department continues to supply veterinarians to sit on the NT University animal ethics committee (AEC) and will largely seek to gain approval as required through the AEC. An interdepartmental AEC also operates in Alice Springs. Most departmental activities are considered to conform to normal humane animal husbandry.

The widespread adoption of the Willis Dropped Ovary Technique has led to an improvement in welfare for cattle that are spayed. A lay spayer accreditation process has been developed.

Policy in relation to the long distance transport of horses was approved and is in use.

All reported animal welfare incidents were investigated. Investigations were made on starving, injured and perishing stock.

PROJECT: Certification

Project Officers: Regional Stock Inspectors and Veterinary Officers

Location: NT Wide

Objective:

- ***Provide property and animal certification for export, interstate and intrastate movements.***
- ***Facilitate interstate 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 the spread of cattle tick from the NT cattle tick restricted area to tick-free areas within the NT and interstate.***
- ***Prevent entry of cattle tick from interstate, particularly acaricide resistant strains, from Queensland***
- ***Prevent the entry of Johne's disease and tuberculosis from interstate.***

Governments, in consultation with industry and consumers, prescribe 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 some industry self-regulation. While market assurance and quality assurance programs have been developed and will continue, there is an industry and consumer expectation that governments have a responsibility to protect the community from health risks and the spread of disease to animals. This applies within the NT (e.g. cattle ticks) and to national and international markets (e.g. bovine tuberculosis and other diseases).

A service is provided to NT producers to facilitate trade by certification, inspection and treatment of stock, if required. Control programs (such as cattle tick) may also be implemented. Mobile spray plants and chemicals are provided for spraying horses for movement.

There is continual review of stock movement controls and area declarations in consultation with State governments and industry associations.

Stock from the tick infected area require clean inspection and treatment to pass into or through the NT tick free area 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 instead of dipping

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. An associated project to improve the reporting and retrieval of disease data for this purpose is the Animal Health Information System. Planned active surveillance programs complement passive surveillance disease monitoring.

Some export protocols require treatment of animals prior to export. Departmental staff provide this service if authorised private veterinarians are not available.

Activity:

There were 322 property of origin health certifications provided for the export of 201,566 cattle from NT properties.

The spread of cattle tick was prevented. There were no outbreaks of cattle tick within tick free areas.

Table 1. Summary of activity 2000/2001 by region

Activity - number of head (number of visits)	**Darwin**	**Katherine**	**Tennant Creek**	**Alice Springs**	**Total**
Cattle inspected and treated for cattle tick	10,130 (40)	3,153 (16)	26,382 (79)	0 (0)	39,665 (135)
Horses inspected and treated for cattle tick	542 (81)	469 (95)	249 (24)	0 (0)	1,260 (200)
Cattle inspected at saleyards	0 (0)	1,625 (3)	0	34,292 (68)	35,917 (71)
Cattle moved interstate from tick free areas (number of certificates issued)	n/a	n/a	87,431 (182 faxes)	20,320 (149 faxes)	107,751 (331)
Cattle inspected for movement to Western Australia	338 (2)	8,374 (27)	18,096 (16)	286 (2)	27,094 (47)

PROJECT: Chemical Residues in Animal Products

Project Officer: A. Brown

Location: NT Wide

Objective:

- ***To present chemical residue-free animal products to the consumer, and protect and maintain the NT meat and milk markets.***
- ***To provide an advisory service on chemical residue issues to industry, government and the public.***
- ***To 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 are no properties under quarantine.

This program has four components:

1. National residue survey (NRS).
2. Beef organochlorines, organophosphates and synthetic pyrethroid residues.
3. Hormonal growth promotant (HGP).
4. National antibacterial residues minimisation program (NARM).

NRS
The NRS is a random sample survey to monitor residues in Australia's agricultural food commodities and has been operating to some extent since the 1960's.

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 2000/2001, DPIF signed an agreement with the NRS to follow-up tracebacks greater than the maximum residue limit (MRL) and take appropriate action.

During 2000/2001, 104 samples were collected from NT stock, primarily through abattoirs. There were 68 cattle, 10 buffalo and 10 camel samples analysed with no detection greater than the MRL/MPC from an NT property. There were no detections of antimicrobials, organochlorines or organophosphates.

Beef organochlorines, organophosphates and synthetic pyrethroids
The main issue for the NT continues to be the interval between the last treatment with cattle tick and buffalo fly treatments and slaughter to satisfy the 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 tick and buffalo fly.

HGPs
Many markets, both domestic and export, 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 usage are underpinned by the *Control of Hormonal Growth Promotants (Stock Act*) (Northern Territory). 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. In the NT, 76 properties purchased 254,450 doses of HGPs last year, twice as much as in the previous 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 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. There is currently only one NT property that is EU accredited. However many others are interested.

The NLIS describes the use of permanent devices containing electronic transponders from which individual identification can be read electronically. Approved devices may be rumen pellets or eartags applied at weaning which then will remain with that animal for life.

Three audits were completed during the year as required under the national HGPs audit program (two users, one EU accredited property). The NRS reimburses the States for this activity at $380/audit.

During the year, use of pink tags with the logotype "HGP Free" was 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. AQIS now uses the pink tag 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 NT. Another initiative by AFFA is the targeted antibiotic residue testing program (TART). This allows AQIS officers in abattoirs to select high-risk animals for sampling for antibiotic residues.

PROJECT: Crocodile Farming

Project Officers: J. Millan and V. Simlesa

Location: Darwin and Katherine regions

Objective:

To provide a regulatory service to crocodile farms in the Northern Territory.

In order to carry out regulatory duties under the *Territory Parks and Wildlife Conservation Act* on crocodile farms in the NT, four DPIF 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 Parks and Wildlife Commission of the NT.
- 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 permits involving farmed crocodile products produced in 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
DPIF is responsible for all regulatory duties associated with the crocodile industry in the NT.

The technical officer gave crocodile industry talks to Rural Women in Agriculture and the Rotary Club of Darwin.

The Australian Nuclear Science and Technology Organisation (ANSTO), DPIF and Wildlife Management International (WMI) carried out a joint research project on lead shot testing in crocodiles.

Live crocodile displays were organised for the DPIF exhibit at Parliament House for the new Administrator and at the DDRF Open Day.

A tour of a commercial crocodile farm and product display was organised for two international groups - Indonesian delegates from the Australia Indonesia Development Area (AIDA) and for the QUADS delegation.

Improvements and repairs to the crocodile research pens were completed. QDPI hosted a half-day seminar in Darwin to present results from RIRDC crocodile research. WMI presented results from NT research. The seminar was well attended by NT crocodile farmers and DPIF officers. A total of 129 NT movement permits were issued, 32 of which were for export. This represents an increase of six permits compared to last year.

A total of 6,564 *Crocodylus porosus* belly skins were exported. A total of 20 skin shipments were inspected and 18 health certificates issued. A total of 2,417 *Crocodylus porosus* belly skins were sold within the domestic market.

A total of 12 disease investigations were carried out between July 2000 and June 2001. Over half the cases were sudden mortalities in hatchlings due to bacterial septicaemias; two were chronic bacterial infections in adult animals; and two were skin lesions (dermatophilosis in yearlings and fungal in hatchlings). In addition there were 13 submissions for the ANSTO research.

PROJECT: Disease Surveillance

Project Officers: D. Pinch, Veterinary Officers and Stock Inspectors

Location: NT Wide

Objective:

- ***Provide credible disease surveillance information to support the sale of livestock and livestock products***
- ***Investigate the occurrence of diseases in Northern Territory livestock***
- ***Participate in national animal health surveillance programs.***

There are several areas of activity that contribute to the successful implementation of this project, and they are discussed separately below. Disease surveillance encompasses:

- the collection of animal health data during disease investigations initiated by the producer (passive surveillance);
- planned surveys to target a specific disease (active surveillance);
- providing NT information as part of national programs to enhance Australia's trading status;
- maintaining a secure and reliable computer system to store and retrieve the data; and
- communication of results to relevant parties.

Hydatid survey
DPIF carried out a survey in 2000 to gather information that would determine if hydatid cyst infection, caused by the tapeworm *Echinococcus granulosus*, occurred in NT-bred cattle. The information can be used to substantiate claims of hydatid cyst freedom in NT cattle for trading purposes.

The prevalence of hydatid cysts in the NT has been reported as low. Surveys conducted over 30 years ago in abattoirs reported no evidence in cattle or pigs slaughtered in Darwin and an incidence of 2% in Alice Springs. No surveys have been conducted since then in the NT. Submissions over the past few years to Berrimah Veterinary Laboratories (BVL) have identified hydatid cysts in livers from cattle. Although these have been traced back to animals bred outside the NT, this survey was conducted to confirm that a cycle had not established involving NT-bred cattle. No surveillance has been conducted in the NT for the presence of *E. granulosus* adults in dingoes or dogs, or for the hydatid cysts in wallabies/kangaroos.

As a first step in confirming that *E. granulosus* does not cycle in the NT, surveillance of cystic lesions in cattle killed at the abattoir in Katherine was conducted between June and September 2000. All cyst-like lesions in the liver and lungs of cattle were collected and submitted to BVL for microscopic and histological examination to determine whether they were hydatid cysts. Records of the property of breeding for the cattle examined were an integral component of the survey, and brand details for each animal were recorded as they entered the killing area.

A total of 4,348 animals were examined, 84% of which were NT-bred. The remaining animals were from Queensland or had brands that could not be read. The cattle came from 62 properties, mainly in the northern half of the NT.

As expected, the survey found hydatid cysts in cattle imported from Queensland. The prevalence in Queensland-bred animals was 5%. Out of over 3,500 NT-bred animals, only one was linked to a hydatid cyst. Due to sampling problems on the day that cyst was collected, it cannot be confirmed that the cyst came from an NT-bred animal. Follow up work will be conducted to confirm if this is a sampling error. Even if this cyst was from an NT-bred animal, the prevalence would only be 0.03%, which provides strong evidence to support the lack of an established *E. granulosus* life cycle in the NT.

Johne's disease zoning
The veterinary committee introduced formal zoning for bovine and ovine Johne's disease (JD) to Australia on 1 August 1999. There are four zones for both bovine and ovine JD: free, protected, control and residual. The NT 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 veterinary committee. During 2001 the NT will be conducting surveillance on properties that have imported cattle from control zones. This surveillance involves testing blood from the imported cattle and from up to 100 in contact cattle.

National animal health information system (NAHIS)
NAHIS is a surveillance program coordinated by Animal Health Australia that has input from the State/NT governments and the Commonwealth. 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 with regard to animal disease surveillance and control.

A quarterly report is provided to NAHIS on NT animal health status, specific testing carried out at BVL and significant animal disease events. Similar reports from all the agriculture/primary industry departments, as well as information from AQIS, NAQS, 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 recipients, including livestock industry groups. There is also information about NAHIS on the Animal Health in Australia Internet site at www.aahc.com.au/nahis/index.htm.

National Newcastle disease virus survey
This survey was specifically designed to obtain information on the type, prevalence and distribution of Newcastle disease viruses (NDV) in Australian poultry flocks. It also aimed to determine the seroprevalence of NDV positive flocks across the Australian commercial poultry industry and to identify possible risk factors for exposure to NDV on Australian poultry farms.

Serum samples were collected from commercial poultry farms in the Darwin region during the first half of 2000, and submitted for haemagglutination inhibition testing for NDV. Farms with positive serology results were also sampled for virus isolation. Results were released at the conclusion of the national survey. In the NT, serological evidence of NDV was found on two properties. No virus was isolated from either.

National transmissible spongiform encephalopathy surveillance program (NTSESP)
Australia is presently free of bovine spongiform encephalopathy (BSE) and scrapie. However the OIE International Animal Health Code requires that countries claiming to be free of transmissible spongiform encephalopathies (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. The 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.

Office International des Epizooties (OIE) guidelines have been used to determine the 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 needs to examine has been calculated according to its cattle or sheep population.

There should be 24 cattle cases examined from the NT annually (and no sheep).

The program operates on the calendar year. The NT achieved 27 submissions from cattle that were negative for TSE in 2000. Samples were collected by government veterinary officers, stock inspectors or at the abattoir. Some of the diagnoses for the animals sampled were zamia plant poisoning, bovine ephemeral fever, encephalitis and septicaemia.

Central Australia animal health network (CAAHN)
Officers attended a meeting on Central Australia disease surveillance in which government veterinarians from western NSW, southwestern Queensland, northern SA and southern NT agreed to communicate on joint issues through CAAHN. Australia has unique issues with respect to isolation, resources required for surveillance and the absence of private services. CAAHN is for government and private veterinarians, stock inspectors, graziers and pastoral companies. An e-mail discussion list has been set up to encourage

communication about disease incidence and control in Central Australia. To join the list, go to http://lists.dpi.qld.gov.au/central-aus-animal-health-net.html

Animal health news from the Northern Territory (AHNNT)
The quarterly publication of this newsletter by staff in BVL and the Livestock Market Access subprogram 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 cover topical animal disease events, animal health surveillance news, information from BVL and other items. Articles are received from laboratory and field staff, in southern and northern regions.

Issues 18 to 21 of the newsletter were produced during 2000/2001, with about 180 copies distributed each quarter. The newsletter is also available from the DPIF Intranet site and the DPIF Internet site www.nt.gov.au/dpif/news_events/ahnnt.shtml

NT animal health information system (NT ANDI)
ANDI is a mainframe database that is accurate and reliable for storing animal health information. NT ANDI is used by both laboratory and field animal health staff for storing and retrieving investigation details and results. Quantitative data for the NT report to NAHIS are extracted from NT ANDI and significant disease event entries are also identified with it.

It is used to record and report details and results on all submissions to BVL from a wide variety of clients such as other DPIF staff in animal production, agriculture, and fisheries, private veterinary clinics and the public.

The system is being reviewed during 2001, as it is almost ten years old, and options other than the mainframe will be explored.

Passive surveillance
Investigation by field veterinary officers and stock inspectors of disease events in livestock, reported by producers, achieves two objectives. Provision of a diagnostic service by veterinary officers and stock inspectors for sick animals assists producers to treat, prevent and control disease in their animals, and thereby enhances profitability. Providing this service also enables passive surveillance for both exotic and endemic livestock diseases to be documented. 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 NT. Advice to property owners is provided on request or following a disease investigation.

Advice may be offered over the phone, or otherwise a property visit is conducted to investigate the history, conduct clinical examinations of stock, and to perform post mortems and collect samples. Following assessment of the property visit, and the results of laboratory findings, producers are advised of the outcome, and control measures are discussed. For the purpose of this project, NT livestock are regarded as cattle, buffalo, working horses, camels, goats, crocodiles, pigs and poultry.

Endemic disease
The number of investigations by region for the July 2000 to June 2001 period is shown below. These figures are for investigations carried out by field veterinary officers and stock inspectors, usually through visits to properties or advice over the phone. The number of investigations is a rough estimate of activity. This is because an investigation can range from a phone call, to examining one animal, to examining and sampling many animals.

	Darwin	Katherine	Tennant Creek	Alice Springs	Total
Bird	1	-	-	1	*2*
Buffalo	3	-	-	-	*3*
Cat	2	-	-	-	*2*
Camel	-	-	-	17	*17*
Cattle	**16**	**36**	**17**	**9**	***77***
Crocodile	13	-	-	-	*13*
Dog	-	1	1	1	*3*
Goat	15	3	-	1	*19*
Horse	6	13	8	-	*27*
Insect	10	1	-	-	*11*
Pig	29	1	-	-	*30*
Poultry	8	-	1	-	*9*
Sheep	-	-	2	-	*2*
Tortoise	-	1	-	-	*1*
Total	**102**	**56**	**29**	**29**	***216***

The 77 cattle investigations were done on 46 properties, and include sampling for the national transmissible spongiform encephalopathy surveillance program. These figures indicate an increase in the number of cattle investigations. The 'insect' investigations in the Darwin region have decreased from last year, but are still important due to sampling of cattle ticks for acaricide resistance testing. There were more investigations on camels, goats and pigs than last year, but fewer for horses and poultry, and about the same number for crocodiles. The total number of investigations has increased from the past three years (182 in 1999/2000, 154 in 1998/99 and 167 in 1997/98).

Diagnostic highlights
Tennant Creek and Alice Springs regions

Birdsville disease: Samples were taken from station horses, some of which had suffered chronic weight loss, and some had died. Multiple factors contributed to these losses, including Birdsville disease, *Crotalaria* spp poisoning, grass seed mouth ulcers and bad teeth. Birdsville disease in horses was also observed at another station. The good season has caused *Indigophera* spp, which cause Birdsville disease to flourish across the region this year.

Camel worms: *Trichuris* sp infestation continues to be a problem in intensively managed camels around Alice Springs. The copraphagic behaviour of camels predisposes to worm burdens when intensively housed, compared with existing relatively worm-free extensive rangeland conditions. Monitoring of worm burdens under various treatment regimes has been undertaken.

Hypothermia: In late October 2000 approximately 240 head of stock died on six large Barkly Tableland properties. Two-year-old steers and heifers were found huddled together after rain and severe cold conditions. No stock was subsequently lost, and it is assumed stock died from hypothermia and exposure, during a cold snap.

Calf losses: First calf heifers were sampled on a Barkly Tableland property in which the herd had lost 25% of its calves since positive pregnancy diagnosis. Losses probably occurred 7 - 12 months earlier, and so it was difficult to identify causes. An observational study is planned in 2001-2002 to identify causes of losses in Barkly Tableland joiner herds.

Strangles: Officers investigated an outbreak of strangles in 50 horses agisted at Blatherskite Park in Alice Springs in late November 2000. Samples collected by private veterinarians confirmed the infection by culture at BVL. The condition affected 14 horses and caused concern among many horse owners and organisations.

Critical to the successful control of the outbreak were restrictions imposed by Park management and the Race Club and widespread vaccination. DPIF provided advice and media releases.

Three-day sickness: Calf losses on a northern Barkly Tablelands property were investigated. The manager observed most of the losses around bores during an outbreak of three- day sickness in mature breeders a month before. During the two days of the investigation, four animals were sampled but only two showed symptoms of the problem. One fresh stillborn calf was sampled for known abortive agents, but cultures were negative.

Meliodosis: A long time resident of the Tennant Creek community became infected with *Burkholderia pseudomallei* in March, and subsequently died in Royal Darwin Hospital. The patient had not been near the Top End for 12 months. Despite all animal and soil tests from his property failing to isolate the organism, health authorities believed the person contracted the infection in Tennant Creek over the exceptionally Wet season. There are other medical references suggesting that melioidosis can become a risk in Central Australia during abnormally wet conditions.

Orbivirus survey: Blood samples were collected from 32 Alice Springs horses and 15 Tennant Creek horses for the orbivirus survey. One aged horse from an Alice Springs station was positive for orbivirus antibody, and had spent 17 years on the property after coming from South Australia.

Egg farm: Officers were requested to investigate the health of hens at the Tennant Creek Egg Farm after a mortality problem some weeks earlier. Lice continue to be a major problem and the lice management program is ineffective. Flooding is also a problem. A report was forwarded with recommendations.

Murray valley encephalitis: Both the Alice Springs and Tennant Creek sentinel poultry flocks seroconverted to Murray valley encephalitis and Kunjin virus during the late Wet season. Widespread public health warnings by Territory Health Services were issued.

Cattle worms: Poor growth in young steers on an Alice Springs station was investigated. Evidence of internal worm burdens indicated that this could have been a factor over the Wet season. Exposure to botulism may also have been a factor in causing weight loss, as serology showed exposure to the toxin.

Pestivirus: A single Brahman heifer weaner on a Barkly Tableland property had high fever, profuse salivation, nasal and ocular discharge, dark scours and was anaemic. The case was investigated and diagnosed as mucosal disease, which is caused by a pestivirus. Cases of clinical pestivirus are rarely seen on extensive pastoral properties, although the disease is endemic, with up to 90% of adult cattle having antibody.

Cattle losses from unknown causes: Three Alice Springs properties reported losses in some herds of up to 15%, for which the cause could not be identified. Prompt attendance has been difficult at times with depleted resources in the regions. Causes were likely to be poisonous plants or bovine ephemeral fever. One property lost 25 of 70 cows sent to South Australia. A private veterinarian investigated losses on the destination property, but the cause remains unknown.

Four out of 400 weaner heifers died suddenly in yards at a Barkly Tablelands property whilst being worked. The stockman described the syndrome as sudden collapse. Unfortunately, no field investigation occurred and so diagnosis is speculative. All heifers had been recently dehorned, and so clostridial infection was a likely cause.

Two cows suddenly went down at an Alice Springs station, similar to other losses over the previous six weeks in introduced cattle. Necropsy on one failed to identify a cause, however bovine ephemeral fever or weir vine poisoning is likely. The remaining 200 cows were trucked to New South Wales with no problem arising.

Katherine region

Tail rot: Investigations into this condition of Brahman cattle continued. There appears to be a widespread prevalence of about 1% of adult cattle in most herds in northern ranges. There may be an association between the presence of eucalypt trees and the disease. The favoured theory at present is the ingestion of a plant toxin, probably in the Wet season, which causes damage resulting in compromised healing of the lesion. There are known examples for cattle of this type of pathological process elsewhere.

Equine encephalitis virus: Cases of encephalitis continue to occur sporadically throughout the hotter months. Characterisation work on the orbivirus V4834 is continuing. Collections of equine sera are being made to help establish the potential distribution of the virus. The virus is thought to be spread by biting insects. Recently a virus has been cultured from a case of 'dumb-form' encephalitis in the Dry season. This virus may be different from V4834.

Chronic salt toxicity: Cattle on well grassed downs country were seen to be performing poorly and occasionally recumbent or dying. Closer investigation revealed that the problem was mostly in lactating cows in the hotter months. Post mortems failed to detect an obvious cause except for reduced fibre and water intake. Analysis of the water confirmed a high salt content at the upper limits for stock water. Corrective action was undertaken.

Blue green algae: Up to 10% of breeders may have died in an extreme case of toxicity in the build-up season. The paddock contained numerous stagnant water holes in various creeks, that would usually have dried up by mid year. Cattle were observed to have died in many locations, with no apparent focus. The deaths were rapid and sometimes in family groups. Clinical cases that were consistent with an encephalopathy were observed immediately after the muster. Post mortem studies confirmed severe liver dysfunction and ruled out other likely causes of staggers and death. The most likely cause is blue-green algae blooms on stagnant water. Despite extensive surveys, the offending algae or any other likely poisonous plant could not be identified.

Strangles: Outbreaks of strangles continued in unvaccinated horses on several properties in the region. Equine herpes virus (EHV1) was also present throughout the region.

Weaner scours: Ill thrift in a group of weaners was investigated, and found to be due to a multi-factorial aetiology (endoparasites, ticks, anaplasmosis and coccidiosis). *Salmonella seftenberg* (z43 phase) was isolated from a weaner that died suddenly. Another station close by reported a similar problem with weaners, although no anaplasma organisms were detected there.

Bovine ephemeral fever: Outbreaks were reported throughout the Katherine region. The virus was isolated from a case at a property near Katherine.

Propionibacterium isolated: A probable *Propionibacterium* sp was isolated from a cow undergoing a subacute infectious process (submitted under the National Transmissible Spongiform Encephalopathy Surveillance Program). The cow was recumbent and unable to stand. It was severely depressed and had a high fever.

Darwin region

Strangles: Strangles was confirmed on four properties in the Darwin region. These included station horses on a pastoral lease, a mob of bucking horses used for rodeo events, and several individual cases in suburban Darwin and the rural area. The cases caused considerable public interest around the time of the Darwin Cup Carnival when the Darwin Turf Club imposed a quarantine on the race track stables to protect horses held there. The outbreak stimulated many horse owners to consider preventative vaccination programs. There was one death, suspected to be caused by strangles.

Bluetongue: Bluetongue virus Type 16 was isolated from sheep at Adelaide River, where 16 Wiltshire horn sheep had been introduced from southern Australia. Virus was isolated from three of the four sheep that died. Out of the remaining 12 sheep, 11 seroconverted to bluetongue virus. The breed susceptibility and the stress associated with moving to the tropics during the peak of the Wet season are thought to have contributed to the expression of clinical disease.

Meliodosis: During the Wet season there were several mortalities and clinical cases due to melioidosis in the Darwin rural area. Pigs and goats were affected. Staff from The Menzies School of Health Research visited two of the properties (one with pigs and one with goats) to obtain water and soil samples as part of a melioidosis research project.

New blood parasite: *Eperythrozoon suis*, a rickettsia that adheres to the outer membrane of red blood cells, was suspected in two piggeries. Pigs exhibited clinical signs consistent with eperythrozoonosis including anaemia, fever and jaundice. Other *Eperythrozoon* species occur in Australia, but *E. suis* has never been recognised here before. Eperythrozoonosis in pigs is reportedly widespread in other countries.

Blood samples were sent to the Australian Animal Health Laboratory for electron microscopy, which confirmed that the organisms were consistent with *E. suis*. Serological testing developed at BVL is being used to determine how widespread the infection is, and the possible duration of infection. Funding has been obtained to develop a PCR test to determine the identity of the organisms.

PROJECT: Emergency Animal Disease Preparedness

Project Officers: J. Millan and Pastoral Division staff

Location: NT wide

Objective:

- ***To participate in contingency planning and training for emergency animal disease preparedness.***
- ***To ensure that DPIF staff, relevant organisations and pastoralists have a continuing high level of awareness in relation to the threat of exotic diseases.***

The NT continues to send veterinary officers to exotic disease courses at the Australian Animal Health Laboratory (AAHL).

'Protect Australian Livestock' week ran nationally from 25 to 31 March 2001. There was no increase in calls to the emergency animal disease hotline during that time.

As part of the national emergency animal disease preparedness (EADP) training program a veterinary officer attended a controllers' workshop.

NT officers attended an emergency animal disease workshop in Cloncurry. A foot and mouth disease (FMD) workshop was held in Darwin involving relevant departments and organisations. The outcome was an NT operational plan for FMD.

Two veterinary officers and two stock inspectors obtained experience by assisting in the UK FMD outbreak. They were posted to northern England, assisting in the eradication program. Their participation was extremely useful in gaining experience with diagnosis, slaughter and disposal methods of livestock and also in the operation of local disease control centres. The outbreak in the UK created a lot of local community and industry interest. As a result there has been increased promotion of FMD awareness through newsletters, media interviews and presentations at NTCA, DPIF, the regions and the DDRF Open Day.

The EADP competency standards and assessment methods for the various tasks within an emergency animal disease response are on the DPIF Intranet site.

PROJECT: Honeybee Industry

Project Officers: K. de Witte, V Simlesa and staff

Location: NT Wide

Objective:

Provide technical advice, disease investigation and regulatory services to the honeybee industry.

There is concern over the introduction of exotic bees and parasitic mites following 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) has been established to detect the presence of 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 greatest distribution and *V. destructor* is of the most threat. The NSHP includes both hives and pheromone traps. The European honeybee hives were established at Darwin port, East Arm port and the port in Gove. The hives have been donated and will be 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 treated by the Bayvarol strip. Sticky boards are submitted to the Entomology Section after 24 hours for identification of possible mites.

The pheromone traps have been established to monitor for the presence of the Asian honeybee. The trap has a pheromone lure attached inside a hollow log of a palm tree. 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 pheromone lures are placed inside the hollow palm log with a small access hole on the side. Each month the pheromone lures are replaced and at this time the presence of any honeybees is recorded and if any are present, they are sampled. There are five traps established in the Darwin region with plans to establish traps in Gove. Pheromone lures are obtained through CSIRO.

Sample collection was coordinated for an RIRDC honey quality-monitoring project.

The apiary officer attended the Northern Territory Bee Keepers' Association annual general meeting in Katherine, and a quarantine awareness and contingency planning seminar for the *varroa* mite in Canberra.

PROJECT: Legislation

Project Officers: B. Radunz, project leaders and Parliamentary counsel

Location: NT wide

Objective:

- ***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.

Notices by the Minister or the Chief Inspector of Stock are prepared to prevent the spread of disease and to provide the necessary legislative powers to enforce required stock movements within the Northern Territory or for importation of stock into the Northern Territory.

There is a compliance 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
Drafting instructions were prepared during 1999 for a draft Bill during 2000. A draft Bill was provided in January 2001. Further review and amendments were made during 2001. Consultation and the National Competition Policy review will be done and the Bill will be introduced to the Legislative Assembly during 2001.

Notices were gazetted relating to Johne's disease for the importation of stock. Bluetongue disease, revised disease control programs for TB and Johne's disease were declared as prescribed diseases. Amendments to the Stock Regulations were completed relating to cross branding, layer hen housing and ruminant feeding bans.

Compliance Program
Audits completed:

a) Health certificates and waybills

	Darwin	Katherine	Tennant Creek	Alice Springs
Abattoir	2	15	n/a	n/a
Export depots	30	2	0	0
Saleyard	1	2	0	50
Horse events	1			

b) Compliance with tick notice

	Darwin	Katherine	Tennant Creek	Alice Springs
Shows, races or camp drafts	1	1	5	0

There were no cases of non-compliance detected during the audits. However there was one case of non-compliance regarding the cattle tick notice, which was investigated

PROJECT: Livestock Identification

Project Officers: K. Small and N. Hamilton

Location: NT Wide

Objective:

- ***Ensure that the national livestock identification scheme (NLIS) can provide a consistent traceback 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 (RFID) contained in a rumen bolus or an ear tag has been adopted by the 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 traceback 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 a property identification code (PIC). The updated pastoral database is now fully operational. The database stores all cattle property details including livestock numbers, property owner and manager details. Regional staff have access to the pastoral database with the distribution of an updated compact disc.

Some states are supporting mandatory implementation of the NLIS RFID identification for cattle and sheep. The proposal is supported by SAFEMEAT. The adoption of NLIS is being promoted as necessary for emergency disease management. The NT system of waybills, PIC's and brands provides more useful data than the NLIS database for tracing purposes in a foot and mouth disease (FMD) outbreak. The NT continues to support the voluntary implementation of the NLIS RFID identification by the cattle industry. The sheep industry has proposed a system using property of birth eartags, vendor declarations and waybills to enhance traceability of sheep. The lack of any tracing system for sheep would be a very real threat to successful management of an FMD outbreak at the present time.

Brands
The updated Brands Regulations reached the final draft stage. No changes to the *Brands Act* will be made until the new Stock Bill is produced.

Stock inspectors carried out a brands audit across the NT in order to maintain the accuracy of the Brands Register and to ensure compliance with the legislation. The Brands Directory is regularly updated and available for public purchase.

PROJECT: Meat Industries

Project Officers: S. Sell and R. McFarlane

Location: NT wide

Objective:

To ensure compliance with national standards for all sectors of the NT meat industry.

DPIF is the government authority responsible for regulating the meat industry in the Northern Territory, from slaughter through to processing and storage for wholesale.

DPIF licenses and regulates:

- abattoirs that slaughter all types of animals, including poultry and crocodiles;
- wholesale meat processing, including the manufacture of smallgoods;
- game meat slaughter;
- game meat processing;
- pet meat slaughter.
- pet meat processing;
- cold stores (domestic meat storage).

Territory Health Services (THS) regulates meat retail outlets.

The official regulatory role of DPIF for the meat industry in the NT is provided in the *NT Meat Industries Act* 1996 and the *NT Meat Industries Regulations*.

The *Meat Industries Act* requires licensed domestic abattoirs, wholesale meat processors, game meat processors and game meat field harvesters to operate within the relevant Australian meat standards (AMS).

The AMS mandate changes from the historical meat industry compliance method of on-line government inspection to a system of company self regulation via government approved and audited quality assurance programs.

Activities:

The transition from on-line government inspection to quality assurance programs has required much DPIF input but is progressing well, with only one abattoir yet to attain quality assurance approval.

The greatest change during the past 12 months has been the licensing of a further five wholesale meat processors, increasing the number from two to seven in the NT.

The five new licensees are all existing meat businesses that were previously unaware of the AMS and all require assistance with quality assurance.

AQIS has issued a number of exemptions to the *Export Control Act* allowing domestic meat from NT licensed abattoirs and processors to be exported to East Timor, Indonesia and Brunei. This meat requires NT health certification by DPIF.

Progress Report:

Meat industry licences issued:

- 13 abattoir;
- seven wholesale processors;
- two pet meat processors;
- 10 pet meat slaughter;
- eight game meat slaughter.

Abattoir details:

- eight red meat (one export, seven domestic);
- four crocodile (two export, two domestic);
- one poultry (domestic);
- Barkly and Consolidated have not opened for a 2001 slaughter season;
- Tenarra is a domestic abattoir, which is operating under an exemption to the *Export Control Act* allowing export of domestic meat to Indonesia and Brunei.

Wholesale processor details:

- four independent boning and packing operations;
- three smallgoods manufacturers.

Meat inspection
On April 5, 2000, Minister Palmer signed the following proposal:

From 1 July 2002, "only abattoirs operating under approved HACCP based QA programs and employing qualified meat inspectors, be issued with an NT abattoir license".

As a result, all remote abattoirs (slaughterhouses) have been notified of the requirement for a qualified meat inspector on each plant from July 1, 2002. The larger town-based abattoirs were given immediate notice and have subsequently had government inspection services removed/replaced by company inspectors.

Game meat
There is one game meat field depot currently operating in the NT. This depot is operated by a person with an NT licence for the slaughter of game animals, in conjunction with an export game meat abattoir in Queensland and is not open to the public.

PROJECT: Monitoring Cattle Dip Strength

Project Officers: K. Small and Regional staff

Location: NT Wide

Objective:

- ***Ensure government and private dipping facilities are run at correct strength.***
- ***Provide an advisory service on correct dip chemical usage, plunge dip management and choice of acaricide.***
- ***Provide a dip analysis service.***

There is minimal use of acaricides except for movement treatments due to the increasing proportion of Brahman content in the breeding herd in the tick endemic areas.

The project involves provision of dip sample bottles, dip sampling sticks and an analysis service for industry and government. Station staff, veterinary officers and stock inspectors collect dip samples. Samples are then sent to the BARC Chemistry Section for analysis. Collectors, station owners/managers and program managers are notified of the results and appropriate advice is given.

A total of 33 dip samples were analysed from NT properties during 2000/2001. Out of them, 17 samples were at the correct strength, three were above strength and 13 were under strength. Corrective action was advised in each case.

Several dips have changed from synthetic pyrethroids to amitraz in response to resistance to synthetic pyrethroids in the Darwin area.

PROJECT: Monitoring and Eradication of Cattle Tick Strains Resistant to Chemicals

Project Officers: K. Small, D. Russell and I. Doddrell

Location: NT Wide

There are two parts to the project on monitoring for and eradication of strains of cattle tick resistant to chemicals. They are described separately below.

Objective:

- ***Locate chemically resistant strains of cattle tick on NT properties and prevent their spread.***
- ***Advise industry on chemical control of any detected resistant cattle tick strains.***

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 were banned as an acaricide in 1987.

There are strains of cattle ticks resistant to one or more acaricides 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 entry 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 resistant ticks (resistant to synthetic pyrethroids and organophosphates e.g. Bayticol, Barricade 'S' and Blockade-S) were found on two properties in the Mary River area in April 1999. Monitoring activity commenced in the Mary River area on the properties with known Parkhurst resistant cattle ticks and the neighbouring properties. Any reports of poor tick kill following treatment are investigated. Parkhurst resistant cattle ticks were found on a third property during 2000. In 2001 a further two properties were found to have Parkhurst resistant ticks.

Eradication
Objectives:

- ***Eradicate Parkhurst strain resistant ticks from the NT.***
- ***Prevent the spread of resistant strains of tick by advising industry on chemical control and implementing effective movement controls.***

Parkhurst strain resistant ticks (resistant to synthetic pyrethroids and organophosphates e.g. Bayticol, Barricade 'S' and Blockade-S) are found on five properties in the Darwin area. A program commenced in 1999 to control the spread of Parkhurst ticks and to survey other properties for the presence of Parkhurst ticks.

A $200,000 program has commenced to eradicate ticks on the infected properties. This involves the supply of Acatak and Amitraz to achieve total tick eradication. Treatment will be carried out over two years, followed by a two-year period of monitoring for freedom from ticks.

Controls are in place, which allow the movement of agistment stock to and from affected properties. The eradication program involves clean paddock musters, total herd treatment, removal of unmusterable stock

and vaccination of young stock for tick fever. Where it is possible a system of paddock rotation and pasture spelling is used to further reduce the survival of tick larvae on pasture. No properties achieved tick freedom in the first year of the eradication program. If ticks cannot be eradicated, movement conditions will remain in place to prevent the spread of resistant ticks to other properties.

SUBPROGRAM: TB Freedom Assurance Program (TBFAP)

PROJECT: Tuberculosis Eradication

Project Officers: B. Radunz, Regional Veterinary Officers and staff

Location: NT Wide

Objective:

- ***Monitor cattle slaughtered at abattoirs to maintain TB free area status.***
- ***Turn-off of cows previously exposed to TB infected animals to remove the remaining group of risk cattle.***
- ***Deal with TB case herds to the satisfaction of the owner and a national TFAP property program group.***

The Tuberculosis (TB) impending free area declaration in November 1992 was a culmination of years of work by many pastoralists, private veterinarians and departmental staff, and the expenditure of $192m. The NT 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 TB freedom assurance program (TFAP) was agreed to and funded from 1998 to 2002 by the States the NT, the cattle industry and the Commonwealth. The national forward estimates for TFAP was $33m of which the expected expenditure in the NT is $13m.

It is expected that a small number of TB cases will be found in cattle previously exposed to the disease, despite having completed the testing programs.

Activities:

The TFAP program is on track to achieve its objectives. There are savings nationally as the number of TB cases have been less than predicted. In the NT the number of TB case herds was close to that predicted in 1998 and 1999. However there are savings as the herds detected in 1999 were relatively small. There were no TB cases detected in 2000.

Eradication
During 2000 the remaining two herds achieved CF2 status. There are no current eradication programs.

Breakdowns
There were no TB cases detected in the NT from July 2000 to June 2001.

National granuloma submission program (NGSP)
The monitoring system includes a granuloma submission program at abattoirs, which is working satisfactorily. A pleasing aspect of the program is that the majority of lesions that are detected through abattoir monitoring are not TB. This increases confidence that meat inspectors are submitting granulomas that will assist in the early detection of TB breakdowns.

During the 2000 calendar year there were about 18,373 cattle and buffalo slaughtered at NT abattoirs. Nineteen granulomas were detected but none confirmed as TB.

TB Testing July 2000 to June 2001

	Number Tested	Number Reactors	Number with TB
Buffalo	0	0	0
Cattle	10,339	11	0

Testing was done on nine properties.

Voluntary Monitor Programs

Cattle previously exposed to TB-infected animals remain very low but possible risk of undetected TB cases despite completion of the eradication program (at CF2 or CF3 status) remains. 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 scope of a future TB case.

Relevant owners were contacted with a voluntary monitor program. The program comprises continued segregation of the cattle previously exposed to TB infected animals, early turn-off of the cattle and a TB test in 2001 if turn-off during 2000 is not possible. The national cattle industry provided about $4m to accelerate the turn-off. This was in the form of a spay subsidy and a freight rebate. Owners who agree to, and implement, a voluntary monitor program will be eligible for all available financial assistance for the program and in the event of a TB case being found. Owners who do not adopt a voluntary monitor program will only be eligible for compensation if destocking is done.

In 1997 there were 50 properties in the NT which records indicate may have stock remaining that were previously exposed to TB infected animals. At the end of 2000, 19 properties had completed the voluntary monitor program. The owners of three properties decided not to adopt the voluntary monitor program. Now 28 properties have active programs.

At the end of 2000 there had been a reduction in category A cattle from 11,500 to 6,800 and category B cattle from 70,000 to 61,500. 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 destocked due to TB or progeny of category A breeders.

Expenditure during 2000/01 was:

Operations	$550,722
Compensation	$109,391
Mustering Subsidy	$79,906
Freight Rebate	$63,267
Type G	$5,159
Type H	$36,076
TOTAL	$844,521

PROGRAM: Berrimah Veterinary Laboratory

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 was assessed for accreditation by NATA (National Association of Testing Authorities) in November 2001 and subsequently gained accreditation 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 in February 2001.

A total of 2,516 submissions were received and processed during the year at BVL, an increase of 10.8% on last year. 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 2,516 submissions consisted of 24,118 specimens and generated some 65,006 individual tests in gross and microscopic pathology, bacteriology, clinical pathology, parasitology, serology and virology. The numbers of tests and investigation reasons are:

- 11,433 tests for diagnosis of disease in production animals;
- 53 tests associated with monitoring for bovine tuberculosis;
- 931 tests for export and movement certification and regulatory purposes;
- 18,117 tests on a service charge basis for companion and performance animals, aviary birds and native fauna;
- 24,038 tests for sentinel herd and flock monitoring;
- 9,965 tests for research and surveillance programs;
- 469 tests for quality assurance.

BVL participates in 21 laboratory tests in the Australian National Quality Assurance Program (ANQAP) for veterinary serology and virology. BVL also participates in quality assurance programs in bacteriology and anatomical pathology. All test results obtained at BVL were within the respective acceptable variation ranges.

The water microbiology laboratory, which is integrated into BVL's management structure but which has a unique (non-veterinary) client base, tested 5,268 water samples from various sources.

Table 1. Laboratory submissions by region and by species

	Darwin	Katherine	Tennant Creek	Alice Springs	Interstate/ Overseas	Total
Bat	9	2				11
Bird (cage and wild)	25		2	5	1	33
Buffalo	12				4	16
Camel	1			23		24
Cat	121	3	1		1	126
Cattle	192	110	35	40	16	393
Clam	1					1
Crab	53					53
Crayfish	4					4
Crocodile	33					33
Crustacean	6					6
Deer	1					1
Dog	787	28	2	1	3	821
Dugong	1					1
Fish	85	2		2		89
Goat	50	5		1	3	59
Horse	88	44	8	7	4	151
Insect	92	28	23	8		151
Monkey	3					3
Mouse	1			1	1	3
Mussel	1					1
Native fauna	85			11		96
Pearl oyster	18				2	20
Pig	110	1		1	6	118
Poultry	73	11	9	10	6	109
Prawn	30				2	32
Puma	1					1
Rabbit	2			2		4
Sheep	28		2		1	31
Shellfish	9		2			11
Tiger	2					2
Turtle	11	1			1	13
Other	34	4		2	31	71
Total	1,969	239	84	114	82	2,488*

* This figure is based on date collected

Table 2. Type and number of laboratory submissions

Diagnostic	496
TFAP**	29
Export	32
Sentinel	301
Research	303
Survey	181
Fee for Service***	1123
Quality Assurance	46
Other	5
Total	2516****

** 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%), H. Parkes, K. Fomiatti (50%), L. Small (60%), G. Paterson, L. Chambers, N. Jolliffe, M. Mahoney, S. Benedict, D. Cumberland, R. Wilson, N. Cox, C. Day, S. Auman and N. Elliot**

Location: Berrimah Veterinary Laboratories, Berrimah Farm

Objective:

To 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 gross pathology, histopathology, bacteriology, parasitology, serology, clinical chemistry, haematology, cytology and urinalysis - the last four are under the heading of clinical pathology. Water microbiology is a section of the pathology area. It has a unique (non-veterinary) client base.

Gross Pathology:

Submissions 228

The activities of this section consist of post-mortem examinations of cadavers and gross examination of pieces of organs and tissues. The range of species is large. Aquaculture submissions consisted of 51 for finfish, 13 for crustaceans and 18 for molluscs, and accounted for 36% of total submissions. Other frequent submissions included 25 for pigs, 17 for goats, 15 for poultry, 12 for cattle, 12 for crocodiles and 11 for dogs.

- Melioidosis, a disease caused by the bacterium *Burkholderia pseudomallei*, is common in the Darwin area. It was diagnosed in goats, pigs, a cat, a parrot, a monkey and a puma.
- Necrotic enteritis and chronic peritonitis were a recurring problem in cultured barramundi.
- Botulism in birds is commonly diagnosed based on clinical signs and in the absence of post-mortem abnormalities. The disease is confirmation by the mouse toxin protection test.
- Leptospirosis in dogs was again detected in the Darwin area.

Histopathology:

Submissions 546

Of the total submissions, 29 were for cattle under the tuberculosis freedom assurance program (TFAP) either as lesions from reactors or as lesions collected at abattoirs under the national granuloma submission program (NGSP). The brains of 20 cattle were examined as an ongoing NT contribution to the NTSESP (national transmissible spongiform encephalopathy surveillance program). This program is designed to demonstrate freedom from BSE and scrapie, and to provide an early detection should these diseases occur.

- Acute, massive hepatic and renal necrosis consistent with a toxic invasion was observed in animals at a cattle station in the Katherine region. Over a period of two to three weeks, 8% of animals died.
- Skin lesions in crocodiles were consistent with *Dermatophilus* sp infection.
- The storage disease neuronal ceroid-lipfuscinosis was diagnosed in a dog. The dog showed neurological signs such as changed behaviour due to storage of ceroid and lipofuscin in nerve cells of the brain.

This section joined the QDPI and NRDAP (national registry of domestic animal pathology) histology quality assurance programs in March.

Bacteriology:

Submissions 602

Fee for service submissions accounted for 43%, diagnostic submissions accounted for 38% and TB submissions dropped to 5% of the total.

Interesting isolations included:

- *Streptococcus equi* subspecies *equi* from horses which confirmed outbreaks of strangles, in Alice Springs, Katherine and in the Darwin rural area.
- *Salmonella* Muenchen from the intestines of a two-week old calf from the Barkly Tablelands.
- *Providencia rettgeri* continues to be a common isolate from septicaemic juvenile crocodiles.
- A rising titre (400 to 1,600) in the microscopic agglutination test (MAT) for *Leptospira australis* in a pup with signs of leptospirosis. Another dog reached a titre of 3200.

The section participates in the IFM proficiency testing program for veterinary microbiology and the three Leptospira MATs are part of ANQAP proficiency testing.

Parasitology:

Submissions 378

The project started last year to investigate if hydatid cysts are present in cattle born and bred in the NT and was completed. Hydatid cysts were seen in 23 out of 4348 animals examined. Of those, 21 cysts were in animals that originated from Queensland and two were in cattle with illegible brands. These results strongly suggest that a cycle of hydatid transmission does not occur in the NT.

The section participates in a faecal egg count proficiency-testing program run by Agriculture WA.

Serology:

Submissions 220

The biggest group was sentinel submissions for bluetongue ELISA testing at 60%, followed by diagnostic submissions at 24%.

Seven tests were conducted in the section as part of the ANQAP proficiency testing.

Clinical Pathology:

The clinical pathology sections illustrate how a service charge for non-production animals can contribute to their maintenance cost because though they are necessary, they would be under-utilised if used for production animals only.

Clinical Chemistry:

Submissions 514

Fee for service submissions accounted for 73% of the total, followed by diagnostic submissions at 20%.

The section participates in the BIORAD international quality assurance program for clinical chemistry.

Haematology:

Submissions 659

Fee for service submissions accounted for 73% of the total followed by diagnostic submissions at 18%.

- *Eperythrozoon suis*, a parasite of pig red blood cells, was seen in blood smears from pigs in a Darwin piggery. If confirmed, this would be the first time the parasite has been reported in Australia.
- Anaplasmosis (a form of tick fever) was diagnosed in cattle in the Darwin region and in the VRD.

The section participates in the RCPA (Royal College of Pathologists of Australia) haematology quality assurance program.

Cytology:

Submissions 122

Submissions from private practitioners on a fee for service basis accounted for 75% followed by submissions for diagnostic purposes from production animals at 10%.

Urinalysis:

Submissions 85

Submissions from private practitioners on a fee for service basis accounted for 84% followed by submissions for diagnostic purposes from production animals at 13%.

Water Microbiology:

Samples 5,268

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: An Assessment of Culicoides spp attacking Livestock under Cover

Project Officers: **L. Melville, N. Hunt, G. Bellis and D. Pinch**

Location: Beatrice Hill Farm and A.L. Rose Virology Laboratory, Berrimah Farm

Objective:

To monitor culicoides spp attacking cattle when under cover in simulated holding and transport situations.

Background:

Largely qualitative and anecdotal evidence suggested *Culicoides* spp would not enter covered areas and this could be used as a method of protection for cattle travelling through a bluetongue endemic area. This hypothesis had not been quantified or validated statistically. Biosecurity Australia provided funding for the work.

Method:

Four groups of four cattle of uniform colour and size were randomly assigned to four pens constructed to simulate livestock crates. Two pens were covered and two were left uncovered. Insects were collected from each group using mechanical aspiration. Collections were made on eight nights over a four-week period, starting two hours before sunset and continuing at hourly intervals until three hours after sunset. The first collections were done in March and the second in June, to accommodate different species of Culicoides dominant at different times of the year.

Collections were noted to species and a record made if they had had a feed recently.

Results:

Collections were made and pre-sorting was completed. The final sorting and counting of species is still continuing. All available data to date has been entered into an Access table in preparation for statistical analysis.

PROJECT: Wildlife Exotic Disease Preparedness Program (WEDPP) - Investigation of Possible Vectors of Japanese Encephalitis in Northern Animal Ecosystems

Project Officers: L. Melville, N. Hunt and S. Aumann

Location: A.L Rose Virology Laboratory, Berrimah Farm

Objective:

To identify major mosquito species feeding on pigs and to test these for vector competence for Japanese Encephalitis.

Background:

In 1995 clinical and serological evidence was obtained of the presence of Japanese encephalitis in the Torres Strait Islands. Since entry and establishment of Japanese encephalitis will depend on competent vectors, possible vector species need to be identical and the level of competence established.

Method:

Mosquitoes are caught in a CO_2 trap, sorted to target species (*Cx. annulirostris* and *Cx. palpalis*) and held for two to three days. Surviving mosquitoes are fed overnight on stock Japanese encephalitis virus in pig blood. Engorged mosquitoes are held for nine days and offered a one to two-day-old suckling mouse to determine virus transmission. Mosquito and mouse infections are confirmed by PCR.

Results:

Approximately 215 mosquitoes have been fed on infected pig blood. Of these, 64 surviving mosquitoes have been individually fed on suckling mice.

No virus isolations or PCR detections have been performed on mosquitoes or mice.

PROJECT: Wildlife Exotic Disease Preparedness Program - Investigations of a New Virus of Horses in Animal Populations in the NT

Project Officers: L. Melville, S. Davis and Regional Animal Health staff

Location: A. L Rose Virology Laboratory, Berrimah Farm

Objective:

- ***To characterise a new virus isolated from two horses with encephalitis and determine the distribution in equine populations in the NT.***
- ***To investigate possible wildlife reserves for this virus.***

Background:

In 1999 viruses were isolated from two horses with encephalitis in the Katherine region. These viruses appeared to be the same and could not be identified using a large panel of antisera to known viruses held both at Berrimah and at the Australian Animal Health Laboratory. Basic information is required about these viruses to enable identification and clarification of disease significance.

Method:

The viruses will be further characterised at AAHL using molecular techniques and specific antisera will be produced at Berrimah to enable comparison with known viruses.

Surveys will be carried out of equine populations in the NT. Sera are tested in a neutralisation test to determine the sero-prevalence of this virus. Possible wildlife reservoirs will also be investigated by serology.

Results:

Between 1993-2000, 411 equine sera were collected and tested. Out of them 40 were found to be positive. These represented 12 locations, all in the northern region of the NT. In 2001, 76 horse sera were collected in the Darwin and Katherine areas. Only five were positive.

Also 129 macropod sera were tested and no significant antibody was detected.

From 1996 to 1999, 24 bat sera were collected which produced nine positive samples with high levels of antibody present. A further 50 samples were collected in 2001 and gave 29 positives, again with high levels.

Also 300 cattle sera were also tested and no significant antibody was detected.

HORTICULTURE

PROGRAM: Vegetable Industry

SUBPROGRAM: Asian Vegetables

PROJECT: Bitter Melon Hybrid Yield Evaluation Trial

Project Officers: M. Traynor and M. Gosbee

Location: CPHRF

Objective:

- ***To determine the yield potential of two selected hybrid bitter melon varieties and the local open pollinated line and to compare production peaks, fruit maturity indicators, fruit uniformity and general plant performance.***
- ***To further assess grower and market acceptance of hybrid types.***

Background:

Bitter melon varietal research has been conducted by the Horticulture Division over the past two years and is funded under the national RIRDC project CQU-10a 'Consolidating the Asian Vegetable Industry'. Local bitter melon growers have been collecting their own seed from an open-pollinated line for many years and most select desirable fruits for this purpose. This practice has stabilised the local line to some degree but the problem of fruit variability remains a major concern to growers.

In an attempt to address this issue, a screening trial of 10 hybrids sourced from Australian and Asian seed companies was conducted in 1999. These were primarily evaluated for vigour, uniformity and desirable fruit characteristics (size, shape and colour).

Growers inspected the fruiting plants and along with researchers selected four hybrids as having some potential. Out of those, *Baizin* and *Moonlight* were selected for yield evaluation in 2000.

Unfortunately, *Baizin* seed was unavailable in Australia during the 2000 season so the very similar performing hybrid 'Known you green' was used.

Method:

The varieties used in the trial were 'Known you green' (hybrid), Moonlight (hybrid) and the local selection (open-pollinated), which was obtained from one of the local growers. Four replicate and randomised plots were planted of each variety. Four plants were in each plot, with 2 m between plants and 3 m between rows and 4 m between plots.

Plants were grown on vertical nylon netting trellis, pruned and trained as per local practice. Nutrients were provided through the irrigation system.

For early growth, 25N: 5P: 18K kg/ha/week was used.

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

Lime and basal fertiliser were applied and the necessary trace elements were provided through irrigation water during early crop growth. The irrigation was carefully monitored with soil moisture tensiometers at depths of 20 and 40 cm. Harvest commenced at week eight and continued until week 17. Pests and diseases were controlled as required.

Results:

As the vines grew together on the trellis, results are not presented per plant but per plot of four plants.

Table 1. Yield parameters per plot (i.e. of four plants) of bitter melon varieties

Variety	Total fruit weight (kg)	Total fruit number	Average fruit weight (g)
Known you green	71.6 a	218.5 b	328 b
Moonlight	73.9 a	256.5 b	288 a
Local selection	66.7 a	177.5 a	376 c

Values are the average of four plots. Values followed by different letters within columns are significantly different ($p<0.05$)

Although the local selection produced fewer fruit, the total weight of fruit was not significantly different between the three varieties (Table 1). When average fruit weight is compared, both hybrids, especially Moonlight, produced significantly smaller but a greater number of fruit. The local selection produced significantly larger but significantly fewer fruit than either hybrid. While analysis shows that the hybrid fruit size was smaller, it was still within acceptable market range.

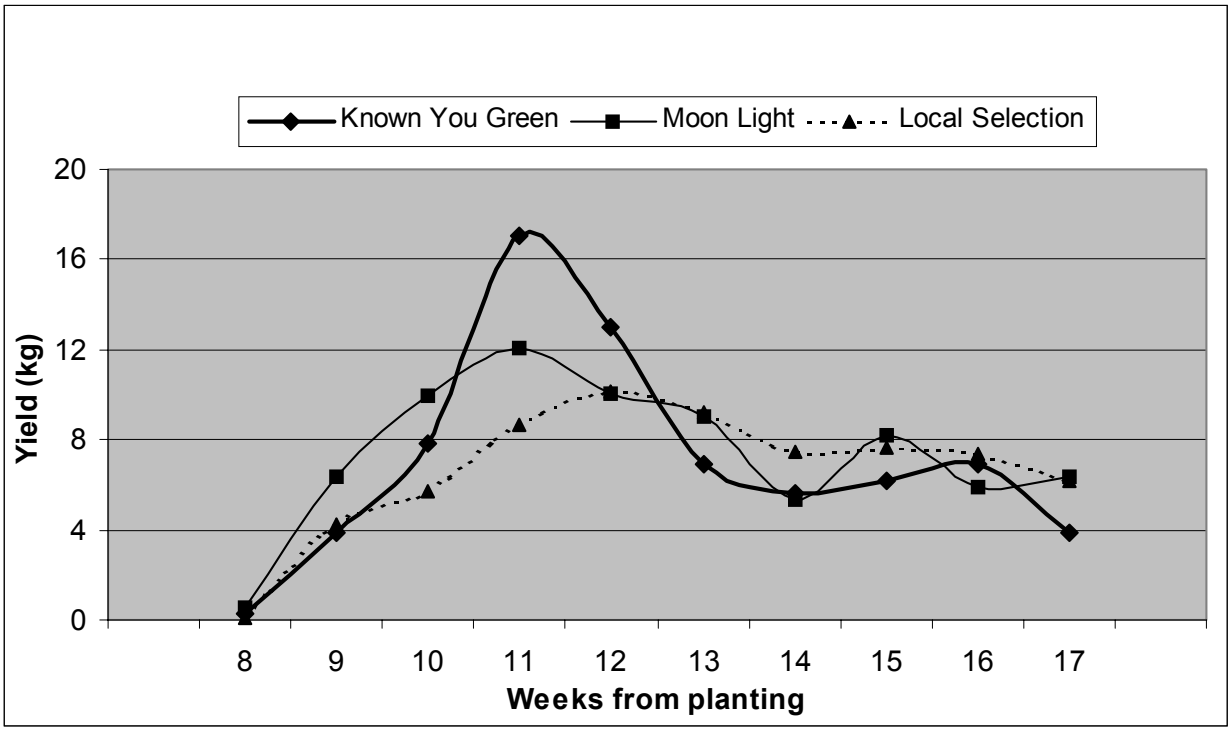


Figure 1. Weekly harvest totals per plot (4 plants per plot)

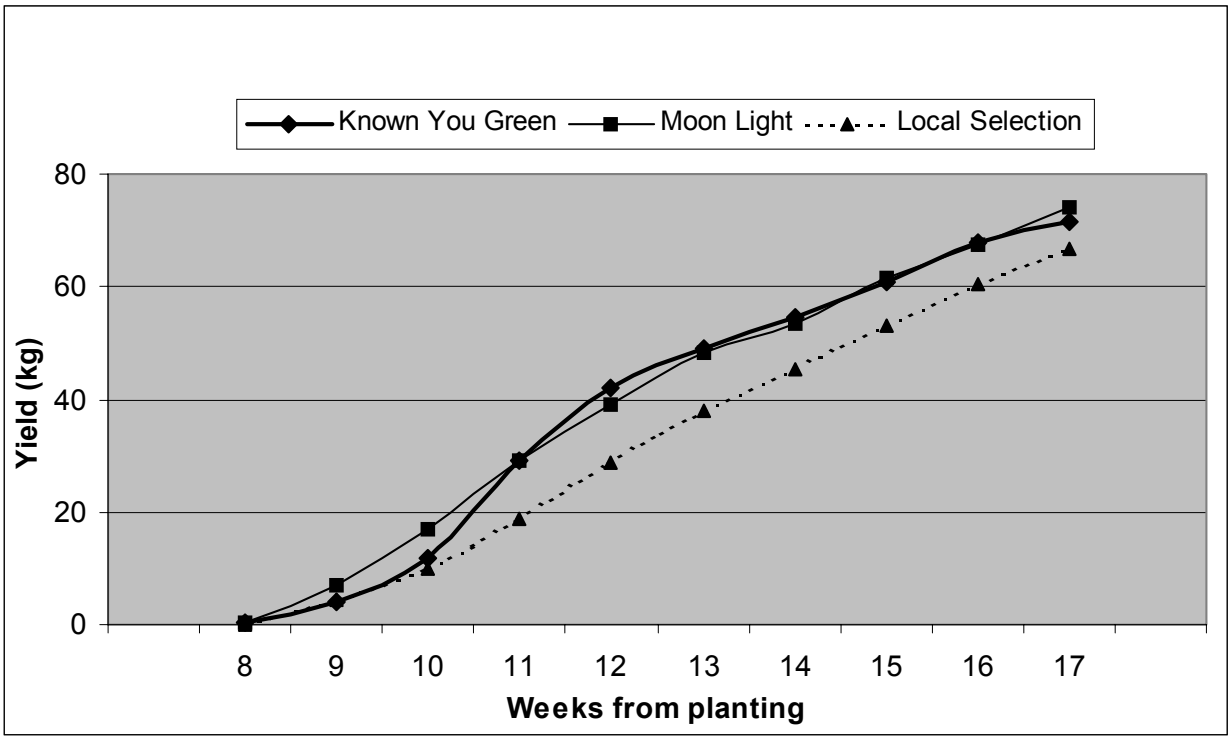


Figure 2. Cumulative harvest (four plants per replicate)

Harvest of all varieties commenced at eight weeks from planting and peaked at 11-12 weeks (Figure 1). This is more distinct with the hybrid lines and is most likely the initial fruit set on primary lateral branches. Further smaller peaks in the harvest would come from the flowering of secondary lateral branching. This trend in flowering and fruiting was also evident in yield figures from another trial promoting 'improved farming systems' on bitter melon and reported in this TAR.

Both hybrids had very similar cumulative yields throughout the trial (Figure 2). The local selection had lower yields early but by week 17, total cumulative yield was not significantly different from the hybrids.

Fruit that ripened on the plant before reaching a marketable size was not included in yield figures. Poor pollination or early injury to fruit can cause early ripening, but is also noted as a varietal characteristic. These fruit were recorded and the data presented as a percentage of total fruit harvested.

Known you green 12.1%

Moonlight 10.8%

Local selection 18.4%

Observations:

Bitter melons are harvested at the 'mature green' stage of development before the onset of ripening. This is an essential market requirement, but is difficult to determine at harvest. Even fruit showing no external colour change may have commenced ripening within the seed cavity. If packed, such fruit will continue to ripen in transit with the production of ethylene causing ripening of the whole box. Regular internal checks of harvested fruit showed that this problem was common in all varieties.

There were obvious differences in fruit uniformity between the hybrids and the open pollinated line. As expected, both hybrids produced very uniform fruit with size, shape and colour remaining constant over the harvest period. While fruit size (weight) of the local selection was fairly consistent, the shape and colour of the fruit was quite variable. This is a common problem for growers. Because growers collect seed from their own crops, the quality of open pollinated fruit can vary between farms. Limited market studies show

consumers prefer bitter melon that are 18-22 cm in length, 6-8 cm in diameter and with mid-green colour. Some growers reject up to 30% of their produce because it does not meet these requirements.

Field assessments of plant growth showed differences in vine vigour. While both hybrids produced adequate growth to support and protect the fruit, the local selection was more vigorous with many fruit totally hidden by vine growth. This may have caused the pale colour of some fruit. The local selection seemed well adapted to the local environment with fewer signs of leaf wilting during periods of heat stress.

Discussion:

After inspecting the trial, growers continued to show a definite preference for the open-pollinated type fruit with rough irregular bumps. It appears that the smooth-skinned hybrids have less market appeal and would require promotion to be accepted by consumers. Growers would like a uniform hybrid line with the rough appearance of the local selection. Unfortunately such a hybrid is not currently available.

Growers need to be more vigilant when selecting seed to minimise the variability in the local selection.

Harvesting fruit at the correct maturity remains a problem, especially for inexperienced growers. Maturity indicators at harvest can be very subtle and difficult to detect.

Further identification of production peaks would assist with planting schedules and completion time of harvest.

Detailed studies on manipulation of the male to female flower ratio (which can be as high as 50:1) could result in significant yield increases.

It is interesting to note that several growers purchased hybrid seed for planting in the 2001 season. This is a direct result of these research trials.

PROJECT: Snake Bean Fusarium Survey

Project Officers: M. Gosbee and K. Bui

Location: Darwin Region

Objective:

To determine the spread of Fusarium on snake beans in the Darwin region.

Fusarium oxysporum f.sp. *tracheiphilum* (Fot) causes ‘early die’ of snake bean crops when they begin fruiting. This disease was first noted in 1999 and since has spread rapidly amongst the Asian vegetable farms. The disease is spread through poor soil hygiene and also infected seed. As considerable departmental resources are invested in finding an alternative resistant line of snake beans, a survey was conducted to determine the actual spread of the disease. Snake bean production in 1999 was worth $1.1 million.

Most Asian vegetable farms were visited and the disease was described. Samples were taken where possible and given to Plant Pathology for identification.

Table 1. Number of properties surveyed for snake bean Fot in the Darwin Region, March 2001

Locality	Infected	Not infected	Snake beans not grown	Total
Humpty Doo	3	4	5	12
Buckley Rd	13	3	6	22
Wanderrie Rd	6	4	2	12
Lambells Lagoon	3	0	1	4
Berry Springs	1	2	0	3
Darwin River	3	1	1	5
Total	**29 (50%)**	**14 (24%)**	**15 (26%)**	**58**

Out of all farms surveyed, 15 (26%) had never grown snake beans on their properties. Of the remaining 43, which had grown beans in the past, 73% were infected. Observations have also indicated that several new blocks had become infected since the survey.

New lines of snake beans are being brought into Darwin and tested for resistance to Fot. A report on this work can by found in the Resource Protection TAR.

PROJECT: Kabocha Variety Trial

Project Officers: C. Kinnaird, J.Bright, M. Gosbee and R. Renfree

Location: KRS

Objective:

To determine whether viable yields could be produced from kabocha cultivars in the Katherine Region.

Background:

In 1999, five varieties of kabocha were grown in a trial at Katherine. Quality was good; however yields were low compared with other regions. This can probably be improved this year with better N control and careful management of pollination. The other possibility was that low temperatures experienced last year reduced fruit set.

Five of the most promising varieties were selected from the previous year's results. These were Tetsukabuto, T110, Sweet Mama, Pacifica and Delica. Kurijiman was also included, as this is one of the main varieties grown by NZ and exported fresh to Japan.

This trial is part of the RIRDC project ‘Consolidating the Asian vegetable industry’, number CQU-10a. This project also includes more information on kabocha grown in several locations nationally, which will be available from RIRDC in late 2001.

Method:

The crop was planted on 19 May 2000. Three randomised plots per variety were used. There were 10 plants per plot, with 1 m spacing within the rows and 1.5 m between the rows.

Flowering started on 3 June 2000. There were two occasions during the trial when irrigation was interrupted for several days due to pump breakdown. Upon rewatering, many fruit split. Two harvests were conducted, one on 15 September 2000 to remove the worst of the split fruit, and the main harvest on 4 October 2000, 138 days after planting.

The crop was planted using black plastic mulch and trickle irrigation to tensiometer values recommended by Top & Ashcroft. Pre-plant fertiliser was applied and fertigation was used after flowering.

Powdery mildew severely affected the crop late in the season, but could be controlled with a carefully implemented spray program.

Results:

Fruit weight, number per plot of 10 plants, and individual fruit weight and diameter were recorded and the figures were analysed. Analysis was performed on total yield (first and second harvest, marketable and split fruit), yield of the second harvest and also marketable yield. Fruit that were either split or showed some other signs of breakdown were considered unmarketable.

Table 1. Total yields, first and second harvest including marketable fruit

Variety	Weight per plot (kg)	Number per plot	Weight per fruit (kg)	Approx % fruit < 1 kg	Tonne/ha*	Marketable (tonnes)
Delica	54.3 a	37.0 a	1.463 b	6.3	36.2	33.9
Kurijiman	50.6 a	36.0 a	1.405 ab	29.6	33.7	23.7
Pacifica	61.8 a	34.3 a	1.810 c	6.8	41.2	38.4
Sweet mama	64.5 ab	35.0 a	1.844 c	18.1	43.0	35.2
T110	46.1 a	38.0 a	1.218 a	40.4	30.7	18.3
Tetsukabuto	99.0 b	69.7 b	1.426 b	19.1	66.0	53.4
P-value	0.090	0.072	<0.001			
LSD (p=0.05)	37.00	25.52	0.1917			

Yield per ha was calculated using 1.5 m rows and 1 m between plants, which equates to 6,666 plants per ha. Calculated as plants/ha * weight per plot/10 (as there were 10 plants per plot). Marketable yield = tonne/ha less fruit that was less than 1 kg in weight.

Tetsukabuto had significantly higher yield than the other varieties. This was due mainly to higher fruit set. Fruit size of Tetsukabuto was relatively small. These results are interesting when compared with those since published by Top and Ashcroft (2000) for kabocha grown in Victoria. Fruit number per plant grown in Katherine was higher, while fruit size was lower. Better management of these factors could further improve production.

The proportion of each variety falling within each diameter grade is presented in Figure 1. This was based on class 1 fruit being more than165 mm, class 2 fruit 130- 165 mm and fruit less than130 mm was too small. A diameter of 130 mm roughly corresponds with 1 kg in weight.

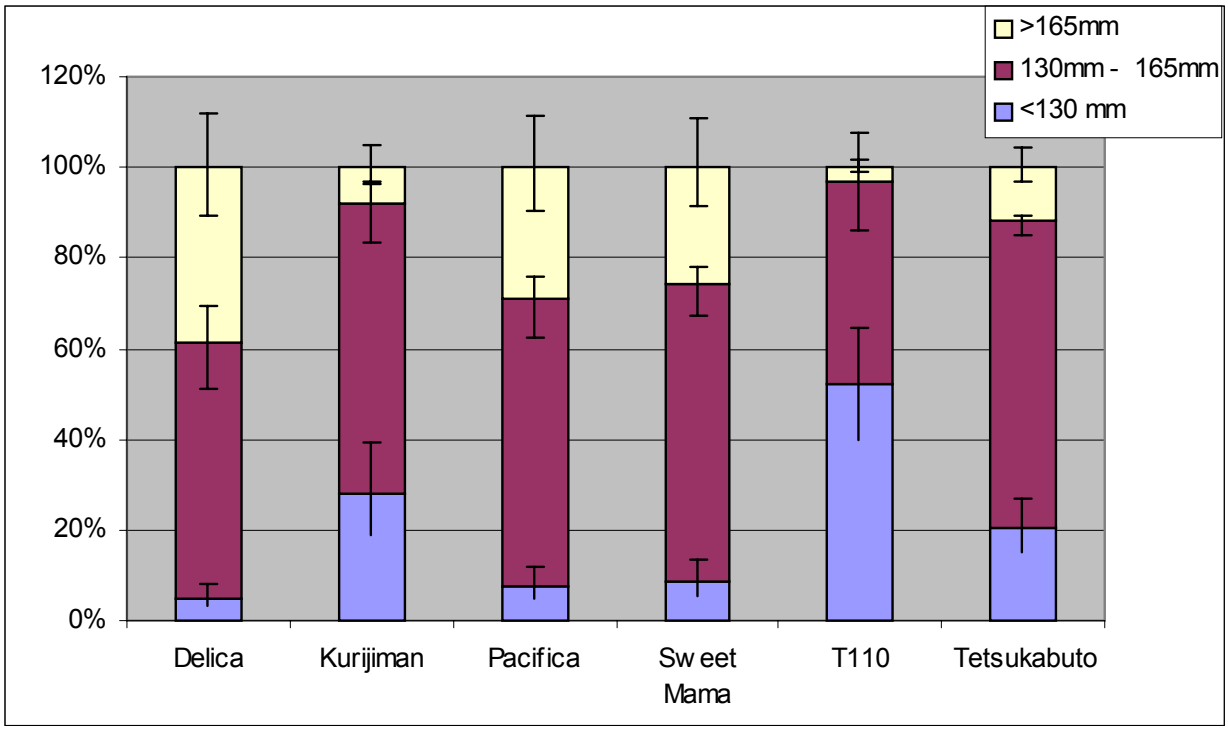


Figure 1. Proportion of fruit within each size group

Conclusions:

Kabocha can be grown in the Katherine region. Whether the profit margin is high enough to cover increased costs due to the location would be up to an individual producer. It is strongly recommended that potential growers check with markets for recommended varieties and grades before planting the crop. Calculated yield per hectare is around the range stated by Top and Ashcroft (2000). The 'best' variety will be determined when quality results from the national trial are available and analysed and market preference. The variety Tetsukabuto had the highest yield and fruit set.

Reference:

Top and Ashcroft 2000. Japanese pumpkin – kabocha. A production manual for Victoria. Second edition. Department of Natural Resources and Environment, Victoria.

PROJECT: Development of Vegetable Production Systems – Snake Bean Variety Evaluation 2000

Project Officers: **M. Traynor, P. Hopkinson and E. Maroulis**

Location: CPHRF

Objective:

- ***To bulk up seed for future testing for fusarium resistance by the Plant Pathology section.***
- ***To conduct a preliminary assessment of agronomic characteristics using the variety* Green pod Kaohsiung *as a standard.***

Introduction:

Fusarium wilt of snake beans is widespread in Asian vegetable farms in the Darwin region. Green Pod Kaohsiung, the variety used by all growers, was quite prone to infection. In an effort to identify a new variety

with Fusarium resistance, 39 seed lines were sourced from overseas and from within Australia. These lines were trialled at CPHRF during the 2000 dry season.

Management:

Plants were grown on vertical trellis using plastic mulch and fertiliser injection. Non–replicated four plant plots were spaced 3 m apart to prevent varieties growing together. Irrigation, fertiliser and pest and disease management was according to current DPIF recommendations. Sufficient beans were harvested for measurements, while the rest were left to fully mature on the plant and were then collected for seed. Plants were assessed for vigour and uniformity. Yield data was not collected on this preliminary assessment.

Results:

Please see Table 1.

Fruit assessments
Bean quality was graded using No.11 (*Green pod Kaohsiung*) as a standard. Of the 39 lines assessed only No.3 (*Minara variety*) and No.37 (*CP 68*) were considered of comparable quality. No.33 (*Tainong 5*) showed good bean characteristics but its purple colour would require market testing.

Plant assessments
Plant uniformity and vigour assessments showed several lines with ratings comparable to *Green pod Kaohsiung.*

All the seed lines will be tested for Fusarium resistance. Those with a less than good quality rating may be useful in a breeding program if they show good resistance.

Table 1. Snake bean plant and fruit assessments

Average of 10 beans

Name	Width (mm)	Length (cm)	Weight (g)	Colour light/mid/dark	Comments/Appearance shape/thick/smoothness	PLANT VIGOUR	PLANT UNIFORMITY
1. Red Eye	8	350-400	125	Light	Bumpy. Colour Variable. Flat areas. Poor	Good	Very Good
2. Green Patch	7	65-75	215	Light	Long/thin - pale. Fairly smooth. Too long - poor	Fair	Good
3. Minara Variety	10	35-45	210	Dark (good)	Sturdy/thick. Round. Skin a little rough. Purple tips. Good type.	Good	Very Good
4. Black Mottled	8	50-60	270	Light	Round/long. A little rough. Even pale colour. Fair	Good	Very Good
5. Kiew Doke No 3	8	50-60	250	Light/mid	Colour variable. A little bumpy - some flat areas. Mostly round. Fair	Good	Good
6. KD 2	7	50-70	210	Mid	Thin for length. Tapering to end. Length variable. Poor	Good	Good
7. KD 4	9	70-75	355	Mid	Very long but round. Even length. Fair bean but too long. Fair/poor.	Fair	Good
8. Mun River	8	40-50	175	Mid/dark	Skin very rough. Some lumps/round unattractive. Fair/poor. Length good	Fair/Good	Good
9. Chi River	7	40-50	175	Mid	Colour variable. Rough skin. Some bumps. Most round. Fair	Fair	Good
10. Phong River	8	40-50	160	Light	Poor colour. Round. Fairly rough skin. Some lumps. Fair/Poor	Fair	Good
11. Green pod kaohsiung	10	40-55	210	Dark	Green pod Kaosuing*. Good colour purple tips. Round/thick. Fairly rough skin. Similar to number 3. Good	Very Good/ Good	Good
12. PI 259759	8	20-25	65	Light/mid	Colour variable. Lumpy - tough skin – will not snap. More like a cowpea - Flat. Very poor	Fair	Fair
13. TVu 2449	8	30-35	90	Very light	Very pale colour. Very lumpy. Tough skin. Very poor	Poor	Fair
14. TVu 2891	8	30-35	95	Very light	Almost white same as number 13. Very poor	Fair	Good
15. TVu 3165	7	35-40	115	Light	Very lumpy. Some flat. Very variable. Poor	Very good	Good
16. She-pai-tou	8	35-45	125	Mid	Variable - some smooth/rough. Mostly flat. Poor	Poor/Fair	Good
17. Han chui yen	7	50-55	135	Very light	Thin and lumpy. Poor colour. Rough skin. Poor	Poor	Fair
18. Lo chien tai	8	50-55	160	Light\mid	Long and thin. A little lumpy. Round. Too pale. Fairly/poor	Poor	Fair
19. PI 419005	8	35-40	140	Light	Round - a little lumpy. Fairly uniform. Too pale. Fair	Fair/good	Good
20. PI 419102	7	35-40	125	Mid	Thin but round. A little pale. Fair	Fair/Good	Good
21. Yi tan hong 752	7	35-45	95	Very light	Lumpy/thin tough skin. Very poor	Very poor	Good
22. Hung cho yang	7	40-50	135	Very light	Same as number 21 Very poor.	Poor	Good
23. PI 419219	9	50-55	190	Light/mid	Colour variable. Shiny tough skin. Will not snap. Fairly attractive. But too tough. Poor.	Good	Good

Name	Width (mm)	Length (cm)	Weight (g)	Colour light/mid/dark	Comments/Appearance shape/thick/smoothness	PLANT VIGOUR	PLANT UNIFORMITY
24. PI 427093	8	45-50	155	Very light	Poor colour. Lumpy/rough skin. Poor.	Poor	Fair
25. Hung tsui yen	8	30-35	125	Mid	Very lumpy. Tough skin. Unattractive. Poor	Fair/good	Good
26. Dagupan pangasinan 1.3	7	40-45	110	Light	Rough skin lumpy. Long and thin. Poor	Poor	Fair
27. 20 – 1	8	45-55	185	Light	Same as number 25 but paler. Poor.	Poor	Fair
28. CP 12	9	45-55	185	Light	Round/thick. Good type but pale. Fair	Fair	Poor/Fair
29. CP 16	9	45-55	205	Light	Same as number 28. But a little bumpy. Fair	Fair/Good	Good
30. China Town	7	40-45	115	Light	Tends to be flat thin. Poor	Fair	Fair
31. Bush sitao	8	35-40	135	Light/mid	Colour variable. Flat spots. Rough skin. Fair/poor	Fair	Fair
32. Tainong 1	8	30-35	110	Very light	Round/short. Too pale. Poor	Fair	Good
33. Tainong 5	9	40-45	170	Dark purple Green tips	Round/Thick solid beans. Good type but colour?	Poor/Fair	Fair
34. K – 30	8	45-50	170	Light	Round/a little bumpy. Too pale. Fair	Fair	Good
35. CP 57	8	35-40	115	Mid	Most flat and lumpy. Tough skin. Poor	Poor/Fair	Poor
36. CP 63	8	35-40	115	Mid	Round/lumpy. Rough skin. Tapered to tip. Poor	Fair	Good
37. CP 68	9	40-45	185	Mid/Dark	Good colour - purple tips. Similar to numbers 3 and 11. Thick/round. Good uniform	Good	Good/Very good
38. 280785 – 0604	8	50-70	165	Light	Long/flat. Tough Skins. Very variable. Poor	Fair	Fair
39. Guilin long bean	8	70-90	220	Light	Long/round. Lumpy - rough poor. Very long/variable	Fair	Poor/Fair

PROJECT: Asian Vegetable Demonstration Plot

Project Officers: G. Owens, M. Traynor, P. Hopkinson, D. Alchin and K. Bui

Location: Melon Patch, Territory Produce Freight Management, Humpty Doo

Objective:

- ***To demonstrate the difference in productivity that can be gained by using best practice vegetable growing methods.***
- ***To create an attitude change in the Asian vegetable growers by demonstrating the ease of implementing best practice vegetable growing methods.***
- ***To create an aspiration to match published production figures by adopting such practices.***
- ***To change the behaviour of Asian vegetable growers adopting such practices.***

Introduction:

On-farm demonstration plots for displaying best practice farming systems have been used in the Asian vegetable growing community for a number of years with mixed success. Those farmers near or associated with the collaborating growers gained from the trial. However, adoption was limited.

In an attempt to increase the awareness of the whole group it was decided to try and locate a demonstration plot at a central location that the majority of the growers visited at least once a week in the vegetable season. A 100m^2 site was selected at the Melon patch just outside Territory Produce Freight Management (TPFM) transport depot for receiving, cooling and consolidation.

A crop of bitter melon was planted using local and best practice methods and the whole process was open to grower observation and comment.

Method:

The demonstration was set up to contrast the two methods of growing one of the major Asian vegetables. The vegetable selected was an open-pollinated local selection of bitter melon, a climbing cucurbit common throughout Asia.

The plot comprised of four rows, each 30 m in length. Plants were spaced at 2-m intervals and the rows 3 m apart for vehicle access.

The vines were directed up a vertical trellis constructed of star pickets, wire and nylon net. Two rows were set up to reflect an average of local growing practices. The other two were set up to a best practice system.

Local practices included individual drippers at the base of the melon plants, weekly side dressing of high analysis NPK fertiliser and mounded bare soil.

The best practice system included plastic mulch on the soil, drip tape and twice-weekly fertiliser injection, based on the current DPIF recommendation for fertigation of cucurbits. It was monitored weekly using petiole sap analysis.

The crop was harvested at least twice a week.

Yield results and fertiliser inputs were periodically updated on a white board located at the demonstration area and close to the roadway used by the growers.

Results and Discussion:

The difference in the growth rates of the two systems was obvious from day one. The best practice system grew much more quickly than the local practice system and covered the same size trellis in dense and lush

growth by week six. The other plants looked small, stunted, with smaller leaf size and open canopy, even though they were getting similar nutrition. The difference was pointed out to growers as they went past the plot to unload their produce.

This approach of having the demonstration out in the open was very effective as growers could see the fertiliser on the ground and the growth and fruit production in the crop. The growers were invited to view pest and disease control as it happened in the crop and to discuss fertiliser application and crop rotation strategies.

The trial produced the predicted result with the yield on the best practice system of 21.1 t/ha from 12 weeks production. The yield from the rows using local growing methods was 8.65 t/ha. At current prices this equates to an increase in income of $21,175/ha for slightly higher establishment and input costs .Not all of this increase in yield is marketable but it substantially increases the margin available in the crop.

The key technical finding was the pattern of production and growth cycles of the plants illustrated in Figure 1. The first production peak at 11 weeks was the strongest fruiting obtained. It is this crop that the local growers miss out on as the plants grown under the local systems do not achieve the leaf area needed to fill the first fruit load.

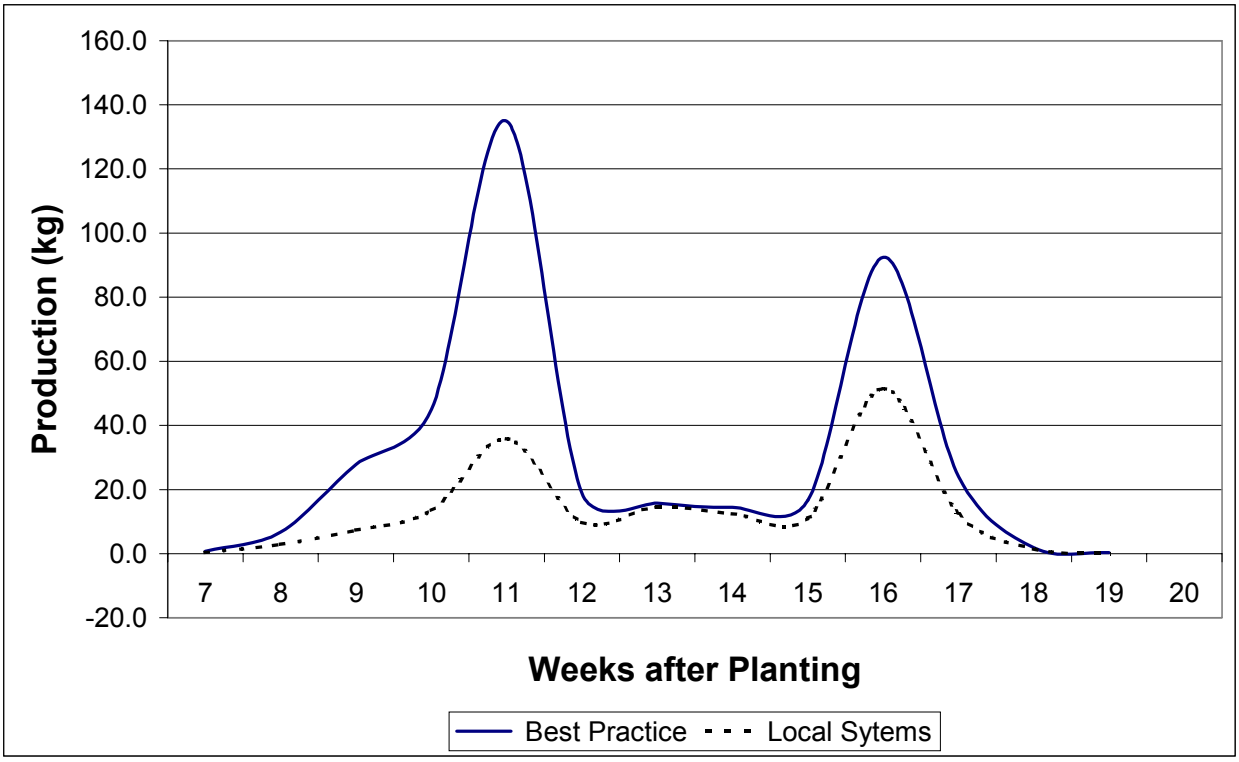


Figure 1. Asian vegetable demonstration plot for 2000

As the growth of the crop grown under local practices caught up to the best practice system the amount of fruit produced in the fruiting cycle started to even out. This has in the past given growers a false sense of achievement as they know they can get a “good” stand of bitter melon eventually. What they did not realise was the amount of first fruit they missed.

The demonstration met some of its objectives. There has been an increase in the number of growers picking up some of the components of the best practice system. It clearly demonstrated that there was no secret to the increased potential yields that were available to each grower. The final report presented to the Asian Vegetable Association stressed the value of adoption of the best practice system and was received positively by the group.

Future Activities:

The demonstration plot at the Melon Patch and TPFM has become a focal point for vegetable growers to look at the best practice systems and should be used in the future to demonstrate green manure crops and other aspects of sustainable vegetable growing systems in the Top End. It is a neutral place where growers feel comfortable to attend workshops, which will include any future demonstration crops and provides a constant reminder for improvements that can be made without the growers having to deviate from their current routines.

Acknowledgements:

We would like to thank Lien Truong for provision of the seed of the local bitter melon selection, Laurence Ah Toy of the Melon Patch, Koolpinyah Station, for provision of the land and services and Bill Gilbert of Territory Produce Freight Management for his support and constant liaison with growers.

PROJECT: Vegetable Management Trial 2000

Project Officers: M. Darcey, M. Gosbee, M. Traynor, E. Maroulis and P. Hopkinson

Location: CPHRF

Objective:

- ***To demonstrate the yield and quality advantages of the DPIF vegetable 'package' which includes plastic mulch, 'T' tape, cover crops, hybrid varieties and fertigation.***
- ***To improve the adoption of more sustainable and profitable vegetable production techniques through quantifiable treatment effects.***

Background:

DPIF has invested significant resources in developing a management package to produce vegetables in the Darwin region. The ‘package’ includes the use of a cover crop in rotation with the vegetable crop, the use of plastic mulch and ‘T’ tape into which the crop is sown and the use of hybrid vegetable varieties, which are expected to produce greater yields. Due to a change in growers entering the industry and a significant shift in commodities grown the ‘package’ has not been widely adopted.

DPIF has conducted regular demonstration plots on growers' properties but little emphasis has been placed on the profitability of adopting the ‘package’ or new technology.

Method:

- Treatments
- Plus and minus plastic mulch with ‘T’ tape
- Open pollinated (OP) versus hybrid okra variety

Both treatments were repeated in cover crop and non-cover crop situations. Therefore:

1.	Traditional	No plastic mulch and drip irrigation Variety -open pollinated local selection (Clemson’s Spineless)
2.	Traditional H	No plastic mulch and drip irrigation Variety – selected hybrid (Spring Pearl)
3.	Package	Plastic mulch and ‘T’ tape irrigation Variety -open pollinated local selection (Clemson’s Spineless)

4. Package H Plastic mulch and 'T' tape irrigation
Variety –selected hybrid (Spring Pearl)

Trial design
The trial was a randomised complete block design with treatments randomised along 20-m rows spaced at 1.5m between rows. There were 10 plants per plot (8 datum plants) with 0.5-m plant spacing along rows.

Management:

The crop was planted on 21 June 2000 and harvested between the end of July and October 2000. The following nutrients were injected into the T-tape irrigation system:

25N: 5P: 18K kg/ha/week was used for early growth up to flowering.
12N: 5P: 18K: 5Ca kg/ha/week was used after initial fruit set or about six weeks onwards.

Lime and basal fertiliser were applied pre-planting. The necessary trace elements were injected during early crop growth. The trial irrigation was carefully monitored with soil moisture tensiometers at depths of 20 and 40 cm.

Pest and disease control was performed as required. All cultural practices were consistent with DPIF and West Industry practices.

Results:

Adoption of the DPIF 'package' for vegetable management significantly increased yields of okra in this trial. The effect of cover crop could not be included in the analysis, as it was not replicated; however the trends between cover crop and non-cover crop is interesting.

Cover crop area
There was significantly more okra produced by the hybrid compared with the open-pollinated (OP) okra variety, and plants grown with mulch produced a significantly greater number of fruit compared with no mulch. No interaction between the mulch and variety was present (Table 1). In terms of the total weight of okra produced however, there was a significant difference due to the mulch but not the variety. The interaction between mulch and variety was not significant. The average weight per fruit was significantly greater on plastic mulch compared with bare soil and the OP variety was significantly heavier compared to the hybrid variety.

Table 1. Total number, total weight (g) and average individual fruit weight (g) of okra grown on soil with a cover crop

	Total number	**Total weight (g)**	**Average weight (g)**
No plastic mulch	751 a	12,810 a	17.15 a
Plastic Mulch	898 b	15,693 b	17.65 b
Hybrid	890 b	14,176 a	15.90 a
Open Pollinated	758 a	14,327 a	18.90 b

Okra was grown either with or without plastic mulch and either a hybrid or open pollinated variety was used. Values between pairs of treatments followed by different letters are significantly different ($p<0.05$).

When the treatments are compared as a group (Table 2) the results suggest:

1. The combination of hybrid variety and plastic mulch produced the greatest number of fruit;
2. The use of plastic mulch increased fruit number regardless of whether the hybrid or OP variety was used; and
3. OP variety produced the heaviest individual fruit.

Table 2. Effects of interaction of treatment combinations of plastic mulch/no plastic mulch and hybrid or open pollinated okra varieties on total number and weight (g) of okra harvested and average individual fruit weight (g) of okra produced when grown with a cover crop

	Total number	Total weight ** (g)	Average weight * (g)
No mulch/Hybrid	800 a	12,533 a	15.71 a
No mulch/OP	702 a	13,087 a	18.60 b
Plastic/Hybrid	980 b	15,819 b	16.10 a
Plastic/OP	815 a	15,566 b	19.21 b

Values between pairs of treatments followed by different letters are significantly different ($p<0.05$).
* The significant differences in these columns can be explained by the main effect of variety.
** The significant differences in this column can be explained by the main effect of mulch.

Non-cover crop area
As with the cover crop area the total fruit number was significantly greater for both plastic mulch and hybrid variety treatments (Table 3). The total weight was significantly greater from the mulch treatment compared with no mulch but not variety. Interestingly a significant difference in average weight was found between varieties only as opposed to the cover crop area, which showed a heavier fruit under mulch compared with no mulch.

Table 3. Total number, weight (g) and average individual fruit weight (g) of okra grown on soil without a cover crop

	Total number	Total weight (g)	Average weight (g)
No Plastic Mulch	593.5 a	9,239 a	15.85 a
Plastic Mulch	849.1 b	13,875 b	16.30 a
Hybrid	774.5 b	11,408 a	14.66 a
Open Pollinated	668.1 a	11,706 a	17.49 b

Okra was grown either with or without plastic mulch and either a hybrid or open pollinated variety was used. Values between pairs of treatments followed by different letters are significantly different ($p<0.05$).

When the treatments are compared as a group (Table 4) the results indicated the same response as was found in the cover crop area; however, the actual increases were greater. The benefits of adopting parts of 'the package' were greater when introduced on poor soils.

1. The Plastic/hybrid treatment combination produced the greatest fruit number.
2. The use of plastic mulch produced the greatest harvested weight regardless of variety.
3. OP variety produced the heaviest individual fruit irrespective of whether mulch was used.

Table 4. Effects of interaction of treatment combinations of plastic mulch/no plastic mulch and hybrid or open pollinated okra varieties on total number, weight (g) and average weight (g) of okra produced when grown on ground without a cover crop

	Total number	Total weight (g)	Average weight** (g)
No mulch/Hybrid	620.7 a	8,664 a	14.35 a
No mulch/OP	566.2 a	9,814 b	17.35 b
Plastic/Hybrid	928.2 c	14,152 c	14.98 a
Plastic/OP	770.0 b	13,598 c	17.63 b

Values between pairs of treatments followed by different letters are significantly different ($p<0.05$).
** The significant differences in this column can be explained by the main effect of variety.

Results:

Extension messages
Because okra is packed as small fruits in 10 kilogram boxes (pack by volume) yield is best described as the number of fruits per growing area (in this case, per plot). The treatment effects between cover crop area and non-cover crop area cannot be analysed; however the trends are important.

The Key extension messages from the research include:

1. Plastic mulch significantly increases okra fruit yield.
2. Mulch works both with and without cover crops.
3. Mulch is even more important if you do not use cover crops.
4. Cover crops are most important if you do not use mulch.
5. You can still expect greater yields from cover crops if you use mulch.
6. Spring Pearl variety (Hybrid) produced significantly more fruit than Clemson's Spineless (the local variety).
7. Clemson's Spineless was 16% heavier (per fruit) than Spring Pearl.
8. Cover crops increased the fruit yield of both Clemson's Spineless (local variety) and Spring Pearl (Hybrid).

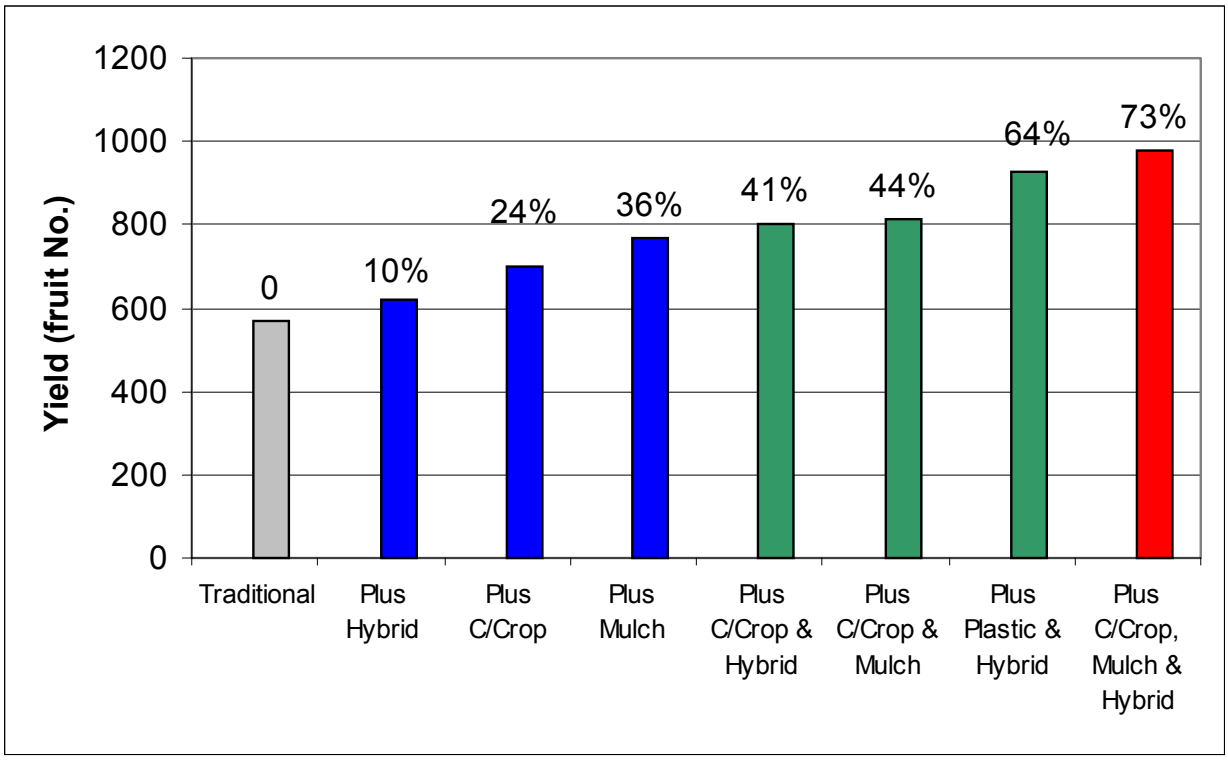


Figure 1. The percentage increase in fruit numbers attributable to each component of the 'package' over the 'traditional' growing technique

Profitability
A key component of this trial was to ascertain the relative financial benefit to growers of adopting the 'package' or parts of it. Using the following assumptions, gross margins per hectare for the various 'package' components were developed.

Assumptions
1. The price of okra was $4.50/kg.
2. The variable costs of producing okra are very similar to capsicum.
3. Plastic mulch and 'T' tape cost $4000/ha.
4. Hybrid seed costs $100/ha.
5. Cover crops cost $100/ha.

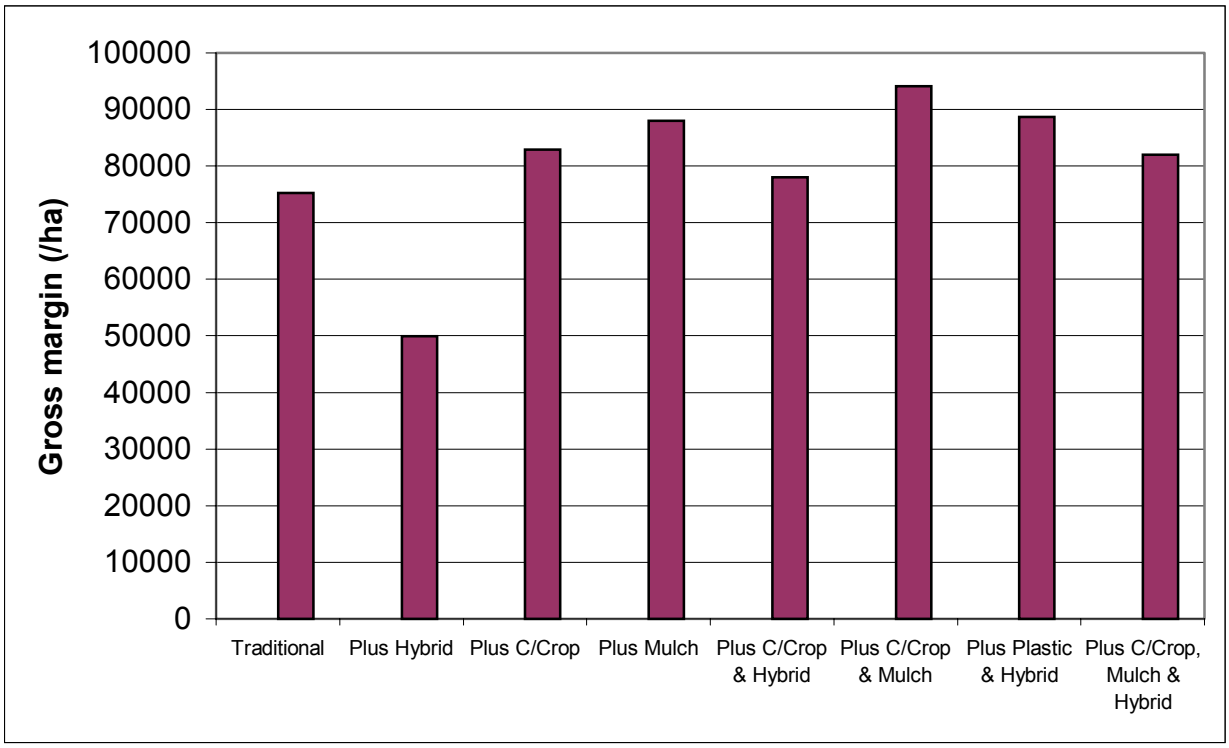


Figure 2. Relative gross margin returns

Figure 2 shows that the greatest gross margin per hectare return was achieved with the use of cover crops and plastic mulch.

SUBPROGRAM: Vegetables

PROJECT: Improved Management Strategies and Vegetable Products for the NT (Identify Vegetable Types Suitable to the Helen Springs region)

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

Location: Helen Springs Station

Objective:

- ***To identify cultivars suitable for both existing and potential markets when grown in the various regions of the Northern Territory.***
- ***To determine a range of vegetable management strategies for various regions.***
- ***To assist growers to optimise their returns by producing vegetables of the required cultivar and quality for the target market.***

In 1998 the possibilities of diversification into vegetable production on a cattle property located 550 km south of Katherine and 120 km north of Tennant Creek were discussed. It was decided that the department would supervise a horticultural planting trial on the property.

Method:

The planting area was an observation block where several varieties of vegetables would be trialled and those that were deemed to have potential would be studied further. Watermelons, pumpkins, rock melons, honeydew melons and corn were among the crops studied. The initial trial crop was planted in the Wet season. It was uncertain whether growing such crops during that time of the year would be successful because of potential disease problems. The trial was therefore treated as a practice run before the Dry season crop was planted.

Results and discussion:

Due to numerous difficulties the crops were quite poor. It is interesting to note that as the crops approached harvest more interest in the plot was observed from employees. Production of all crops was greatly reduced because of a lack of pollinators in the region. Most of the fruit aborted prior to maturity. Beehives were recommended for the site but were not obtained.

Because of the great distances involved we were able only to visit the site once a fortnight. This meant that at best a problem would be identified one day after it occurred, at worst 14 days after it occurred. Due to several reasons, the successful production of horticultural crops was restricted. The reasons included lack of infrastructure to perform tasks, delays in amending problems due to distance, lack of pollinators and waterlogging.

Growing conditions were not favourable due to the prolonged Wet season. The constant windy conditions during the growing season may require future trials to include windbreaks either side of the plot. The windbreaks could include barna grass, forage sorghum and millet.

If more properties and communities in the region express the need for diversification to horticulture it may be necessary to locate a horticultural extension officer at Tennant Creek.

Further evaluation of diversification to horticultural crops is probably not practical for the department given the distances involved. There is a need for a more comprehensive evaluation of several crops once the limitations are addressed. This would involve locating an externally funded officer nearer the crop production area.

PROJECT: Improved Management Strategies and Vegetable Products for the NT (Vegetable Grower Discussion Groups – Katherine)

Project Officer: J. Bright

Location: Katherine Region

Objective:

- ***To identify cultivars suitable for growing in the various regions of the Northern Territory for both current and potential markets.***
- ***To determine a range of vegetable management strategies for various regions.***
- ***To assist growers to optimise their returns from the production of vegetables of the required cultivar and quality for the target market.***

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

Nutrition:

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

Irrigation:

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

Cultivars:

- Cultivar trials for a range of crops.

Post-harvest:

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

Entomology:

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

Pathology:

- Etching of butternuts.
- Fungicide pre harvest.

Management:

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

Weeds:

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

Land and water:

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

The above items were voted on (in a ranking type system) and even the people that raised them saw several of the items as being not so important.

It was pointed out to the growers that several of the issues raised were in fact items that the grower could look at himself, that is on farm research, with the assistance of DPIF. This has happened in a few cases giving in departmental staff more time to address pressing issues.

Another Katherine vegetable growers' meeting was held in March 2001. At this meeting a report was presented to the growers on what the issues were for last season and how they were addressed. Several “new” vegetable growers were present at the 2001 meeting. When asked what were the potential issues for the year, the new growers said that they had no issues as they had no experience growing vegetable in the region yet. The experienced growers listed wireworm control, cover crops and irrigation efficiencies as some of the issues.

SUBPROGRAM: Bamboo

PROJECT: Bamboo

Project Officer: M. Traynor

Location: CPHRF

Objective:

In the wake of poor preformance by B. oldhamii, to try other bamboo species suitable for local conditions.

Due to the poor performance of *B.oldhamii*, project participants decided to terminate research on that species and concentrate on the species preferred by researchers and local growers. The trial of *B.oldhamii* was discontinued in May 1999 and replaced with *D.latiflorus* and *D.asper* in November 1999.

***D. Latiflorus* – Preliminary Observations:**

Shoot size in clumping bamboos is strongly affected by the number of culms or stems per clump. Fewer culms for the rhizome to support means larger shoots will be produced. The effect of total culm number and their age on shoot and culm diameter is a component of future research. The seven plants of *D.latiflorus* in the variety collection at CPHRF have been harvested during the last three Wet seasons. These clumps have been managed with a total of 18 culms per clump. This means that after each yearly thinning, three generations of culms remain (six each of one, two and three year old). The shoot yield data for these clumps is presented in table 1. Shoots were graded by base diameter of cut and trimmed shoots.

Table 1. *D. Latiflorus* shoot yield (kg) average of seven clumps

Harvest season	90 mm		100 mm		110 mm		120 mm		130 mm		Total shoots	Total weight	Av shoot weight
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.			
1998/1999	8	6.09	10	10.03	7	9.14	5	8.15	2	4.24	33	37.65	1.13
1999/2000	5	3.67	7	6.57	5	6.52	4	6.12	2	4.83	24	27.70	1.17
2000/2001	4	2.98	6	6.04	5	6.24	4	5.30	2	4.26	22	24.82	1.14
Av. grade Wt.		0.74		0.95		1.25		1.47		1.89			
% shoots/grade	21.5		30.4		22.8		16.4		8.9				

Av. = Average, Wt. = Weight.

From Table 1, several points regarding the performance of *D.latiflorus* are worth noting:

- At 200 clumps/ha yields range from 5.0 to 7.5 tonnes/ha.
- Average shoot weight over three harvests remains constant.
- Shoot number seems variable and could be a result of the intensity and duration of Wet season rainfall.
- There appears to be a high percentage of shoots of less than 1.0 kg. The culm density of 18 may be restricting potential shoot size.
- The sample of *D.latiflorus* clumps is too small to draw firm conclusions from this data.

Future Research:

The ‘vegetable bamboo shoot production’ project will focus research on the following activities:

- 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 growers' sites.
- Thinning rate investigations on grower sites with *D.asper* and *D.latiflorus* in relation to shoot size and yield.
- Post harvest research and marketing studies of fresh bamboo shoots.
- Shoot covering techniques to maximise eating quality.

Acknowledgments:

This research is partially funded by ACIAR and involves the Central Queensland University, two local commercial growers and CPHRF.

PROGRAM: Fruit Industry

SUBPROGRAM: Mango

PROJECT: Mango Varietal Trials (Evaluation of Mango Selections and Lines in the Katherine Region)

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

Location: KRS

Objective:

- ***Develop and release new cultivars with potential in identified domestic and export markets.***
- ***Expand the harvest season with cultivars maturing earlier and later than Kensington Pride.***

The final phase of the "Monoembryonic seedling selection" trial has been initiated. This trial involved the collection and planting out of 550 seedlings from Glenn trees growing at six different pollination distances from Kensington Pride trees. An explanation of this project has been published in previous Horticulture Division Technical Annual Reports under the project "Monoembryonic Seedling Selection".

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

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

2. Optimum Tree Density sub-project - Determining the optimum tree density for evaluating breeding trials by examining how close mango seedlings can be planted without affecting seedling performance and assessment.

3. Juvenility sub-project - Examine whether cultivars that are quick to come into bearing as grafted trees pass on this characteristic to their progeny.

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

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

In 1998/99 several of the rootstock trees in the juvenility sub-project were grafted. Replants were carried out where plants had died. These sites will be treated as missing sites.

Progress report:

Monoembryonic Seedling Selection Sub-project
Of the 550 original Glenn/Kensington Pride trees planted at Katherine Research Station as part of the project "Monoembryonic Seedling Selection", four have been chosen for further evaluation. These four trees were grafted on to Red Cross common rootstocks and will be compared with numerous cultivars that may have potential in the region. The cultivars were planted in May 2001. Selections of the monoembryonic seedlings

include N10E10 (treatment E), N10E56 (treatment C), N8E54 (treatment C) and N6E35 (treatment C) where:

Treatment C is Manbulloo 1st Glenn tree beside Kensington Pride

Treatment E is Manbulloo 1st Glenn tree beside Kensington Pride from Kensington Pride side only.

Other cultivars being assessed include Kensington Pride (as the industry "Standard"), Celebration, Chene, Joa, Neldica, E10-5/3 and Heidii. Selections from the national breeding trial, Tango and Honey Gold were requested but the breeders felt it was not appropriate to include these cultivars in this trial.

Breeding sub-project
There are no results from this sub-project at present.

Optimum high density planting sub-project
Measurements of trunk circumferences at 20 cm above ground reveal a trend for larger circumferences for the tree at wider spacings (see Table 1).

Table 1. Girth circumferences at different spacings

Spacing (m)	Circumferences (cm) 2000	Circumferences (cm) 2001
1	30.2	36.65*
2	34.5	37.08
3	34.9	40.18
3.5	35	41.9*

* Significantly different (p=0.05).

Flowering for 2000 included six trees at 3.5 m, four trees at 3 m, four trees at 2 m and two trees at 1 m. Given these figures, it would appear that in a breeding trial situation where trees are only in the ground for four years we may be better off to plant out at the 2 m and 1 m spacing rather than the 3.5 m or 3 m spacing. On a per hectare basis, this would be at 5 m between rows. We will have more plants flowering and available for assessing and therefore a greater efficiency. See Table 2.

Table 2. Number of trees that flowered in trial and on a per hectare basis

Spacing	3.5 m	3 m	2 m	1 m
Plants per hectare	571	666	1000	2000
Flowered 1999	1	0	0	0
Flowered/ha 1999	17	0	0	0
Flowered 2000	5	4	4	2
Flowered/ha 2000	89	83	125	125
Total flowered in two years	106	83	125	125

Assessment will continue for 2001.

Juvenility sub-project
This trial has experienced some tree losses. Despite this it is becoming quite clear that parent seed is having an effect on the length of the juvenile period of its progeny. The trend was expected.

Table 3. Proportion of trees fruiting in juvenility trial 2000

Seed Parent	% Fruiting in 2000	*Fraction fruiting*
Lippens	0	0/21
Zill	8.1	3/37
Irwin	9.7	3/31
Royal Special	19.2	5/26
Willard	38.5	10/26

Also of interest at this stage of the trial is that the Irwin density trial has approximately 12% fruiting which is on par with Irwin in this trial. Tree vigour differences are being observed between the different cultivars.

PROJECT: The National Mango Breeding Program

Project Officers: V. Kulkarni and D. Hamilton

Location: Mareeba's South Edge Research Station (SERS) and CPHRF

Objective:

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

Background:

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

Method:

Progeny was produced through controlled crossing using hand pollination techniques. A total of 38 parental combinations were crossed to generate hybrids. In all but a few cases Kensington Pride (KP) pollen was used as the male parent. Each hybrid seedling was replicated once by means of grafting onto a KP seedling. All of the grafted hybrids were planted at SERS, and all of the original seedlings were planted at CPHRF for screening. Initial screening and selection of promising hybrids will be done at both sites. Further evaluation of the selected trees will be carried out in the major growing regions in larger field trials to determine their commercial suitability.

Results:

In the first phase of the program, from 1994 to 1997 approximately 1,851 progenies were produced between the four agencies.

The second phase of the program, the initial selection and characterisation of the hybrids, commenced in 1999-2000. At SERS some 343 hybrids produced fruit, while only 30 produced fruit at CPHRF. Approximately 30 of the hybrids appeared to have some promising features and were displayed at a presentation of fruits to industry representatives in both Queensland and the Northern Territory. These presentations were very warmly received.

Six hybrids were selected out of the 343 evaluated at SERS in the 1999-2000 season for further evaluation on research stations. They consisted of two Irwin x Kensington, Palmer x Kensington, Lippens x Kensington, Van Dyke x Kensington and Glenn x Kensington. In the 2000-2001 season, of another 690 hybrids evaluated, four more were selected for further evaluation. These were Haden x Kensington, Glenn x Kensington, Irwin x Kensington and Tommy Atkins x Kensington.

Another 75, somewhat promising hybrids, have been selected on the “B” list, 27 from 1999-2000, and 48 from 2000-2001. Growers located throughout the various mango districts will further evaluate a selection of the best of these hybrids at a later date.

Phase three of the project has commenced with the planting of replicated evaluation plots of the 10 "A" selections at SERS and CPHRF. A few old seedling trees have also been top worked with A selections. These trees are expected to start fruiting much earlier than the young grafted plants.

A common set of evaluation criteria was developed for the two sites. Three specific objectives were considered while selecting these criteria.

1. Identification of outstanding hybrids and their comparison.

2. Inheritance studies including an assessment of relative expression of different characteristics for determining dominance.

3. Comparison of parents to identify preferred donor cultivars for selected traits.

Preliminary Analysis of Inheritance of Characters

General Comments:

Assessment was carried out on the limited hybrid lines that produced fruit in the 1999/2000 season. In most cases the numbers of hybrids in any one parental combination were small, limiting our analysis of many characteristics at this stage. However some of the early trends are discussed below. Many are based on hybrids of Irwin and Kensington Pride that were well represented (39 hybrids) in the cropping trees

Blush Colour (orange, pink, red, and burgundy)
Scoring was generally consistent, although there was not always a clear distinction between categories 3 (red) and 4 (burgundy). One line of Irwin x KP was scored separately as 1 (orange) and 3 (red). Of the 39 Irwin x KP hybrids assessed, 28 (72%) were scored as having red or burgundy blush colour. In this combination, therefore, red blush colour can be considered an incompletely dominant character.

Embryo Type (polyembryonic, monoembryonic)
The hybrids between Irwin and KP gave 19 mono to 16 poly. Other combinations involving monoembryonic female parents and KP as pollen donor indicated 1:1segregation for this character. A similar pattern was seen when polyembryonic Nam Dok Mai was used as a pollen parent, suggesting that Kensington Pride and Nam Dok Mai are both heterozygous for gene(s) conditioning polyembryony. The 1:1 segregation is consistent with polyembyony being controlled by a single dominant gene, as suggested by Aron et al. (1998) but in contrast to earlier studies.

Flavour (unacceptable, Floridian, Indian, Kensington, and South East Asian)
Scoring was consistent, given the inherent difficulties in categorising fruit flavour, as well as possible variation according to fruit maturity. In the combination Irwin x KP, 23 of the hybrids (58%) were scored as having KP flavour, suggesting incomplete dominance of this character, or alternatively heterozygous for genes controlling production of the unique flavour compounds in KP.

Fruit Weight
There was really very good consistency in this character between different samples of a given line. There was a wide distribution of fruit. Thus, although most of the Irwin x KP hybrids (74%) fell in the range 300 – 600 g, there were five lines with fruit below 300 g, and two with fruit greater than 1,000 g. This suggests transgressive segregation of genes controlling fruit size in mango, since many lines are producing smaller or larger fruit than the parents Irwin (262 g, previously) and KP (414 g, previously).

Pulp Texture (Common, Tommy Atkins, R 2 E2, Kensington and Nam Doc Mai)
There was remarkable consistency in scoring of this character. In the Irwin x KP hybrids, pulp texture category 4 predominates with 22 (or 56%) scored as KP-type.

PROJECT: Improvement of Mango Production through the Manipulation of Flowering

Project Officers: V. Kulkarni and D. Hamilton

Location: CPHRF and Commercial Orchards

Objective:

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

Experiment 1. Mango Flowering Project

Background:

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

Method:

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

Results:

In 2000, the second year of the project, fortnightly observations of flowering during May-August indicated that the potential for fruit production was generally higher in the P treatment than in the M and C treatments (Figure 1). Harvest data confirmed that the greater flowering observed in P was reflected in greater numbers of fruit compared with the other two treatments, which were similar (Figure 2). There was little difference in average fruit weight between the treatments with fruit from all treatments being in the range of 0.51 0.55 kg. This project concludes in 2001. More detailed results will be provided later.

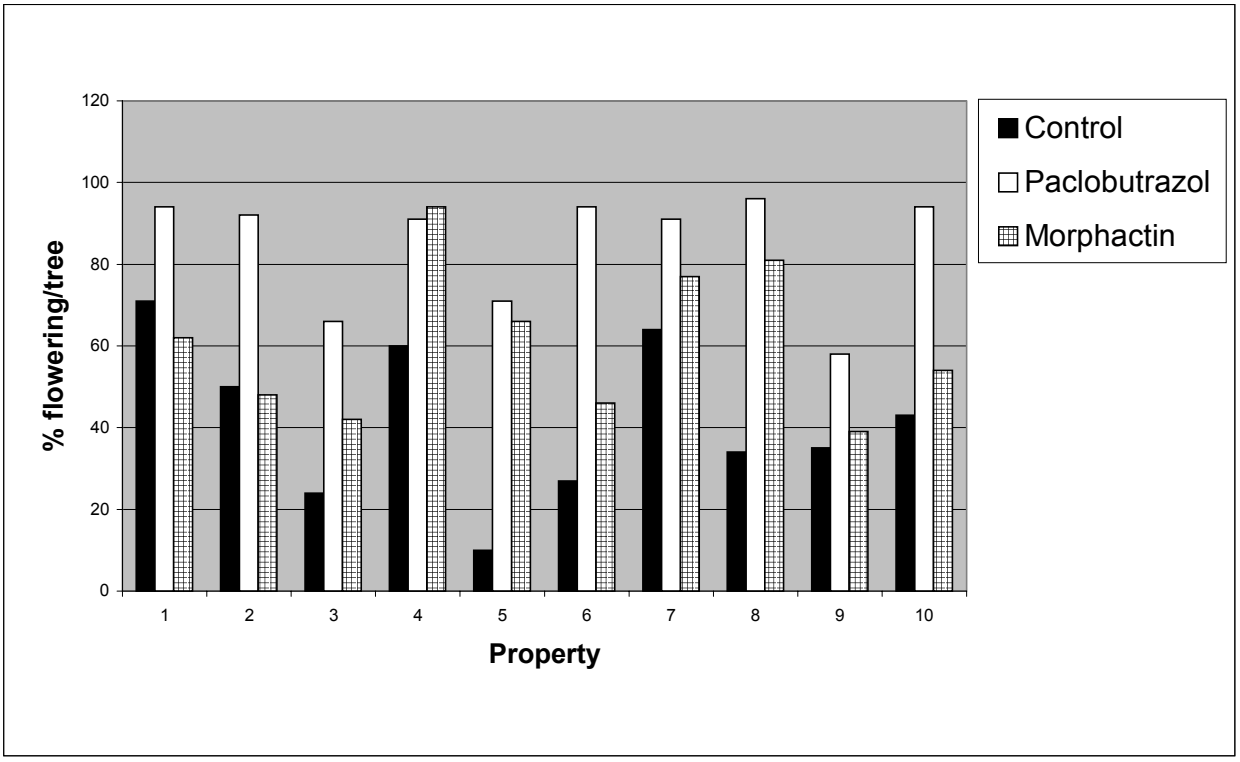


Figure 1. Flowering summary, 2000

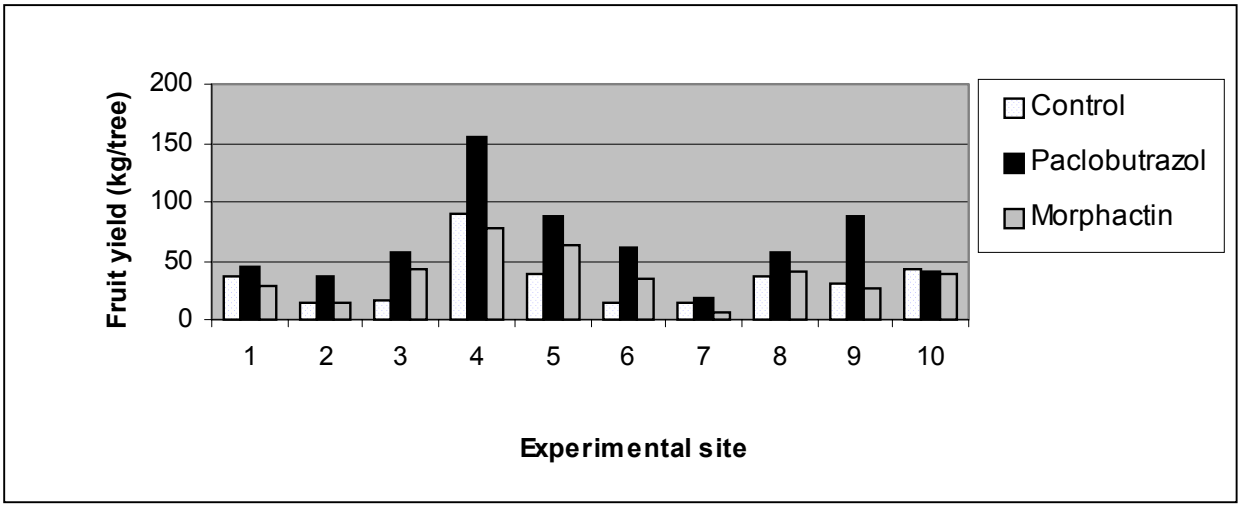


Figure 2. Yield of marketable fruit, 2000

Experiment 2. Effect of Root Pruning on the Productivity of Kensington Pride

Background:

Root pruning has been used commercially to reduce tree size and promote flowering and fruiting in tree crops such as apples. It has been particularly effective at reducing vigorous vegetative growth.

Kensington Pride (KP) normally produces very vigorous vegetative growth throughout six months of the year. As a result growers are faced with the ever-increasing size of trees with reduced yield efficiency. Treatments that reduce the vigour of KP tend to increase flowering and thence yield efficiency. Current practices to improve tree productivity, such as the use of plant growth retardants, pruning and irrigation techniques produce unreliable results. Root pruning offers a non-chemical alternative. A previous trial using root pruning on eight-year-old trees over one season showed improved productivity of trees where tree size was reduced

and fruit numbers increased substantially. The aim of this experiment was to assess the effects of root pruning on KP mango at an earlier age while tree size is still manageable.

Method:

Five-year-old KP trees, grown at a spacing of 7 m x 7 m, was selected for this trial over a three-year period. Root pruning treatments were applied in December and April. A trenching machine was used to cut the roots at a distance of 0.6 m from the trunk, and at a depth of 0.6 m. Treatments were replicated four times in a randomised design:

- Two cuts in December
- Four cuts in December
- Two cuts in April
- Four cuts in April
- No root pruning

The following measurements were recorded: amount of vegetative growth, yield, leaf nutrient status, photosynthesis and post-harvest quality parameters.

Results:

Increased root pruning consequently reduced vegetative growth the most (Figure 3). Four cuts reduced growth by two thirds compared with the non-root pruning treatment. Consequently, the yield of treatment 2 was almost three times greater than treatment 5 with no root pruning (Figure 4). Similarly, yields of treatment 4, four cuts in April, were three times greater than treatment 5. Reduced vegetative growth (not shown) was not a factor implicated in increased yield in this case, as treatment 4 was applied four months after substantial growth had already occurred.

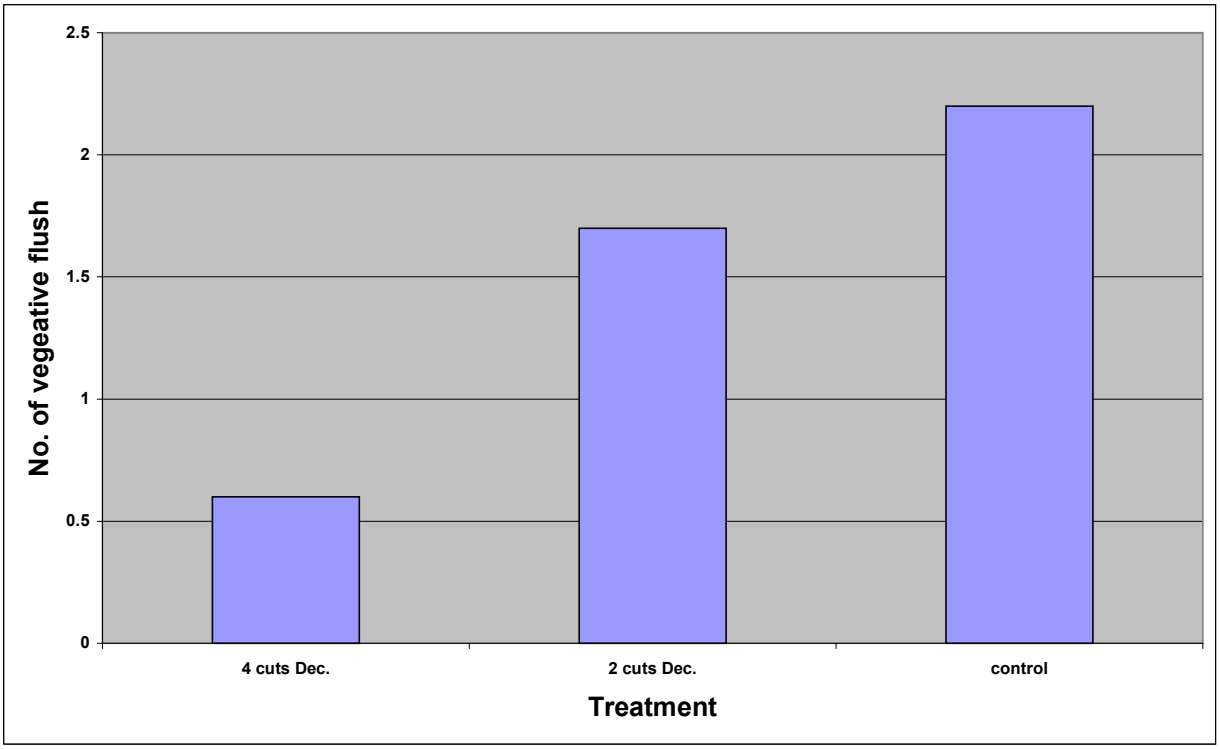


Figure 3. Amount of vegetative growth flush

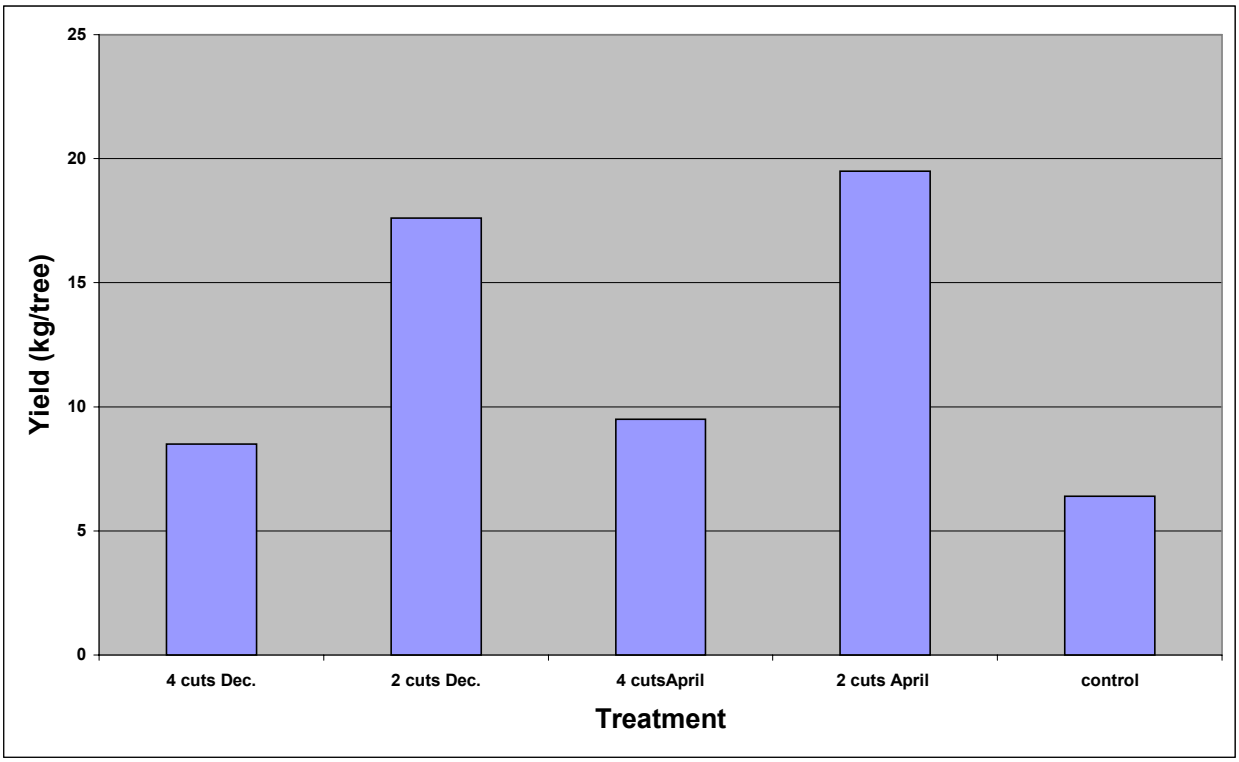


Figure 4. Effect of root pruning on yield

Photosynthesis rates measured prior to flowering showed substantially reduced rates for treatments with four root pruning cuts in December and April, compared with the non root pruning treatment (Table 1). This finding could be an indication of a feedback inhibition effect with high carbohydrate levels, as yields were substantially higher in these treatments compared to the control. Leaf nutrient levels were measured prior to flowering also (results not shown). The nitrogen levels were similar for each of the treatments and above the

standard level. Calcium levels, however, were similar for each of the treatments, but below the standard level. Potassium levels were similar for all treatments, and within the standard range for all treatments. Similar results are shown for magnesium levels. Phosphorus levels were all below the respective standard level, but tended to decrease with an increased number of cuts. Boron levels were similar for all treatments and within the standard range. Zinc levels were similar but below the standard level for all treatments.

Table 1. Effect of root pruning on photosynthesis rates

Treatments	**Treatment 1** 2 cuts in December	**Treatment 2** 4 cuts in December	**Treatment 3** 2 cuts in April	**Treatment 4** 4 cuts in April	**Treatment 5** pruning
Photosynthesis rate	7.2	4.7	6.5	4.7	8.5

The above results show that root pruning can substantially reduce vegetative growth, if done early in the growth season, and subsequently lead to increased yields compared to non root pruned trees. Nevertheless, the results also show that imposing a root pruning treatment after the growth season can also lead to increased yields. These findings are similar to a trial reported on earlier in which much larger trees were subjected to the same treatments. However, we did not measure photosynthesis in that previous study, but the result shows here that perhaps with the production of increased carbohydrate levels in root pruned trees photosynthesis is shut down temporarily. As one would expect photosynthesis would certainly contribute to the yielding capacity of the tree. The above findings suggest that certain root pruning treatments may allow trees to assimilate and distribute assimilates more efficiently than non- root pruned trees. When this project concludes, more detailed results will be provided.

PROJECT: Improvement of Mango Productivity - Project in Katherine

Project Officers: J. Mansfield, T. Maddern, C. Kinnaird and R. Renfree

Location: Co-operators' properties in the Katherine Region

Objective:

- ***To increase regular, early and profuse flowering and fruiting in Kensington Pride mango in the NT.***
- ***To develop a high density planting system as an option for NT conditions.***
- ***Adoption of complete management systems for optimum sustainable production for the 2002 mango season by the majority of industry.***

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

Method:

In a joint study between staff in the Darwin and Katherine regions, six sites in both regions have been selected for evaluation. At the Katherine sites tree performance, climatic and management parameters are being measured. The performance of trees is being assessed by determining their growth patterns (recording at what time of the year the trees are producing new leaves, flowers or fruit), the yield and fruit quality. Data

loggers are used to record temperature and relative humidity. The management of trees is assessed by taking soil samples to monitor soil nutritional status, leaf samples to monitor leaf nutritional status and irrigation inputs using water meters. In addition the growers are recording when and how much fertiliser they apply and when they carry out other management operations. From this information, the relations between tree performance and climatic and management factors will be assessed. The trial started in Katherine region in July 1998. The sites were visited weekly in 1998 and 1999 seasons, fortnightly in 2000 and monthly in 2001, to take readings and samples.

Results and Discussion:

Monitoring in this project will cease with the harvest in November 2001. All the data from the three years of this project is being recorded in databases for analyses. It is anticipated to use this information in conjunction with data collected by the CSIRO Horticulture staff in Darwin to develop a model on mango growth.

PROJECT: Foliar Nitrogen Nutrition Trials in Mango

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

Location: KRS

Objective:

- ***To investigate the role of nutrition in the productivity of trees.***
- ***To standardise nutrition management practices in the Darwin and Katherine regions.***

The nitrogen nutrition of mango remains an area of much debate and confusion. Over the last decade in the NT there have been major swings in the quantity of nitrogen recommended for commercial orchards. Current rates range from zero to 300 g N per tree per year. Foliar application of nitrogen has received limited attention.

Method:

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

Results:

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

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

Although there were no significant differences between treatment groups on quantity (weight and number) of fruit produced, during the five years (1996-2000), the control group (no nitrogen) produced significantly fewer fruit than some of the groups that received nitrogen. Overall the application of nitrogen at golf ball and post harvest stage resulted in significantly more fruit than in the control group. Also, the rate of 140 g appears to be more productive than the control, with no detrimental post harvest blemishes. Again using Bonferroni's inequalities, we conclude:

- Control versus nitrogen treatments: Nitrogen applied groups produced significantly higher cumulative marketable weights and numbers of fruit than controls ($p<0.05$).
- Timing of nitrogen: Post harvest and at golf ball size applications gave significantly higher marketable weight and numbers of fruit than controls ($p=0.05$).
- Nitrogen rates: Trees that received 140 g nitrogen gave significantly higher marketable weight and number of fruit ($p=0.05$) than controls. There is suggestion here of a linear relationship; that is as the rate of nitrogen application increases, the cumulative marketable weight of fruit also increases.
- Interaction between timing and nitrogen rates: The application of 140 g nitrogen post harvest, 140 g at golf ball size and 90 g golf ball size gave significantly higher marketable fruit weights and numbers ($p=0.05$) than did the control.

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

Discussion:

As mentioned last year data for individual years (from a statistical point of view) gives no indication of a significant difference between the rates of nitrogen applied and the timing of nitrogen application. The enormous variability produced in individual years is marginally overcome when we look at cumulative values for each of the treatments. It was thought last year that various strong trends that were not backed by statistical significance were worth noting. Some of the treatment means differ by more than 100% and yet the probability values were too high to be considered significant. I commented that 140 g nitrogen at golf ball size appeared to give a better yield in marketable weight and number than the other treatments. In 2000 the individual year analysis provided no significant differences in yield between timing and rates of nitrogen application. However, cumulative analysis support these previously identified trends using Bonferroni's inequalities. Perhaps in future trials with Kensington Pride, it would be necessary to consider cumulative values as well as individual yearly values in order to deal with the high variability of the crop.

The application of nitrogen has significantly increased fruit numbers and weights when compared with no nitrogen over the five-year period (cumulative years). Some applications of nitrogen (pre flowering) have caused excessive flush and had a detrimental effect on production. The nitrogen application at golf ball size appears to have given a good yield (fruit number and weight) when compared with other treatments. Over the five years the higher rate of nitrogen has produced higher marketable fruit weight and numbers. This was especially obvious (although not significant) in the higher yielding years 1997 and 1999. The other two treatments that were of significantly greater benefit (cumulatively) were 90 g at golf ball size and 140 g post harvest. The post harvest analysis has shown us that these high rates of nitrogen (which we increased in 1998 to purposely induce disorders in post harvest) are by no means enough to cause significant post harvest disorders. Perhaps current recommendations of rates of nitrogen should be reassessed.

It is interesting to note that the plants that were not given nitrogen (control) over the five-year period did not appear to be severely deficient as would be expected. Leaf analysis indicated that all trees were within the DPIF recommended optimum range. Perhaps we may also need to review leaf analysis. From this trial we can suggest that leaf analysis is not a very reliable source for determining yield potential. We can also assume from the leaf analysis that the control crops (0 nitrogen) are able to obtain nitrogen from other sources. This does not imply that no nitrogen be applied, because yield from these trees was well below that from the trees that received nitrogen.

PROJECT: Rootstock Effects on Mango Productivity - Katherine

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

Location: Co-operator properties in the Katherine Region

Objective:

- ***To evaluate potential rootstocks to control tree vigour and performance.***
- ***To identify salinity tolerant rootstocks for the Mataranka region.***

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

This project covers information published in previous Horticulture Division Technical Annual Reports under the titles "Root stocks for saline soil conditions" and "Rootstock effects on mango productivity".

Method:

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

Rootstocks included in the trial were:

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

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

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

The experiment sites, approximate conductivity, and planting dates are shown in Table 1

Table 1. Experimental location, conductivity and planting date

Site	Conductivity μS/cm	Planting date
Broome (WA)	3,900	May 1998
Mataranka (NT)	1,500	August 1997
Bowen (QLD)	3,000	Not Planted
Rockhampton (QLD)	Unknown	Not planted

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

Results and Discussion (progress report):

Rootstocks for saline soil conditions sub-project
The Mataranka trial crop was harvested for the first time in 2000. Several replants have not flowered this year. Although there were some obvious differences between rootstocks, the variability within each treatment was so large that no significant differences were reported. This high variation will decrease with age and cumulative yields over time. The Broome site was abandoned because of loss of plants.

Rootstock Evaluation on Blain and Tippera soil types sub-project
The Blain site crop was harvested for the first time in 2000.

The crop at the Tippera site was first harvested in 1999. As the plants are young an interpretation of the results is difficult since young trees give variable results. The analysis coefficient of variation was very high, more than 40%. In some instances certain rootstocks have not yet produced fruit. As the trees get older the variation is expected to decrease. Future work will analyse tree height and trunk circumference in an attempt to analyse yield efficiencies. Currently these trials are being evaluated to determine if they address current industry needs.

PROJECT: Effect of Temperature on Mango Quality

Project Officers: M. Gosbee and H. Jessup

Location: Berrimah Farm

Objective:

To replicate various handling scenarios on mangoes and record the effects on fruit quality.

Background:

The ideal temperature for ripening mangoes is between 18 and 22ºC. At temperatures of 15ºC or lower, fruit softens but flavour development is impaired, and fruit may taste acidic. Above 24ºC, skin colour development is retarded, and the fruit may retain some green colour on the skin (Jobin Decor MP 1988). Ambient temperatures in Darwin during October are usually 24 - 32ºC, and warmer than this in the rural area. Breaks or delays in cooling fruit are common. The effects of several of these handling possibilities on mango eating quality were evaluated.

Method:

Mature green mangoes cv 'Kensington Pride' were obtained from Berrimah Farm. Dry matter at harvest was 15.2%. Mangoes were desapped and 30 fruit were randomly allocated to one of six storage scenarios (Table 1). Fruit at 22 and 15 ºC was stored in separate cool rooms, while those at ambient temperatures were left in an outdoor shed. Core temperature of one mango per treatment was measured throughout the experiment (Figure 1). A temperature of 15ºC was chosen as in refrigerated trucks, for the four-day journey to southern markets. Fruit was then held at 22ºC until it became soft enough to eat.

Table 1. Intended temperature (ºC) regimes of the various treatments

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8 etc
Ideal	22	22	22	22	22	22	22	22
Low temp	15	15	15	15	22	22	22	22
Delay	35	15	15	15	15	22	22	22
2 day break	15	35	35	15	15	15	22	22
3 day break	15	35	35	35	15	15	15	22
Ambient	35	35	35	35	22	22	22	22

Actual core temperatures are presented in Figure 1.

Once fruit reached eating soft it was assessed for a range of parameters. Weight loss was calculated as the percentage of initial fruit weight lost from Day 0 of the experiment until eating soft. Eating quality was assess on a 9 point scale: 1 = terrible, 2 = off flavours, 5 = edible 7 = good and 9 = unbelievable. Brix was measured on two juice samples from each fruit and the average taken. Acidity was determined on frozen juice from 10 of the fruit from each treatment. A 5 mL sample of juice was titrated with 0.1 N NaOH using phenolphthalein indicator to determine acidity. Internal disorders and external disease symptoms or lenticel spotting were recorded, and the proportion of fruit with these problems calculated. The total of the fruit surface area affected by spotting or disease was also recorded. Skin colour was also assessed.

Results and Discussion:

Unfortunately, Darwin experienced the coldest October day for 30 years which meant that any treatments in ambient temperature on that day did not have the exposure to high temperatures that was expected. Fruit temperatures on that day remained at 25ºC, which was not very different from 22.3ºC, the temperature at which fruit from the 'ideal' treatment was stored. It was expected that the temperatures would be up around 29ºC in the fruit (Figure 1).

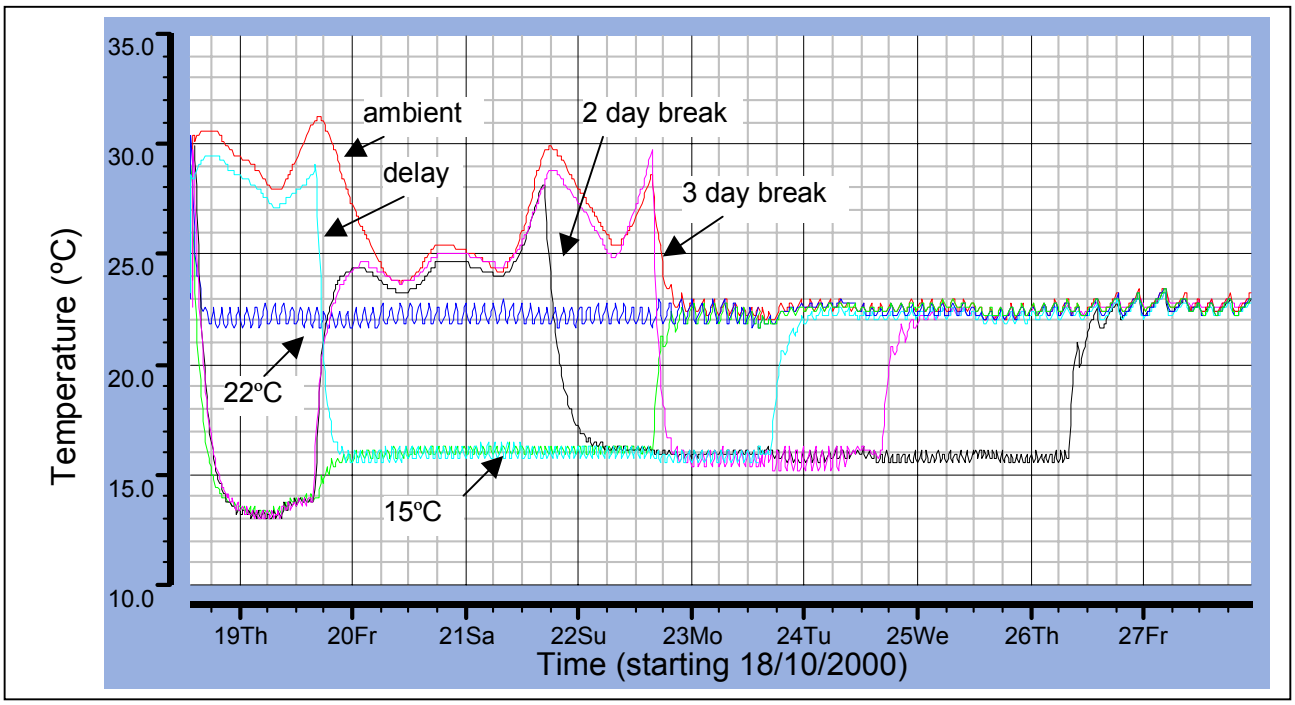


Figure 1. Core temperature of mango fruit at various temperature regimes

Weight loss was greater by about 1% in the fruits, which were left out in ambient temperatures for long periods. In a 7 kg tray of mangoes, this is an extra 70 g of weight lost which contributes to the development of loose packs in the markets.

Table 2. Internal quality parameters of mangoes stored at various temperatures

Treatment	% Initial weight lost	Days to eating soft	Eating quality (1-9)	Brix (%)	Acidity (%)	Internal disorders (%)
Ideal	5.90	13.6	5.6	15.2	0.069	0
Low Temperature	5.49	14.9	5.9	15.0	0.080	6
2 day break	5.88	14.8	6.1	15.2	0.063	0
3 day break	6.82	16.1	6.3	15.1	0.066	10
1 day delay	5.36	13.9	6.0	15.2	0.087	3
Ambient	7.07	11.6	5.9	15.7	0.077	16

Table 3. External quality parameters of mangoes stored in various temperature regimes

Treatment	Disease		Lenticel spotting	
	% Fruit with disease	Average % surface area	% Fruit with spotting	Severity
Ideal	33	3.8	38	2.0
Low Temperature	77	1.7	45	1.8
2 day break	70	2.3	55	2.0
3 day break	70	1.9	36	1.8
1 day delay	37	5.0	26	1.8
Ambient	36	3.7	36	1.6

Fruit which were stored at ambient temperature for two to three days, appeared to take longer to reach eating soft. This is due to the subsequent storage of the fruit at 15ºC afterwards. Storing fruit at 15ºC slowed the ripening process at any stage.

Fruit kept at ambient temperatures became eating soft two days earlier than fruit which was kept at 22ºC. Mangoes stored at ambient temperatures also had higher acidity and higher number of internal disorders, at 16%. This is equivalent to three fruit in a carton of 18. These conditions are similar to that of non-refrigerated transport of mangoes.

Delaying reaching the cool room by one day had less of an effect on fruit eating quality than anticipated. Acidity was higher but everything else was comparable to the fruit in the ideal treatment.

Disease was increased in fruit that had been stored at low temperatures, or fruit which had a break in the cold chain. The most common diseases were black spot, with lower levels of anthracnose and stem end rot. These diseases increase rapidly once the fruit reaches eating ripe.

The number of internal disorders such as jelly seed or soft nose also increased to 10% of fruit when they were left out at ambient temperatures for three days.

No effects on average eating quality or brix were determined between any of the treatments. All fruit showed good skin colour with over 90% of the fruit surface area yellow when the fruit reached eating soft.

Conclusions:

This data should help mango growers interpret what effects problems with the handling chain or cold storage of mangoes will have on their product. It is not a prescription for the best conditions, but should give some information on implications of breaks in the cool chain.

- Fruit held at low temperatures tends to have more disease. This is most likely because the fruit is older. This has implications for shipping, and also if the cool chain is broken.

- Internal disorders such as jelly seed increase when fruit is left at ambient temperatures for more than two days.

- Days to eating soft are reduced when mangoes are stored at ambient temperatures.

- Delaying cooling reduced shelf life of mangoes by one day compared to mangoes which were put into cool store straight after harvest.

- Removal of the fruit to ambient temperatures increased weight loss compared to fruit which was cool stored directly after harvest, and to fruit which was left at ambient temperatures for one day before cooling.

- Lenticel spotting was not affected by the treatments. This follows current thought that it is affected by pre-harvest factors.

Reference:

Jobin Décor, MP. (1988). Mango ripening guide. *Queensland Agricultural Journal* November-December, 369-371.

SUBPROGRAM: Banana

PROJECT: Banana "Tropical" Race 4 Panama Disease Management

Project Officers: M. Darcey, G. Walduck (Project Leader April 2001) and C. Kelly

Location: CPHRF

Objective:

To find and develop a commercially acceptable banana variety resistant or tolerant to Panama "tropical" Race 4 for the NT banana industry and to simultaneously develop field management methods to reduce the spread of the disease.

Background:

- To commission and operate a world class Quarantine Facility capable of undertaking secure research on Fusarium oxysporum cubense - Tropical Race 4 [Foc4].
- To 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.
- To test the commercial acceptability of any variety found resistant or tolerant to Foc4.
- To develop and commercialize any resistant or tolerant variety found to be commercially acceptable.
- To develop field management techniques aimed at reducing the spread of the disease.
- To attempt to develop field techniques aimed at disinfesting currently infested areas.

Progress:

1. Completed the construction of a secure facility at Coastal Plains Banana Quarantine Station [CPBQS]. Transport and Works conducted the construction and in spite of delays caused by wet weather, work was completed on time and within the budget. The Minister for Primary Industry and Fisheries opened the facility on 9 July 2001.

2. Some 16 of the planned 20 test varieties have been supplied as tissue culture by Panama disease researchers in QDPI and have been established in a disease free site at CPHRF. These have been used to supply material to establish the test plantings within the secure area at CPBQS. Planting was completed on 1June2001. Remaining varieties from overseas sources are currently undergoing quarantine clearance requirements.

3. Quarantine protocols for CPBQS have been developed and tested and are scheduled to be operational in August 2001,well before the site is inoculated.

4. Matt Darcey and Geoff Walduck attended the Australian Banana Industry Congress in Cairns in June and presented a display to show the Australian industry what progress and commitment was being made.

Completed wash down facility at the entrance to the property of Charlie Crow in an attempt to keep his property free of FOC4.

SUBPROGRAM: Citrus

PROJECT: Improved Citrus Products for the NT - Evaluation of Mandarin Cultivars in the Top End - Katherine

Project Officers: J. Bright, R. Renfree and A. Maddern

Location: KRS

Objective:

- ***Identify cultivar/rootstock combinations suitable for both existing and potential markets when grown in various regions of the NT.***
- ***Help growers to optimise their returns through the production of fruit of the required cultivar and quality for the intended market.***

Early cultivar assessments of mandarin production in Katherine were not encouraging given poor management, which resulted in low flowering and low erratic yields. Recent trials have shown promising results on other citrus with modification of management, using moisture stress to enhance flowering and fruit thinning to increase yield and individual fruit size. The NT citrus industry has requested that mandarin cultivars be assessed again so as to increase the available options to growers so as to produce fruit that has the widest market appeal. Since the last assessments, a number of new cultivars and cultivars from climates similar to Katherine have been made available. There is virtually no Australian production of mandarin/tangor types during the months of January, February and March. Early maturing cultivars at Katherine could be harvested in February and March. This trial will focus on 26 cultivars, nine of which are bred by CSIRO. The Imperial and Murcott have been included in the trial as reference cultivars.

Method:

Table 1. The cultivars used in the trial

CSIRO 2762*	Imperial
Cemintard*	Fremont
CSIRO 2107*	CSIRO 2103*
CSIRO 2552*	Fortune*
Temple	CSIRO 2105*
CSIRO 2127	Topaz
Can Sanh	Encore
CSIRO 2350*	Nova*
CSIRO 2728*	Sunburst
Clausallina	Daisy*
CSIRO 2336*	Quit Dong
Fallglo	Murcott
Emperor	Algerian Clementine

*Planted at the time the report was written

Twenty-six mandarin cultivars grafted on to Swingle rootstock, have been or will soon be planted out at the Katherine Research Station. Treatments are single tree plots replicated four times.

Other mandarin material sourced as seed from various countries will be planted as guard trees.

PROJECT: Improved Citrus Products for the NT - Evaluation of Citrus Cultivars in the Top End - Grapefruit

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

Location: KRS

Objective:

- ***Identify cultivar/rootstock combinations suitable for both existing and potential markets when grown in various regions of the NT.***
- ***Help growers to optimise their returns through the production of fruit of the required cultivar and quality for the intended market.***

The grapefruit industry was traditionally based on fruit with white internal colour. Recently grapefruit with red internal colour was released for commercial production. The 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 grapefruit.

Method:

There are two plantings of grapefruit at the Katherine Research Station.

Planting 1
Five super red cultivars: Star Ruby, Rio Red, Flame, Ray Ruby and Henderson were planted on a range of rootstocks at KRS during 1992-1995. These rootstocks were C35 citrange, Swingle and Trifoliata. However, not all scions were grafted onto each rootstock. There is one tree of each of the following combinations:

- Flame on Swingle (planted 14/7/92 and budded October 1995);
- Ray Ruby on C35 (planted 14/7/92 and budded 15/12/92);
- Rio Red on C35 (planted 14/7/92 and budded 11/8/94);
- Rio Red on Swingle (planted 14/7/92 and budded 11/8/94);
- Star Ruby on C35 (planted 14/7/92 and budded 11/8/94); and
- Star Ruby on Swingle (planted 14/7/92 and budded 15/12/92).

There are two trees of Henderson on Trifoliata (planting date unknown) and Ray Ruby on Trifoliata (planted 14/7/92 and budded 15/12/92). There are three trees of Henderson on Swingle (planted 14/7/92 and budded 15/12/92) and Ray Ruby on Swingle (planted 14/7/92 and budded 15/12/92). There are no trees of Flame on either C35 or Trifoliata, Henderson on C35, Rio Red on Trifoliata or Star Ruby on Trifoliata.

Planting 2 (This planting was made as part of the National HRDC Red-flesh Grapefruit Cultivar Trial)
Eight cultivars of grapefruit were budded on to two different rootstocks and planted in randomized, single tree plots in 1995. They are Marsh, Oroblanco, BCP3-Ruby type grapefruit, Henderson, Ray Ruby, Rio Red, Star Ruby and Flame (established eight months later). The rootstocks were Swingle Citrumelo and Carrizo Citrange. Originally, there were four replicates of each cultivar/rootstock combination. However, the planting was rationalised in January 1999 when half the trees were removed. This then left two replicates of each combination except for Flame on Swingle (one replicate) and Oroblanco on Swingle (three replicates).

Measurements

Fruit was picked from both plantings for the determination of quality in "late March" (samples taken between the 15 and 27 March) and "early May" (samples taken between 30 April and 2 May). The main harvesting of fruit occurred following the May evaluation. The number of fruit and total fruit weight were used to calculate average fruit weight.

Results and Discussion:

Planting 1
The average yield of the scion/rootstock combinations ranged between 45 and 104 kg. The average fruit weight ranged between 277 g and 584 g. An interesting point was that the lightest fruit were from the cultivar Ray Ruby on the C35 but the heaviest fruit were from the same cultivar on the rootstock trifoliata. It is stressed that results should be interpreted with caution due to the small number of replications of each combination (Table 1).

Table 1. Estimated total yield and average fruit weight for Planting 1

	Rootstocks					
	C35		Swingle		Trifoliata	
Cultivar	Yield (kg)	Average weight (g)	Yield (kg)	Average weight (g)	Yield (kg)	Average weight (g)
Flame	No trees		No assessment		No trees	
Henderson	No trees		103.7	448	83.8	367
Ray Ruby	45.7	277	89.6	489	56.1	584
Rio Red	No assessment		No assessment		No trees	
Star Ruby	No assessment		No assessment		No trees	

The values are an average of one, two or three trees depending on the combination.

The current market standard for grapefruit is a juice content above 33% (NSW Grading, Packaging and Labeling Requirements). The readings for all cultivars/rootstocks combinations were above this standard when determined in "late March". Some combinations had juice content levels higher than 40% when measured in "Late March" but all combinations, except Ray Ruby on C35, had levels higher than this in "early May" (Table 2).

Table 2. Juice content (%) at various sampling times for Planting 1

	Rootstocks					
	C35		Swingle		Trifoliata	
Cultivar	Late March	Early May	Late March	Early May	Late March	Early May
Flame	No trees		42.1	-	No trees	
Henderson	No trees		39.5	44.7	42.35	46.25
Ray Ruby	33.1	37.5	40.4	43.5	36.05	43.75
Rio Red	No assessment		39	-	No trees	
Star Ruby	No assessment		30	-	No trees	

The current market standard for grapefruit is a brix:acid (sugar/acid) ratio of 4.5:1 (NSW Grading, Packaging and Labelling Requirements). The brix:acid ratio was above 6:1 for all cultivars/rootstocks combinations when determined in "late March". When measured in "early May" the ratios were higher than the "late March" values for all combinations (Table 3).

Table 3. Brix:acid ratio at various sampling times for Planting 1

	Rootstocks					
	C35		Swingle		Trifoliata	
Cultivar	Late March	Early May	Late March	Early May	Late March	Early May
Flame	No trees		8.6	-	No trees	
Henderson	No trees		7.3	7.6	6.7	7.1
Ray Ruby	6.6	6.8	6.6	7.2	7.4	7.6
Rio Red	No assessment		8	-	No trees	
Star Ruby	No assessment		8.2	-	No trees	

Planting 2
The average yield of the scion/rootstock combinations ranged between 2 and 105 kg. The trees are still recovering from heavy pruning in 1999. It is expected that the trees will be more productive in the 2002 season. The average fruit weight ranged between 455 g and 1,223 g. The heaviest fruit were produced by

Oroblanco. It is stressed that the results should be interpreted with caution due to the small number of replications of each combination (Table 4).

Table 4. Estimated total yield (kg) and average fruit weight (g) for Planting 2

	Rootstocks			
	Carrizo		Swingle	
Cultivar	Yield (kg)	Average weight (g)	Yield (kg)	Average weight (g)
Flame	No assessment		No assessment	
Henderson	5.0	620	30.4	640
Marsh	7.0	738	40.3	677
Oroblanco	10.9	952	4.3	1223
Ray Ruby	96.8	581	104.3	566
Rio Red	36.8	745	17.3	847
Ruby	2.0	673	75.8	455
Star Ruby	No assessment		0.9	880

The juice content was higher for all cultivars on the swingle rootstock than on the carrizo rootstock at both sampling times. The cultivar Oroblanco had very low juice content (11%). The juice content from the "early May" sampling was higher than or similar to that in "late March" (Table 5).

Table 5. Juice content (%) at various sampling times for Planting 2

	Rootstocks			
	Carrizo		Swingle	
Cultivar	Late March	Early May	Late March	Early May
Flame	No assessment		No assessment	
Henderson	35	40	39.2	39.2
Marsh	29.3	32.7	33.0	36.9
Oroblanco	11.8	-	No assessment	
Ray Ruby	37.7	41.3	40.1	45.2
Rio Red	25.7	36.2	36.4	36.45
Ruby	No assessment		40.5	40.2
Star Ruby	No assessment		No assessment	

The brix:acid ratio was above 6:1 for all cultivars/rootstocks combinations at both sampling times. For most combinations, the ratios were higher on the swingle rootstock at both sampling times. In most cases the ratios at "early May" assessment was higher than those recorded in "late March" (Table 6).

Table 6. Brix:acid ratio at various sampling times for Planting 2

	Rootstocks			
	Carrizo		Swingle	
Cultivar	Late March	Early May	Late March	Early May
Flame	No assessment		No assessment	
Henderson	6.3	6.9	6.9	8.1
Marsh	6.8	6.6	6.4	7.3
Oroblanco	13.8	-	-	-
Ray Ruby	6.1	6.4	7.4	7.5
Rio Red	7.7	8.1	6.4	7.2
Ruby	No assessment		7.7	7.8
Star Ruby	No assessment		No assessment	

PROJECT: Improved Citrus Products for the NT - Evaluation of Citrus Cultivars in the Top End – Lemon

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

Location: KRS

Objective:

- ***Identify cultivar/rootstock combinations suitable for both existing and potential markets when grown in various regions of the NT.***
- ***Help growers to optimise their returns through the production of fruit of the required cultivar and quality for the intended market.***

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

Results and Discussion:

The lemon trees were heavily pruned during late 1999 so as to reduce tree size and improve internal branch structure. The trees failed to flower and fruit during the 2000 season and they also did not fruit in the 2001 season except for a small amount of fruiting on the Meyer tree. However, the trees have recovered from the pruning and now have good canopy structure.

PROJECT: Improved Citrus Products for the NT - Evaluation of Citrus Cultivars in the Top End - Pummelo

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

Location: KRS

Objective:

- ***Identify cultivar/rootstock combinations suitable for both existing and potential markets when grown in various regions of the NT.***
- ***Help growers to optimise their returns through the production of fruit of the required cultivar and quality for the intended market.***

The pummelo is considered to be the most suitable of the citrus species for tropical conditions. However, a major obstacle to the development of a large-scale pummelo industry 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 (OSP) strain of tristeza and citrus fruit borer are all potential quarantine risks that could be introduced via propagating material from overseas. Therefore, it is very difficult and expensive to import cultivars. However, seeds from some overseas cultivars have been introduced. The trees currently grown in

Australia have been 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 of importing known cultivars from overseas. However, it is advantageous as a way of selecting superior cultivars within Australia since a wide range of plants with different characteristics is available – although most are of inferior quality.

Method:

Planting 1
Seedlings of six pummelo lines introduced from overseas by CSIRO Merbein, Victoria were planted at Ti Tree Farm on 11 June 1987. The seedlings of CS43 Blood red pummelo showed the most potential with five seedlings (CS43-4, CS43-5, CS43-6, CS43-8 and CS43-9) producing fruit with some potential. “CS43" is the CSIRO Division of Horticultural Research identification number. It was originally an introduction from the Horticultural Research Laboratory, USDA, Orlando. The number after the "CS43" is the seedling number.

Budwood from these five seedlings were used to propagate more trees for further evaluation at Katherine Research Station. Each selection was grafted onto Trifoliata and Swingle rootstocks and one replicate of each combination was planted in June 1994.

Planting 2
Seed of a red-fleshed pummelo type from Israel was sown at KRS in September 1996 and transferred to the field in July 1997. A total of 46 trees from this seed have been established (on their own roots). Seed from a low acid pummelo type (Leeman pomello) from Darwin was also sown at KRS, from which 24 trees were field planted in May 1997 (on their own roots).

Results and Discussion:

In Planting 1, all but three of the trees have died due to termite damage and other causes. The three remaining trees were becoming unthrifty and were pruned in 2001 in an attempt 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 their canopy size.

PROJECT: Improved Citrus Products for the NT - Evaluation of Rootstocks for Lemons and Grapefruit in the Top End

Project Officers: J. Mansfield and A. Maddern

Location: Co-operators' properties in the Katherine Region

Objective:

- ***Identify cultivar/rootstock combinations suitable for both existing and potential markets when grown in various regions of the NT.***
- ***Help growers to optimise their returns from the production of fruit of the required cultivar and quality for the intended market.***

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

- tree shape and size;
- yield;
- maturity time;
- size and colour of the fruit;

- adaptability of the tree to certain soils and climates;
- resistance to diseases.

Method:

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

Three cultivars of grapefruit were budded to seven different rootstocks, but not all were undertaken, resulting in 19 cultivar/stock combinations. Cultivar/ stock combinations were originally replicated four or six times depending on the site. Field layouts have been designed with cultivar/ stock combinations randomly assigned to single tree plots. The three scion cultivars include Rio Red, Flame and Star Ruby. The seven rootstocks include Benton Citrange, Cox Mandarin, Cleopatra Mandarin, Carrizo Citrange, Trifoliate Orange (*Poncirus trifoliata*), Nelspruit hybrid 639, and Swingle Citrumelo. The trial was conducted on two different soil types namely Tippera and Blain. The Tippera site was established in mid-1996 and the Blain site was planted in November 1997.

Results and Discussion:

In previous years, the trials at both sites were reduced in size. However in 2000 the co-operators removed the remaining trees at both sites as they wished to grow other crops. The trees at both sites had failed to grow sufficiently. There were a number of factors responsible for this but the primary reason was that subsequent to the planting of the trials both co-operators changed their minds about proceeding with commercial plantings of citrus. Before the removal of the trees, their girth circumferences were measured and photos were taken of the graft unions. A report on the trial is being prepared and will be released in the coming year.

PROJECT: Evaluation of Navel Oranges, Lemon and Mandarin Cultivars

Project Officers: N. Isgro, A. Nesbitt, D. King and I. Broad

Location: Alice Springs Region

Objective:

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

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

Method:

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

The mandarin cultivars were planted in early 2000. The mandarin cultivars consist of five Ellendales on the rootstock Swingle, five Ellendales on Troyer Citrange, five Imperials on Sweet Orange and five Imperials on Cleopatra.

Assessments will be made on fruit quality and yields to determine which cultivars have commercial potential for production in Central Australia. Also assessment will be made on fruit maturity to determine harvest times with a view to supplying domestic markets when supplies are limited

Ti-Tree Research Farm
A planting of Navel, Lemon and Mandarin of selected cultivars on a variety of rootstocks was established in the spring of 1999 at TTRF. Future work will be carried out on evaluating the fruit for its maturity and adaptability to our climate

Results and Discussion:

Data collected from AZRI includes sugar/acid ratios and juice percentages for both navel oranges and lemons.

Maturity of navel oranges is determined by calculating the brix sugar/acid ratios of the fruit where maturity of lemons is determined on fruit size and juice percentage. The national standards state that the minimum brix sugar/ acid ratio for navel oranges is 10:1. For lemons a minimum juice percentage of 33% is required.

Navel Oranges
The data collected and analysed in mid April indicates maturity was well above the Australian standard for brix sugar-acid ratios in navel oranges (Brix/Acid ratio of 10.0:1). Table 1 shows the final maturity characteristics for navel oranges. It is difficult to differentiate between the cultivars at this stage as trees are only in their first year of production. Average yields per tree for each cultivar can be seen in Table 2.

Table 1. Maturity data for navel oranges on 25 June 2001

Cultivar	Rootstock	% Juice	Brix	Brix/Acid ratio
TOC Summer navel	Troyer/Citrange	36.7	9.8	12.2
Washington navel	Troyer/Citrange	38.2	9.1	11.7
Leng navel	Swingle	42.3	8.8	9.5
Washington navel	Citrange	36.4	8.7	10.8
Barnfeild S navel	Trifoliata	36.2	8.8	10.4
Australian Standard Brix/Acid Ratio				10.0

Table 2. Yield data for navel oranges for 2001

Scion/Rootsstock	Fruit No.	Yield (kg)	Average fruit weight (g)
TOC/Troyer Citrange	100	32.0	322
Leng/Swingle	39	9.6	260
Washington/Troyer Citrange	84	28.1	342
Washington/Citrange	56	17.5	309
Barnfeild/Trifoliata	19	5.8	288

Lemons
Most of the mature varieties had reached the Australian standard for juice percentage (33%) by mid-February (Table 3). However, the younger trees, including Fino, Verna, and young Lisbon, were slow to mature.

Table 3. Juice percentage for lemon cultivars

	2000		2001	
Cultivars/Rootstocks	**Mid February (%)**	**Mid April(%)**	**Mid February(%)**	**Mid May (%)**
Lisbon/Troyer Citrange (Mature)	29	39	32.5	42.3
Lisbon/Citrange (Mature)	31	35	34.5	41.6
Eureka/Citrange (Mature)	23	38	38.0	41.7
Fino/Citrange (Young)	N/A	N/A	N/A	44.6
Verna/Citrange(Young)	N/A	N/A	N/A	37.4
Lisbon/Citrange (Young)	N/A	N/A	N/A	42.2

The yield data for 2001 (Table 4) shows that Eureka out-performed all other cultivars for mature trees. Also, Lisbon seems to perform better when Citrange is used as a rootstock compared with Troyer Citrange.

It is difficult to draw conclusions from the data presented in Table 4 for the young trees: Fino, Verna and Lisbon, as this was their first year of production.

Table 4. Yield data for lemons for 2001

Scion/Rootstock	Fruit No	Yield (kg)	Average fruit weight (g)
Lisbon/Troyer Citrange (Mature)	380	58.1	155
Lisbon/Citrange (Mature)	558	77.8	149
Eureka/Citrange (Mature)	1048	175.0	168
Fino/Citrange (Young)	378	46.8	125
Verna/Citrange (Young)	219	29.6	137
Lisbon/Citrange (Young)	295	47.4	160

Pest and Disease:

The occurrence of both Citrus Leafminer (*Phyllocnistis citrella*) and large populations of Queensland fruit fly (*Bactrocera trioni*) deserve a mention, as they either reduced net productivity or fruit quality. Pest management programs are being implemented to deal with these pests, particularly for Citrus Leafminer, which was recorded for the first time in Alice Springs this season.

Future Work:

As mentioned above, a number of trees in the planting are only in their first year of production. Assessment of these trees will continue for another three years, while the older trees will be assessed for one more year only.

New trials using deficit irrigation to promote flowering, increase yields and reduce water consumption for lemon cultivars are planned for 2001/2002.

PROJECT: **Management Strategies for Citrus in the NT - Assistance to the Citrus Industry and its Future Expansion - Top End**

Project Officers: **J. Mansfield, D. Hill, M. Darcey, M. Connolly, S. Smith G. Owens and M. Connelly**

Location: Katherine and Darwin

Objective:

- ***Determination of a range of management strategies for various regions.***
- ***Adoption of management strategies by industry.***

In 2000, a survey conducted by DPIF in conjunction with the NT Citrus Growers' Association estimated that there were 70,000 citrus trees in the Top End. They included:

- 30,000 grapefruit trees;
- 26,000 lemon trees;
- 12,000 lime trees; and
- 1,000 other citrus trees (mainly mandarins) (Figure 1).

Most of the planted trees in the Top End are still young and over 80% of them are yet to produce fruit.

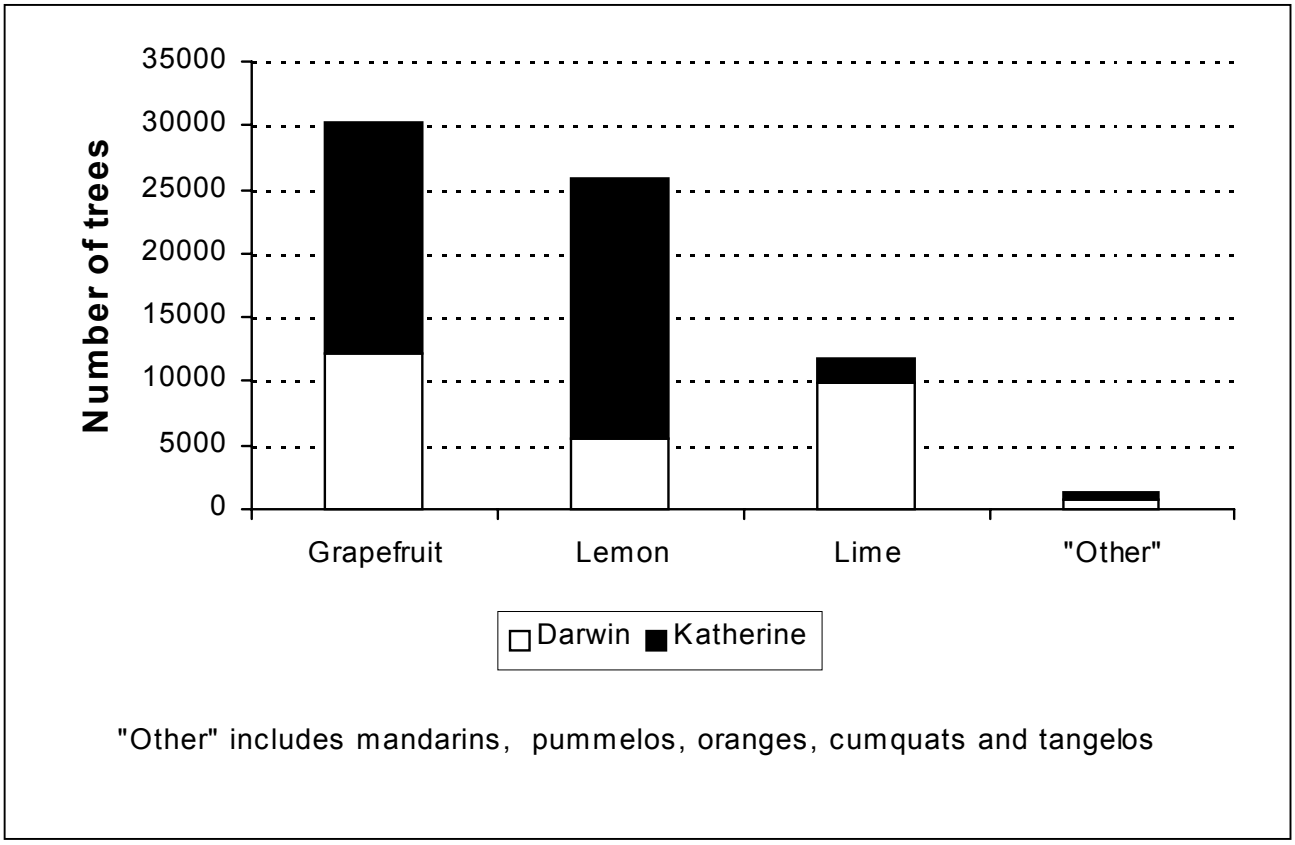


Figure 1. Total number of trees of each citrus type in the (blank) Darwin and (black) Katherine regions

During 2000/2001, the Department in conjunction with the NT Citrus Growers' Association conducted three workshops.

In August/September 2000, Dean Morris, a citrus grower and packer from NSW, was brought to the Northern Territory to discuss management, harvesting, packaging and marketing issues. Ron Hutton, a researcher with the NSW Department of Agriculture, accompanied Dean on his visit. Ron came to the Northern Territory to discuss his HRDC-funded *Heat sum mapping project* with departmental staff and collect information on phenology of citrus in the Top End. Dean and Ron visited growers in Darwin, Katherine and Kununurra. They also attended discussion group meetings in Katherine on 29 August, Kununurra on 31 August and Darwin on 2 September, to discuss citrus issues with growers.

In May 2001, a weekend forum was conducted for citrus growers from Darwin and Katherine, where:

- Departmental staff delivered presentations on herbicide usage in orchards, a possible citrus management strategy for the Top End, and DPIF and the NT citrus industry partnership.

- Neil Eagle, past President of the Australian Citrus Growers' Association gave a presentation on the past, the present and the future of the Australian citrus industry.

- Tony Eggington from the Office of Resource Development gave a brief presentation on marketing.

In addition to delivering technical information, the aim of the forum was to expose growers to some of the "bigger picture issues" affecting their industry so that they would consider participating in strategic business planning sessions. The forum achieved this when in June 2001, a number of citrus growers attended the first of these sessions.

In June 2001, workshops on Integrated Pest Management (IPM) in citrus were conducted in Darwin and Katherine. Commercial IPM expert, Dan Papacek from "Bugs for Bugs", conducted the workshop in Darwin. The workshop in Katherine on 30 June was more detailed than the Darwin workshop. In addition to a presentation by Dan Papacek, staff from the Entomology Branch provided training to growers on insect monitoring and principles of IPM.

PROJECT: Management Strategies for Citrus in the NT - Developing Management Strategies to Manipulate Cropping Patterns in Citrus in Northern Australia

Project Officers: J. Mansfield and C. Kinnaird

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

Objective:

- ***Determination of a range of management strategies for various regions.***
- ***Adoption of management strategies by industry.***

The water requirement of citrus in other growing regions of Australia is well established. However, because the climate in the Katherine region is different from those other areas, irrigation requirements for citrus are also different. By taking soil moisture readings on some of the different citrus species, a pattern of water usage in relation to phenology and climate will be developed. This information will then be used to develop an irrigation scheduling method for citrus trees in northern Australia.

A period of stress may be beneficial in synchronising flowering in citrus in northern Australia. The absence of a cool period in the Top End causes flowering to be erratic. Causing stress in citrus by withholding water ("drought") for a period will induce flowering. The timing of such stress can be used to manipulate the time of production to fill market niches.

Method:

A water stressing "drought" trial was established on a co-operator's property in the Venn area near Katherine. In the 1999/2000 season an environscan was installed at this property to get an understanding of the water usage oft the trees in the area. It was intended to water stress the trees in 2000 to induce cropping in the 2001 season but this did not occur due to a lack of vigour in the trees

In April 2001, eight rows of 20 lemon trees (Lisbon on Troyer rootstock approximately four years old) were chosen to conduct an experiment on water stressing. Four of these rows were "control" treatments and were watered regularly. The other four rows were used for the water stress treatment and were subjected to a period of no watering. Capacitance probes were installed on a tree in each row. The probes had sensors at depths of 20, 40, 60 and 100 cm. A bank of three tensiometers (20, 40 and 80 cm) was installed near each environscan probe. An additional 40-cm tensiometer was installed on a second tree in each row. Taps were installed on each row to water the control rows but not the stressed rows. A water meter in one row of each control treatment measured the amount of water used. The stressed rows did not receive water for five weeks, from 22 May 2000 to 26 June.

During the stressing period, leaf moisture content was measured from trees in each treatment using a pressure bomb chamber. The readings were taken pre-dawn three times a week during the stress period. At each sampling time one leaf was taken from each of four trees in each treatment. To determine the diurnal leaf moisture content, readings were taken at intervals of several hours from pre-dawn to sunset on two occasions, once prior to the onset of stress and the other about three weeks into the stress period.

Five trees in each row were tagged to collect phenological and harvest data. Following stressing, the tagged trees were rated on a fortnightly basis to monitor phenology. Data will also be collected to determine the amount of fruit drop, yield and fruit size.

Results and Discussion:

Analysis of the data from the capacitance probes showed that in the rows where the water was turned off, "onset of stress" occurred in the whole profile on 25 June. At the depth of 20 cm, the "onset of stress" occurred on 1 June and "permanent wilt" was reached on 19 June. At the depth of 40 cm, the "onset of stress" occurred on 6 June and "permanent wilt" was reached on 26 June. When the water was turned on again, the trees appeared to quickly recover from the stress as water uptake occurred almost immediately. The control trees did not show stress at any time.

The data from the monitoring of tree phenology and production will show if stressing influenced tree performance.

PROJECT: The National Red Fleshed Grapefruit Trial

Project Officers: N. Isgro, A. Nesbitt, D. King and I. Broad

Location: Alice Springs Region

Objective:

- ***Evaluate the adaptability of new grapefruit cultivars to growing conditions in Central Australia.***
- ***Assess fruit quality and yields to determine which cultivars have commercial potential for the best production in Central Australia.***

Introduction:

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

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

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

Method:

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

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

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

Results and Discussion:

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

A summary of the 2001 yield data for each of the seven varieties planted at AZRI can be seen in Table 1. The table shows that Oroblanco and Rio Red had similar yields. However, because of Oroblanco's large sized fruit, Rio Red is seen to have a far superior crop. Star Ruby has again performed below average with the lowest yield. In 2001 there was no difference between the rootstocks used.

Table 1. AZRI fruit counts and weights per tree for 2001

	Swingle			Carrizo Citrange		
Variety	Fruit No	Average fruit weight (g)	Average yield per tree (kg)	Fruit No	Average fruit weight (g)	Average yield per tree (kg)
Marsh	557	460.3	64.1	730	473.8	86.5
Oroblanco	673	557.7	93.8	460	548.5	63.1
Ruby Pink	642	462.9	74.3	696	507.6	88.3
Henderson	624	383.1	59.8	577	436.7	84.0
Ray Ruby	620	386.1	59.8	727	391.1	71.1
Rio Red	797	470.3	93.7	700	479.0	83.8
Star Ruby	394	476.8	47.0	285	577.8	41.2

Maturity of citrus is determined by calculating the sugar/acid ratio of the fruit. The National Standards state the minimum sugar/acid ratio for grapefruit is 4.5 to 5.0:1 and minimum juice percentage of 33%. A summary of the 2001 brix sugar/acid data for AZRI can be seen in Table 2.

Table 2. Maturity data for 2001 season (19 April), AZRI

	Swingle				Carrizo Citrange			
Variety	% Juice	Brix	Brix/Acid ratio	Average fruit diameter (mm)	% Juice	Brix	Brix/Acid ratio	Average fruit diameter (mm)
Marsh	38	8	5	106	35	8	6	99
Oroblanco	29	9	12	117	27	10	16	108
Ruby Pink	41	9	5	99	38	8	6	107
Henderson	43	9	6	95	40	8	5	102
Ray Ruby	46	8	5	93	38	8	5	91
Rio Red	35	9	6	105	42	8	5	98
Star Ruby	41	9	5	101	37	8	5	107

Oroblanco again had the highest sugar content, but had the lowest juice percentage because of large rind thickness. All other varieties performed similarly. Although most varieties had reached maturity by early April, this was seen to be two weeks later than the average for previous years. This could have been due to unusual seasonal weather conditions including lower temperatures and higher rainfall.

Ti- Tree Research Farm

Similar data was collected for TTRF as for AZRI. A summary of the 2001 yield data for TTRF can be seen in Table 3. Extremely large increases were seen compared with last year for all varieties. The yield increases for Swingle and Carrizo Citrange grafted varieties were approximately 900% and 600%, respectively from 2000 to 2001. Many reasons may explain this increase including climatic, managerial and cultural. Continuing observations for next season will show whether or not this season's yield was a one-off event, or a trend likely to continue.

Table 3. Fruit counts and weights per tree for 2001 season, TTRF

	Swingle			Carrizo Citrange		
Variety	Fruit count	Average weight (g)	Total weight (kg)	Fruit count	Average weight (g)	Total weight (kg)
Marsh	374	372	139	451	392	177
Oroblanco	286	533	153	390	521	203
Ruby Pink	300	353	106	434	355	154
Henderson	0	0	0	447	277	124
Ray Ruby	488	344	168	280	359	101
Rio Red	541	402	218	476	399	190
Star Ruby	546	336	184	81	136	11

A summary of the 2001 maturity data for TTRF can be seen in Table 4. The table shows that only Henderson did not reach the standard for sugar/acid content (4.5-5.5), while all others were mature by late March. Similar to AZRI data, Oroblanco grown at TTRF on both rootstocks did not reach juice standard mainly due to rind thickness. Likewise, Rio Red grown on Swingle did not reach juice percentage standards by late March, but did by mid-April.

Table 4. Maturity data for 2001 season (30 March), TTRF

	Swingle		Carrizo Citrange	
Cultivar	% Juice	Brix/Acid ratio	% Juice	Brix/Acid ratio
Marsh	41.8	5.82	42	5.09
Oroblanco	26.7	5.89	26.7	13.13
Ruby Pink	45.6	5.06	43.6	5.76
Henderson	35.7	4.36	42.5	4.59
Ray Ruby	46.5	5.45	41.1	5.82
Rio Red	27.3	5.35	38.59	5.43
Star Ruby	44.73	5.89	37.5	6.06

Pest and Disease:

The occurrence of both citrus leafminer (*Phyllocnistis citrella*) and large populations of Queensland fruit fly (*Bactrocera trioni*) deserves a mention, as they either reduced net productivity or fruit quality. Pest management programs are being implemented to deal with these pests, particularly for citrus leafminer, which was recorded for the first time in Alice Springs this season.

Future work:

Future work in the area will consist of:

- Recording flowering, fruit maturity and quality data.
- Recording and measuring growth performance and cropping characteristics.
- Nutrition (collecting leaf samples each February for nutrient analysis).
- Irrigation monitoring and scheduling with the use of tensiometers.
- Ongoing tree management including control of pests, diseases and weeds and pruning.

SUBPROGRAM: Table Grapes

PROJECT: Develop Irrigation Management Guidelines for Table Grapes

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

Location: Alice Springs

Objective:

To improve sustainable irrigation management.

Successful vineyard management starts with good irrigation practices. In a desert environment like Ti Tree, irrigation is critical and mistakes in scheduling water can lead to other problems such as nutritional deficiencies and increased salt uptake. Under-watering in such a climate can result in excessive stress. In order to minimise this, growers often play it safe and over-water. This can lead to nutritional problems, salt uptake, soil compaction, delayed maturation and poor berry quality. It also wastes water and can increase power or fuel costs. The bore water at Ti Tree is of a good quality, but does have high levels of nitrogen and bicarbonates. Over-watering can thus increase the intake of nitrogen and promote excessive vigour leading to a delay in the development of berries and maturity. Careful monitoring and scheduling of irrigation can reduce unnecessary irrigation and waste of water.

In order to establish irrigation guidelines and improve water use, initial studies were conducted where moisture levels in three vineyards were monitored throughout the growing season from August 2000 to February 2001. The varieties Red Globe/Ramsey, Flame, Crimson/Ramsey, Menindee, Menindee/Sultana and Menindee/Schwarzmann were monitored. Both tensiometer and neutron probe measurements suggest that over-watering was taking place in most cases. Moisture tension levels at this time were always above -20kPa and in some cases rarely fell below -15kPa. This corresponded with volumetric moisture levels measured by the neutron probe. Moisture levels in all vineyards rarely dried to refill point (140 mm) from flowering to maturity. Analysis of bore extraction also suggests that over-watering was taking place. This information will be useful in future studies with a more pro-active approach to irrigation scheduling, and the establishment of crop coefficients.

PROJECT: Improving Nutrition of Table Grapes – Petiole Nutrient Standards

Project Officers: S. Nagarajah and A. Nesbitt

Location: Alice Springs

Objective:

- ***To establish grapevine petiole nutrient standards for table grape cultivars.***

Grapevines require adequate amounts of nutrients to grow and produce fruit. Both nutrient deficiencies and excessive nutrient supplies are harmful to vines. The common diagnostic method used to find out whether vines are affected by nutrient problems is to measure petiole nutrient levels and compare the results with nutrient standards. The reliability of this method depends on whether accurate nutrient standards are used to interpret the results. The nutrient standards that are widely used in Australia are those published by Robinson et al. (1997). However, they have three limitations:

- The standards were established for own rooted Sultana vines.

- The standards are valid only at flowering and not for the whole season.
- The nitrogen standard is only for nitrate nitrogen and not both total nitrogen and nitrate nitrogen.

The standards established for Sultana vines may not be valid for other cultivars/rootstock vines. Therefore, it is important to validate or modify the standards when used for other cultivars/rootstock vines.

When standards are available for at flowering only, petiole analysis can be carried out only at this time. This is not satisfactory because vines can have adequate nutrient levels at flowering but develop nutrient deficiencies in the post-flowering period due to factors such as inadequate irrigation, high salt levels and a heavy crop load.

The nitrogen standard is important because nitrogen has a very strong influence on the productivity of vines. Both nitrate nitrogen and total nitrogen have drawbacks as diagnostic measurements. Nitrate nitrogen is affected by other factors such as soil water levels and salinity. Total nitrogen is slow to respond to changes in soil nitrogen levels. These drawbacks should be taken into account when interpreting the results. Total nitrogen is likely to provide a better indicator of nitrogen status than nitrate nitrogen.

Studies carried out in Mildura showed that potassium and phosphorus requirements at flowering for Ramsey rootstock vines were different from own rooted Sultana vines (Nagarajah 2000). This study also established total nitrogen requirements at flowering and nitrogen, phosphorus and potassium requirements for the whole season.

A study was carried out to validate or modify nutrient standards established by Robinson et al (1997) and Nagarajah (2000) for the different cultivars grown at Ti Tree by monitoring the nutrient levels in different cultivars at periodic intervals during the last two seasons. The grapevine cultivars used were Sultana, Flame, Menindee, Menindee/Sultana, Menindee/Schwarzmann and Red Globe/Ramsey.

Two sets of petiole nutrient standards were established. The first set of standards is valid at flowering (September) and the second set valid from October to January. The nutrient standards at flowering are essentially similar to that of Robinson et al (1997), with the exceptions mentioned below.

Table 1. Standards at flowering (September)

Nutrient	**Adequate range/Level**
Nitrate nitrogen, mg/kg	500 – 1200
Phosphorus, %	0.2 – 0.3
Potassium, %	2.4 – 3.0
Calcium, %	1.2 – 2.5
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:

- 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 %.

The total nitrogen standard for all the cultivars at flowering is 0.8 to 1.0%.

The above standards are tentative standards, which will be revised, as more information becomes available.

Table 2. October to January – nitrogen, phosphorus and potassium

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 valid for vines on Ramsey or Schwarzmann vines and **not** for Menindee/Sultana. For Menindee/Sultana, the standards are the same as those for Sultana vines.

**The exception to the above is the potassium standard for Menindee Seedless which is 3 – 4%.

Table 3. October to January – calcium and magnesium

	October	November	January
Calcium, %	>1.5	>2.0	>2.5
Magnesium, %	>0.5	>0.8	>1.2

October to January – sodium and chloride and micronutrients

The standards at flowering are valid for the rest of the season.

Reference:

Nagarajah, S. (2000). Improving grapevine nutrition by taking out the guesswork. Australian Viticulture May – June

Robinson, J.B., Treeby, M.T., and Stephenson, R.A. (1997). Fruits, vines and nuts. In: 'Plant analysis – an interpretation manual". Eds. D.J.Reuter and J.B. Robinson (CSIRO Publishing: Melbourne) pp 347-389.

PROJECT: Improving Nutrition of Table Grapes - Rapid Sap Nutrient Tests

Project Officers: S.Nagarajah, G. Kyle, A. Nesbitt and S. Willoughby

Location: Alice Springs and Chemistry Laboratory Darwin

Objective:

To develop rapid sap nutrient tests to measure phosphate, calcium, sodium and chloride.

Method:

The usual method of measuring the nutrient levels in petioles is by conventional analysis. This is a slow process because it takes a week to ten days to prepare the petiole samples and carry out analysis. In order to speed up the process, a research program was started to develop rapid sap tests to measure petiole nutrients. Sap tests were developed for nitrate and potassium in grapevine petioles in earlier work carried out in Mildura (Nagarajah 1999). This work was continued in Alice Springs and sap tests were developed for phosphate, sodium, chloride and calcium. Petioles used to develop these sap tests were collected at Ti Tree. A brief description of the sap test is mentioned below.

Initially, the petioles were frozen and thawed to rupture cells. Thereafter, the petioles were macerated in a blender containing water and the extract filtered through cotton wool. The petiole residue was dried in order to express the results on a dry weight basis. The phosphate and calcium levels in the extract were measured using Merck RQflex® test strips. The colour intensity developed on the test strip was measured using a Merck RQflex® II reflectometer. Sodium was measured using a Cardy® meter, which has an ion selective electrode. Chloride was measured using the Aquamerck® chloride test, which is a titration method. The four

sap tests were checked against conventional analysis and found to be accurate. The phosphate phosphorus levels measured using the sap test and total phosphorus in the petiole were closely related. Therefore, phosphate level measured using the sap test can be used to calculate the total phosphorus level. About 83% of the total phosphorus in the petiole was present as phosphate phosphorus. However, the calcium measured using the sap test and total calcium in the petiole were not closely related. Only 23% of the total calcium was measured using the sap test. The sap tests are not expensive and can provide quick information to assist in improving vine nutrition.

Reference:

Nagarajah, S. (1999) A petiole sap test for nitrate and potassium in Sultana grapevines. Australian Journal of Grape and Wine Research 5, 56-60.

PROJECT: Improving Nutrition of Table Grapes - Nutrient Problems in Ti Tree Vineyards

Project Officers: S. Nagarajah and A. Nesbitt

Location: Alice Springs

Objective:

To identify the nutrient problems in Ti Tree vineyards

A study was carried out to identify nutrient problems in grapevines at Ti Tree by monitoring the nutrient levels in different grapevine cultivars at periodic intervals over the last two seasons. The results were then compared with nutrient standards developed for Ti Tree and the nutrient problems identified. The cultivars used were Sultana, Flame, Menindee, Menindee/Sultana, Menindee/Schwarzmann and Red Globe/Ramsey.

The nutrient problems were:

- high levels of nitrogen, zinc, copper and manganese;
- deficiencies of phosphorus, calcium, zinc and copper;
- toxic levels of sodium and chloride.

High nitrogen was caused by nitrate present in the bore water and excessive irrigation. Ramsey rootstock vines in particular had very high nitrogen levels because the extensive root system of these vines absorbs large amounts of nitrogen. High zinc and copper levels were due to repeated foliar sprays of these nutrients. High manganese levels were found even when foliar sprays were not applied to the vines. The reason for this is not known. Phosphorus and calcium deficiencies were mainly due to inadequate levels of these nutrients in the soil. Zinc and copper deficiencies were caused by the alkaline soil, which makes these nutrients less readily available to the vines. Sodium and chloride toxicities were caused by the presence of salt in the bore water and excessive irrigation. These nutrient problems can affect vine health and reduce vine productivity.

PROJECT: Improving Nutrition of Table Grapes - Potassium Sulphate

Project Officers: S. Nagarajah and A. Nesbitt

Location: Alice Springs

Objective:

To study the response of grapevines to potassium fertiliser.

Potassium is an essential nutrient for grapevines. The uptake of potassium by vines is far greater than any other nutrient. A large amount of potassium is used during berry maturation. Potassium deficiency affects the sugaring and colouring of berries. Furthermore, bunches are small and tight and berries ripen unevenly in potassium deficient vines. In order to prevent its deficiency, potassium fertilisers are used in vineyards at Ti Tree. However, it is not known whether the fertiliser has any beneficial effect. This question is being raised for three reasons:

- Bore water supplies large amounts of potassium to the vine (about 260 kg/ha/annum). It is not known whether additional potassium fertiliser is required at Ti Tree.
- Vines do not absorb excess potassium when they have adequate levels of the nutrient.
- High sodium levels in the vine inhibit the uptake of potassium.

A potassium response trial was carried out to determine whether potassium fertiliser had any beneficial effect. Three cultivars were used: Menindee, Sultana, Flame and Menindee/Schwarzmann. The treatments were 0, 20, 40 and 60 kg potassium/ha using potassium sulphate. The responses measured included potassium levels in the petiole and soil, brix, acid, pH and potassium levels in the berry juice. The fertiliser treatments did not have any effect on these measurements. It is most likely that the vines did not show any response because they already had adequate levels of potassium. A useful outcome of the trial was that it showed that there was adequate petiole potassium at flowering in the four cultivars. The trial will be continued for one more season to confirm the results.

PROJECT: Improving Nutrition of Table Grapes – Response to Phosphorus Fertiliser

Project Officers: S. Nagarajah and A. Nesbitt

Location: Alice Springs

Objective:

To study the response of grapevines to phosphorus fertiliser.

Phosphorus performs a number of functions in the plant. Therefore, phosphorus deficiency 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 leads to zinc deficiency. But information on the phosphorus requirements of vines at Ti Tree is lacking. In order to obtain this information, a phosphorus response trial was started at Ti Tree.

Method:

Two cultivars were used in the trial, Menindee/Sultana and Menindee. The rates of phosphorus used were 0, 20 and 40 kg/ha using super phosphate as the fertiliser. The fertiliser did not increase the petiole phosphorus level but increased the soil phosphorus level. It was not surprising that petiole phosphorus levels did not

increase because it takes a few years before vines show a response to phosphorus fertiliser. Soil (Olsen) phosphorus results suggest that 20kg/ha/year appears to be sufficient at Ti Tree. Significant reductions in soil (Olsen) phosphorus were observed in the trial. This suggests that it was "fixed" in the soil. However, it is possible that part of this "fixed" phosphorus is available to the vine over a period of time. The trial will be continued for at least another two seasons.

PROJECT: The Use of Dormancy Breaking Agents for Early Table Grape Production in the NT - Season 2000

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

Location: Ti Tree/Territory Grapes

Objective:

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

Introduction:

The development of the table grape industry in Central Australia is based on the production of an early maturing, high quality product to supply domestic markets. Table grape varieties grown in the Ti Tree/Pine Hill area, 200 km north of Alice Springs, begin to mature from the last week of October with the bulk of the harvest completed by Christmas.

The amount of winter chill received by grapevines in this area through the winter months varies considerably from year to year. Often the number of chill hours is not adequate and can result in an erratic bud burst. This has implications for the management of the crop. The timing of the application of Gibberellic acid sprays can be difficult and a proportion of the crop may mature late.

The application of the dormancy-breaking agent Dormex® (hydrogen cyanamide) to vines is an essential management tool in Central Australia. This chemical is usually applied to grapevines at the maximum recommended rate of 5% v/v (2.5% active ingredient). The chemical is expensive; however the high returns from the early market fruit have ensured its viability to date.

Past research has indicated that one of the factors determining the response of vines to the application of Dormex was how effectively it was applied. A thorough and even wetting of canes/spurs, and buds and the crown of the vine while minimising run-off is essential. The spray application rate required to achieve this is around 400 mL per vine (500 L/ha). Due to the cost of the chemical and the rates at which it is applied, industry has identified a need to investigate methods to improve productivity and spray efficacy.

Work to investigate the efficacy of various Dormex applications in combination with surfactants commenced in Central Australia in 1995. DPIF, in cooperation with researchers from the University of California, established a number of trials at "Territory Grapes", a property located on Pine Hill Station, approximately 190 km north of Alice Springs.

Dormex Research Project – 1999:

Research work in 1999 involved the evaluation of the effectiveness of Dormex combined with various surfactants when applied at various rates compared with Dormex applied at the recommended rate of 5% v/v. The recommended application of Dormex at this rate also included the addition of a "non ionic wetter".

Treatments consisted of 5% Dormex®+ .05% Agral® (recommended standard treatment), 2% Dormex ®= 3% Chemwet 600®, 1% Dormex® + 3% Chemwet 600®, 2% Dormex® + 3% Pulse, 1% Dormex®+ 3% Pulse®, 2% Dormex® with no surfactant and control (unsprayed).

Dormex Research Project – 2000:

Research was conducted in 2000 to further assess the effectiveness of a number of the treatments used in the previous season.

Treatments varied between cultivars and consisted of the following:

Flame Seedless - Dormex 5% + Agral 0.1% (D5% A 0.1%), Dormex 5% + Chemwet 0.1% (D5% C 0.1%), Dormex 2% + Chemwet 3% (D3% C3%.), Dormex 12% + Chemwet 0.1% (D12% C 0.1%).

Menindee Seedless - Dormex 5% + Agral 0.1% (D5% A 0.1%), Dormex 4% + Chemwet 0.5% (D4% C0.5%), Dormex 2% + Chemwet 3% (D2% C3%) and Dormex 12% + Chemwet 0.1% (D12% C 0.1%).

Thompson Seedless - Dormex 5% + Agral 0.1% (D5% A 0.1%), Dormex 4% + Chemwet 0.1% (D4% C0.1%), Dormex 2% + Chemwet 3% (D2% C3%).

Note that Dormex 12% + Chemwet 0.1% was applied to Flame Seedless and Menindee Seedless. This was the result of an incorrect spray mix. The results are included to demonstrate that higher rates of Dormex do not increase the rate of budburst.

Method:

The trials were conducted in three commercial table grape plantings on the Territory Grapes property. The plantings comprised *Vitis vinifera* cultivars Flame Seedless on own roots, Menindee Seedless on Sultana H5 and Thompson Seedless on own roots.

Ten two-bud spurs on Flame Seedless vines were tagged. The varieties Menindee Seedless and Thompson Seedless were cane-pruned. A total of 20 buds were tagged on the eight canes on vines of these varieties.

Treatments were applied from 4 to 6 July 2000, using the accepted commercial method, using a boom mounted on a 3,000 litre trailed spray unit.

The marked buds on the spurs and canes of the treated vines were assessed twice each week beginning on 2/8/2000. The effectiveness of each treatment was assessed by comparing the number of days it took for buds, which had been tagged to reach 80% bud burst.

Results:

Flame Seedless
When assessments began on 2/8/2000 all treatments except Dormex 12% Chemwet 0.1% had reached more than 45% bud burst with D5% A 0.1% at 52%, D2% C3% at 49% and D5% C 0.1% at 47% budburst.

On 19/8/2000 D5% A 0.1% had reached 94% bud burst, D5% C 0.1% had reached 87% bud burst and D2% C3% had reached 84% bud burst.

On 25/8/2000 D5% A 0.1% had reached 99% bud burst, D5% C 0.1% had reached 93% bud burst and D2% C3% had reached 87% bud burst (Figure 1).

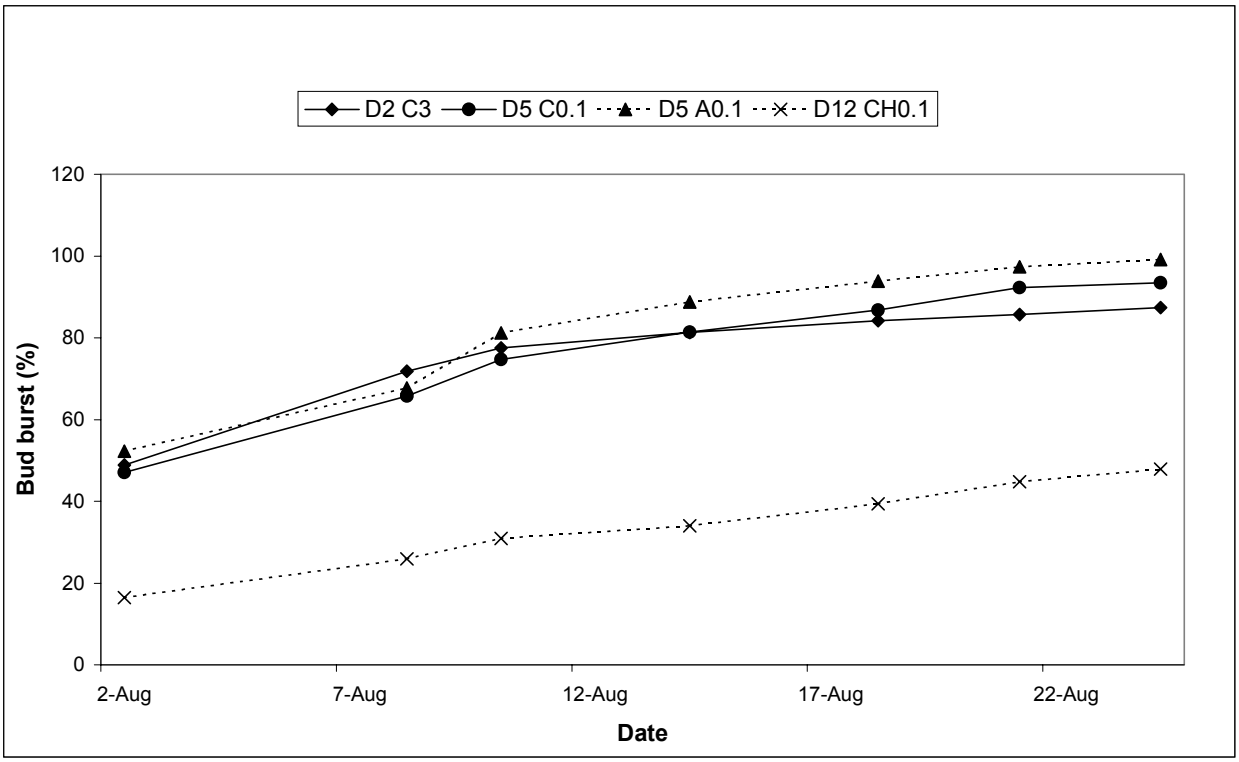


Figure 1. Number of days to reach 80% bud burst in Flame seedless using various Dormex/surfactant combinations

Menindee Seedless

When assessments began on 2/8/2000 D5% A 0.1% had already reached 53% bud burst. D4% C 0.5% had reached 41% bud burst. D12% C 0.1% had reached 20% bud burst and D2% C3% had only reached 9% bud burst.

On 9/8/2000 D5% A 0.1% had reached 78% bud burst. D4% C 0.5% had reached 60% bud burst, D12% C 0.1% had reached 41% bud burst and D2% C3% had reached 38%.

On 30/8/2000 D5% A 0.1% had reached 89% bud burst. D4% C 0.5% had reached 80% bud burst. D2% C3% had reached 76% bud burst and D12% C 0.5% had reached 64% bud burst (Figure 2).

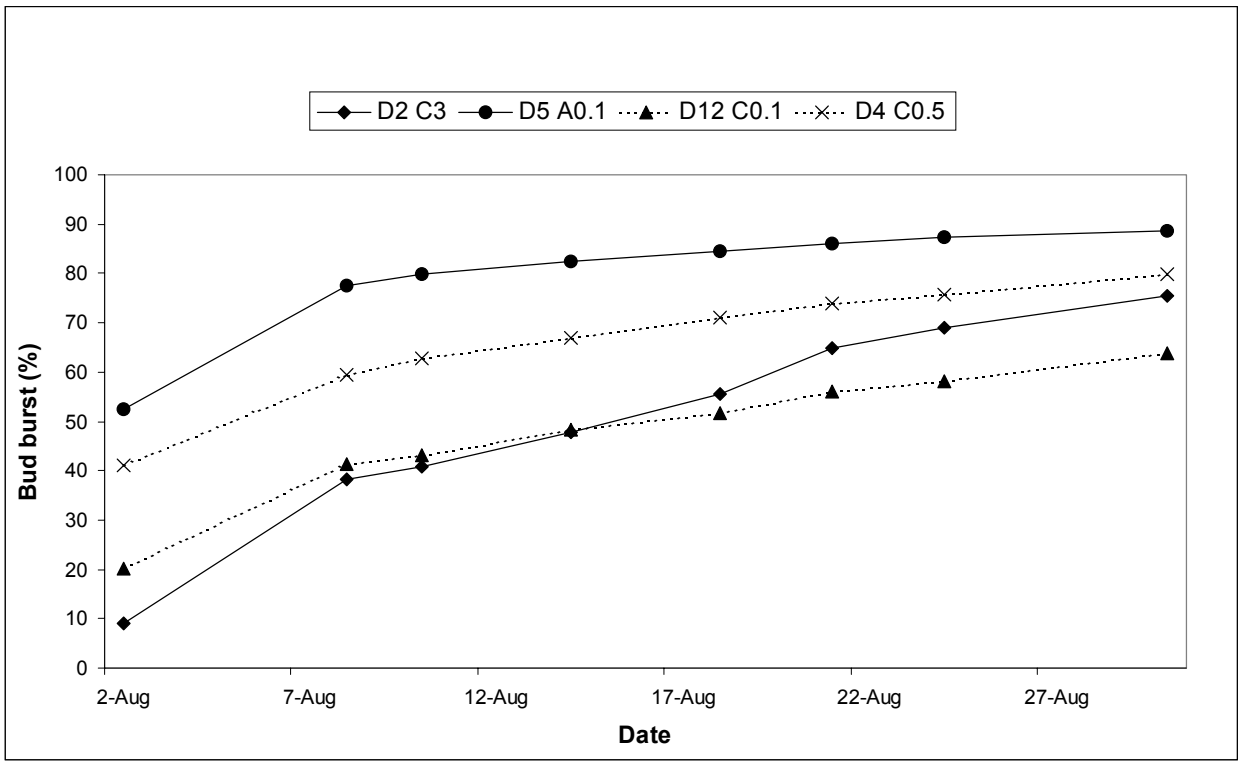


Figure 2. Number of days to reach 80% bud burst using various Dormex/surfactant combinations

Thompson Seedless
When assessments began on 2/8/2000 D4% C 0.1% had reached 27% bud burst. D2% C3% had reached 23% bud burst and D5% A 0.1% 20% bud burst.

On 20/8/2000 D4% C 0.1% had reached 63% bud burst. D2% C3% had reached 56% bud burst and D5% A 0.1% had reached 50% bud burst.

On 7/9/2000 D4% C 0.1% had reached 75% bud burst. D2% C3% had reached 74% bud burst and D5% A 0.1% had reached 64% bud burst (Figure 3).

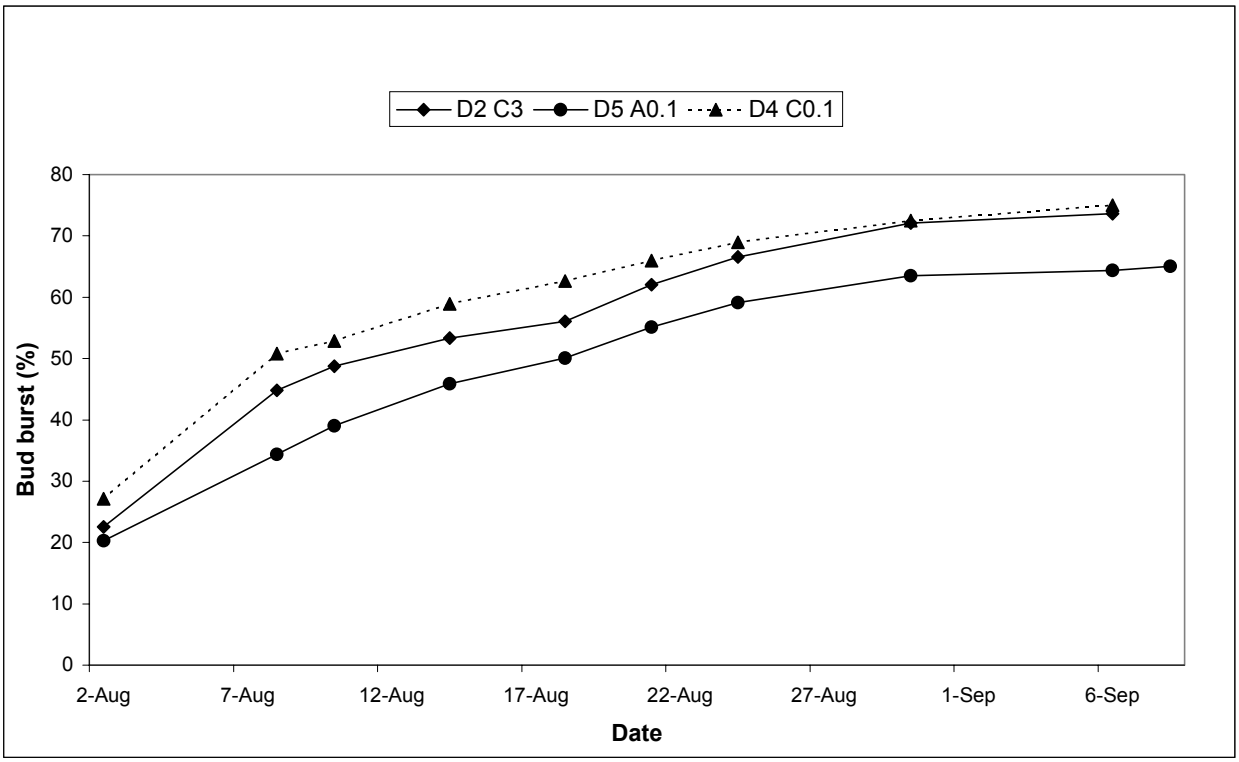


Figure 3. The number of days to reach 80% bud burst using various Dormex/surfactant combinations

Discussion:

Results from work conducted in 2000 were variable in terms of how effective the various Dormex/surfactant combinations were on promoting bud burst. With the exception of Flame Seedless the percentage of buds that had actually burst when assessments were completed were below expected levels for that time of the season. The standard treatment of Dormex 5% +Agral 0.1% was the most effective at achieving the highest rate of bud burst in Flame seedless closely followed by Dormex 2% + Chemwet 3% and Dormex 5% + Chemwet 0.1%.

Menindee Seedless vines receiving the standard treatment of Dormex 5% + Agral 0.1% reached 80% bud burst first. Vines treated with Dormex 4% + Chemwet 0.1% and Dormex 2% + Chemwet 0.1% did not reach 80% bud burst at the time the assessments were completed.

At the time assessments of budburst in Thompson Seedless were completed none of the treatments had reached 80% bud burst. Dormex 4% + Chemwet 0.1% and Dormex 2% + Chemwet 3% performed well while the standard treatment of Dormex 5% + Agral 0.1% did not perform as well in terms of overall bud burst and the rate of bud burst.

Observations of the rate of bud burst showed the trend of vines treated with higher rates of Dormex and lower rates of surfactant usually began bud burst earlier and took longer to reach 80% bud burst. Vines treated with lower rates of Dormex and higher rates of surfactant generally began bud burst slower; however they usually attained as a high rate of bud burst as the treatments using a higher rate of Dormex.

There are other variables, which also had some influence on the rate and total percent of bud burst. Weather conditions were unusual in that the days and nights were generally colder than the average for the month of August and the first week of September. The application of the Dormex/surfactant combinations was standardised across all treatments; however the uniformity of the application of the sprays is difficult to assess.

Acknowledgment:

The cooperation of the owners and management of Territory Grapes is gratefully acknowledged.

SUBPROGRAM: New Crops

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

Project Officers: C. Wicks, J. Orchard, N. Leibel and G. Dunker

Location: CPHRF

Objective:

- ***To generate an in-depth knowledge of cocoa production in northern Australia.***
- ***Use that knowledge to refine an economic model for cocoa production to determine the economic viability of cocoa production in northern Australia.***

In late 1997, Cadbury Schweppes Australia proposed to DPIF, Agriculture WA and QDPI to collaboratively start a feasibility study to develop a cocoa industry in northern Australia. Cadbury Schweppes wanted to ensure that there would be new and reliable sources of cocoa available to it at a time when demand was increasing for its products from Eastern Europe and China, but supplies were dwindling from traditional growing areas. The current low prices for cocoa are forecast to increase significantly over the next five years.

At present Australia imports approximately 40,000 tonnes of cocoa (dry bean equivalent) for its chocolate, beverage and confectionery requirements. To replace half of this requirement, at an average yield of 4 tonnes/ha of dry beans, would require 5000 hectares of producing trees. At current world prices, the value of this production would be $50 million per year.

After various study tours and an economic analysis by an independent consultant, a number of meetings were held. Participants included representatives from DPIF, Cadbury Schweppes, RIRDC, QDPI and the WA Department of Agriculture. These organisations agreed to form a group called 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 DPIF would be directly involved in cocoa yield evaluation and clonal introduction projects.

Both these projects are progressing well. The problems with sourcing the first-choice seed for the hybrid evaluation trial from Malaysia discussed last year necessitated the use of material from PNG. The crosses planted, in order, are KA82 x KEE5, KA82 x KEE12, KA2-106 x KEE12 and KA2-106 x KEE23. A fifth cross, KA82 x KEE43 was also purchased but is not being used in the hybrid trial as it is susceptible to *Phytophthora* diseases and vascular streak dieback. These lines have been planted out in the hybrid trial and assessment has commenced. Table 1 shows that there are some differences between the lines as well as differences between the single and double planting systems.

Table 1. Lines planted in the trial

	Planting Density					
Hybrid	**Single**			**Double**		
	% Jorquett	Jorquett height (cm)	Total height (cm)	% Jorquett	Jorquett height (cm)	Total height (cm)
1	13	100	79	31	95	121
2	28	95	99	3 9	102	138
4	26	108	116	46	102	138
5	26	112	129	35	109	132

The clonal material has been collected from the cocoa germ plasm collection at Reading University, UK. The lines that were requested from the UK were NA33, PA300, Amazon1515, SCA6, IMC67, P4A, P4B, EET399, ICS1, ICS8, ICS95 AND ICS98. These lines are all now in the NT and multiplication has commenced. These lines will be planted out for field assessment late in 2001.

As part of its commitment to cocoa research in Australia, Cadbury Schweppes is funding a Ph.D. project based in the NT, undertaken by Mr. Nathan Leibel who is being supervised by the University of Technology, Sydney and the Northern Territory University. He is working mainly on the physiological responses of cocoa plants to the high light regimes in the NT. This work will develop strategies for the use of shade for cocoa production in northern Australia.

This project is scheduled to finish in 2003.

PROJECT: Miscellaneous Fruit Research

Project Officers: G. McMahon and C. Wicks

Location: CPHRF, BARC

Objective:

- ***To research, identify and evaluate suitable fruit crops for Top-End production. Multiply and release known Pitaya varieties and low land Longan varieties to industry.***
- ***To identify suitable multiplication techniques, and develop best management practices for Top End conditions.***

New Introductions:

There were no new introductions of exotic fruit this year. The longan material brought in last year has been released from quarantine and will be planted at CPHRF during the wet season.

Several of the previous introductions have been planted out at the BARC orchard. These include several *Artocarpus* sp., *Garcinia combogia, Sterculia chicha, Spondias tuberosa*, and *Grewia asiatica*. The remaining accessions will be planted at CPHRF later in the year. Two rows of rambutans have been removed from the netted area, and they will be replaced with mangosteens. Trees of interest in the old BARC orchard are being multiplied in order to relocate them. Also some of the odd trees in the exotic net have been replicated ready to be moved which will make room for more assessment trials.

Longan
The longan, *Dimocarpus longan*, from the Sapindaceae family, of which the rambutan and the litchi also belong, has been introduced from Vietnam and planted in the exotic netted area at CPHRF. They are being assessed for growth, phenology, and suitability as a fruit crop for local conditions. This season a second accession of longans from Vietnam have been planted in the exotic netted area into the assessment trial.

These trees have been planted in the spaces in each row, thereby increasing the density. Phenology and growth measurements of the trial are being recorded.

Two of the varieties being assessed, Mata Kuching and Xuong com vang, are beginning to display very different habits. Mata Kuching is a very upright tree with a single trunk, and branches freely from the trunk. The leaves are large, bright green and relatively soft. They are also fairly susceptible to insect damage. Xuong com vang is quite the opposite, with very shrublike behaviour, thick and bushy with multiple stems from the ground. Leaves are small, thick, green above and pale below, and the new flush is pink to red.

Pitaya
The pitaya trial at CPHRF is continuing, with plant growth being assessed every three months. Growth has been rapid and the plants are now branching at the top of the pole and hanging down, with branch numbers increasing. This season the plants should come into full production and yields will be assessed. Last season a number of plants produced fruit, and average fruit weight appears below.

Table 1. Average fruit weight 2000/2001

Plant No.	Flesh type	Weight (g)	Length (cm)	Width (cm)	% Brix
R3P1	white	393.82	11	7	13.5
R3P4	red	196.13	9	5.5	15.1
R2P2	white	432.58	10.5	7.5	13.8
R4P1	white	383.02	10.25	7.12	14.8

Nutrition is also being looked at and a fertiliser program has been put in place. Samples of sap are being analysed to identify any patterns in nutritional requirements. A few problems with the methodology have been encountered, but the results so far are promising, and will be published in future reports, when sufficient data has been collected.

PROJECT: Miscellaneous Fruits Research - Katherine Component

Project Officers: J. Mansfield, C. Kinnaird, D. Hill and R. Renfree

Location: KRS

Objective:

To research, identify and evaluate suitable fruit crops for Top End production.

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

A number of subtropical species such as avocado and lychee have in the past failed to fruit in the Katherine region. This is due to the warm conditions and the lack of sustained periods of cool nights. While for some species in this trial only seedling trees have been planted, for others such as avocado, annona and lychee a range of cultivars have been planted. For avocado, it is only cultivars from the West Indian avocado race, or hybrids derived from them, that are considered to possess the ability to fruit under conditions at Katherine. The primary aim of this project is to record the growth patterns of trees in the region in relation to the timing of fruit harvest.

Method:

The following trees are planted in the horticultural research block at the Katherine Research Station:

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

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

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

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

Jackfruit: One seedling (planted 1993).

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

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

Feronia limonia: One seedling (planted 1993).

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

Imbe: One seedling (planted May 1995).

Mamoncillo: Two seedlings (planted 1994 and 1995).

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

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

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

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

Results and Discussion:

From June 2000 to June 2001, the growth pattern of all trees was monitored on a fortnightly basis. This information is currently being collated to produce a report summarising the performance of various trees in the Katherine region.

Bird damage to fruit has been a consistent problem with the sapodilla and guava trees. It appears that some form of bird control, such as netting the trees, may be necessary for commercial production of these species in the Katherine region. Carambola trees flowered profusely, but produced little fruit, perhaps due to problems with pollination.

Most of the avocado trees flowered profusely in July/August 2000, but most flowers either failed to set fruit or the fruit dropped when still small. Some fruit was harvested from the avocado trees in late February 2001. Most of the trees produced less than 10 fruit each. However, two different Zutano seedlings produced 117 and 27 fruit, respectively. All trees had fruit of around 200 g or less, except Peterson and Victoria, which produced fruit of more than 650 g (Table 1).

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

Date	Cultivar	Weight (kg)	Number	Average fruit weight (g)
28/2/01	Kimberley *	1.14	6	190
28/2/01	Peterson	0.66	1	660
28/2/01	Semil 34	0.7	4	175
28/2/01	T6	0.96	6	160
28/2/01	Victoria*	2.32	3	773
28/2/01	Zutano seedling	15.08	117	129
28/2/01	Zutano seedling	5.56	27	206

* Average of 2 trees; all others are from single trees.

PROJECT: Stone Fruit Evaluation in the Alice Springs Region

Project Officers: D. King, N. Isgro, I. Broad, A. Nesbitt and G. Kenna

Location: Arid Zone Research Institute and Ti Tree Research Farm

Objective:

To enhance the profitability and productivity of stone fruit in the Alice Springs region.

Introduction:

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

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

Method:

New plantings were established at AZRI in 1996, 1997 and 1998 consisting of peaches, nectarines, apricots and plums. Presently there are six varieties of apricots, five of plums, 10 of peaches, and 17 of nectarines. Four new varieties of apricots were planted in 1999.

A planting was also established at the Ti Tree Research Farm in 1998. It includes eight varieties of peaches, five of nectarines and two of apricots. These will produce fruit in 2001.

The aim of these plantings is to evaluate the potential for commercial production of dessert stone fruit in Central Australia, using a range of rootstocks and to assess the suitability of varieties with varying chill requirements.

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

Results:

In 1997 low chill peaches and nectarines, in their second year, produced their first crop. Flowering began at the end of August and harvest commenced in mid November. Fruit counts, weights and diameters were recorded. In 1998 the same trees carried their second crop and were assessed as for 1997, including brix measurements. In 1999, during the third crop there was an overall increase of 18.16 kg of fruit per tree. In 2000, the 'Unknown' variety produced 265 kg, 'Sunraycer' 193 kg, and 'Sundowner' 190 kg - a distinct increase over previous years.

Results from leaf nutrient analysis in 1999 have indicated low to deficient levels of zinc throughout the planting. Copper and calcium levels were marginal. Copper oxy chloride sprays have been used to overcome the copper deficiency problem.

A major problem in the past at AZRI has been fruit damage by birds at ripening. The use of a gas powered 'scare' gun has reduced the damage of birds, but early maturing crops still sustain heavy losses.

Table 1. Stone fruit average yield per tree (kg) during four years

Variety	**1997**	**1998**	**1999**	**2000**
Sundowner (6/3) [N]	2.51	15.32	14.59	38
Sunraycer (84/16) [N]	1.14	3.52	8.35	48.4
Unknown [N]	2.46	4.06	10.61	66.5
Flordagold [P]	1.66	11.8	12.3	31.9
Flordaglo [P]	4.24	14.66	23.24	23.2
Desert Red [P]	0.94	12.05	9.41	41.3
Moorpark Early [A]	0	0.02	N/A	7
Trevatt [A]	0	0.16	N/A	5.4
Moorpark [A]	0	0.05	N/A	N/A

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

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

For the year 2000 trends changed, with Desert Red having the highest yield followed by Flordagold while Flordaglo remained stable

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

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

In 2000 the average yield/tree increased markedly with all three varieties producing large crops.

Apricots
The apricot trees yielded their first crop in1998. The yield was very low with the Trevatt variety being the only producer. In 1999 and 2000 the trees again had light crops. These trees need more time to establish but it is expected that their yield will increase in future years.

Table 2. Average Brix for each variety of stone fruit harvested

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

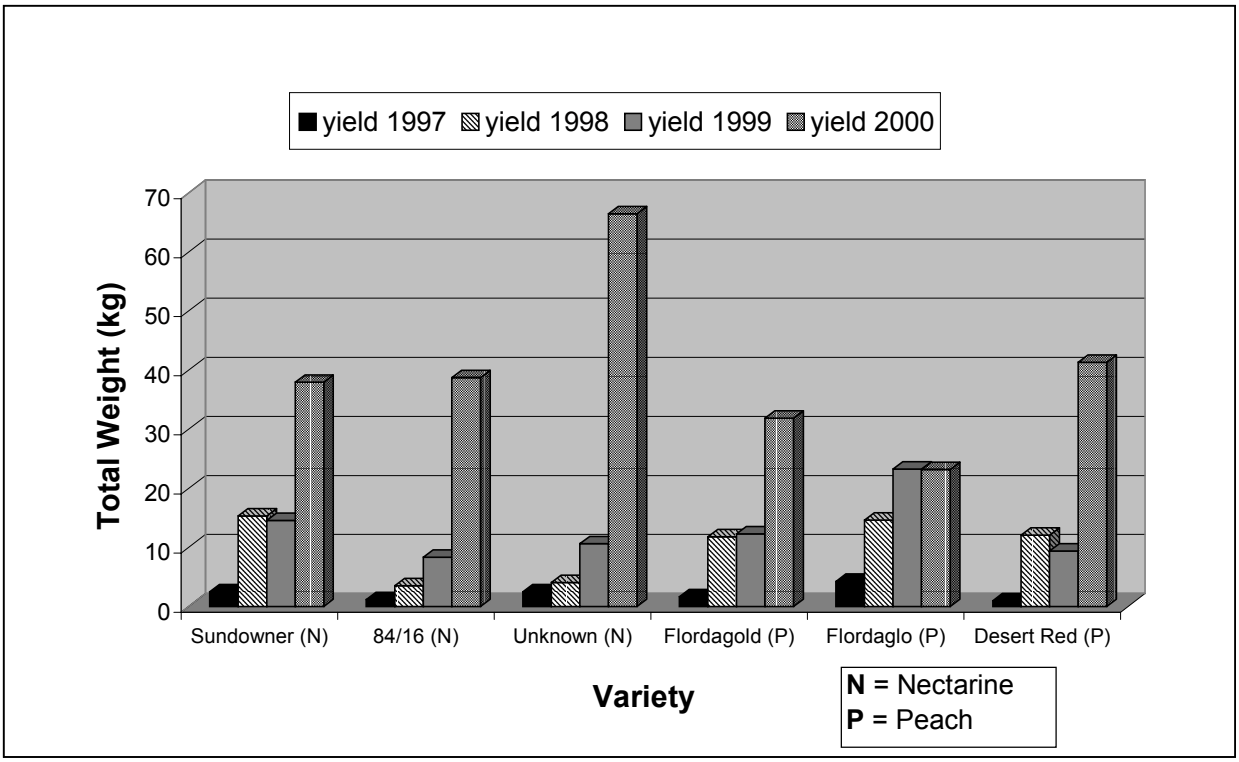


Figure 1. Average yield per tree

Summary:

Overall commercial yields of three varieties of medium and low chill nectarines and peaches planted between 1996 and 1998 were higher than in previous years. Three varieties of apricots planted in 1999 produced a small crop.

Although signs are promising, yield was affected by fruit fly infestation, a brush fire in an adjacent paddock and severe bird damage.

Future Work:

Variety assessment is to continue on nectarines and peaches. Collation and assessment of nutrition and irrigation results will continue. Variety performance observation will continue on apricots for a further two years.

Pome fruit

Summary:

Variety performance at AZRI and TTRF has continued on nutrition and irrigation of the trellised apples.

Future Work:

As apples do not come into production until five years after planting, variety performance will need to continue for a further two years.

SUBPROGRAM: Minor Crops

PROJECT: Control of *Phytophthora* Diseases in Durian

Project Officers: C. Wicks, A. Hosking and G. McMahon

Location: BARC, CPHRF and Mrs Siah's Durian Block at Lambells Lagoon

Objective:

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

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

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

Mulch and Green Manure Trial in 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) living manure. There are three mulching treatments (none, hay, hay+chicken manure) and three living manure treatments (none, Wynn Cassia, Sabi grass) which results in nine treatments in total. Each treatment is replicated four times and the entire trial is blocked twice. Measurements are taken for temperatures, soil water status, tree phenology and size (including root assessments) plus qualitative assessments of soil biota status.

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

The Wynn Cassia is growing so well that it is competing with the young trees, again possibly predisposing them to attack by *Phytophthora*. This competition is demonstrated best by the respective tree heights. All measurements after April 2000 were taken after removal of the Wynn Cassia that was in direct competition with the trees.

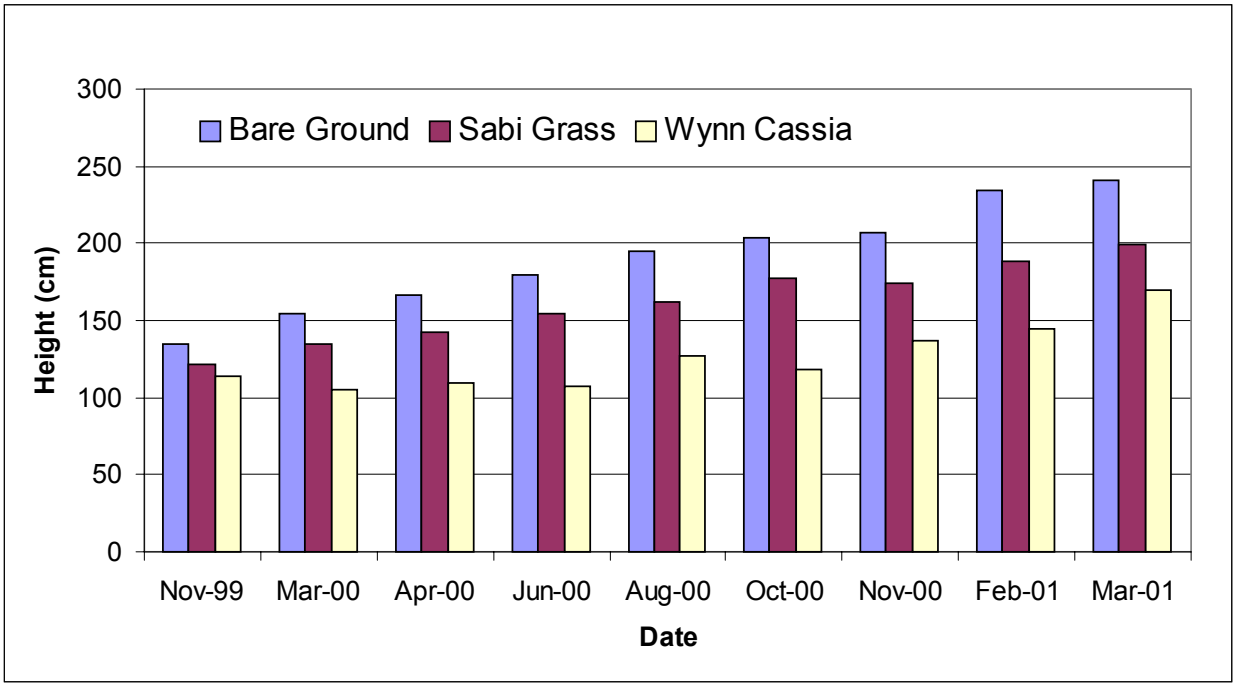


Figure 1. Cover effect on height of durian trees at Lambells Lagoon

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

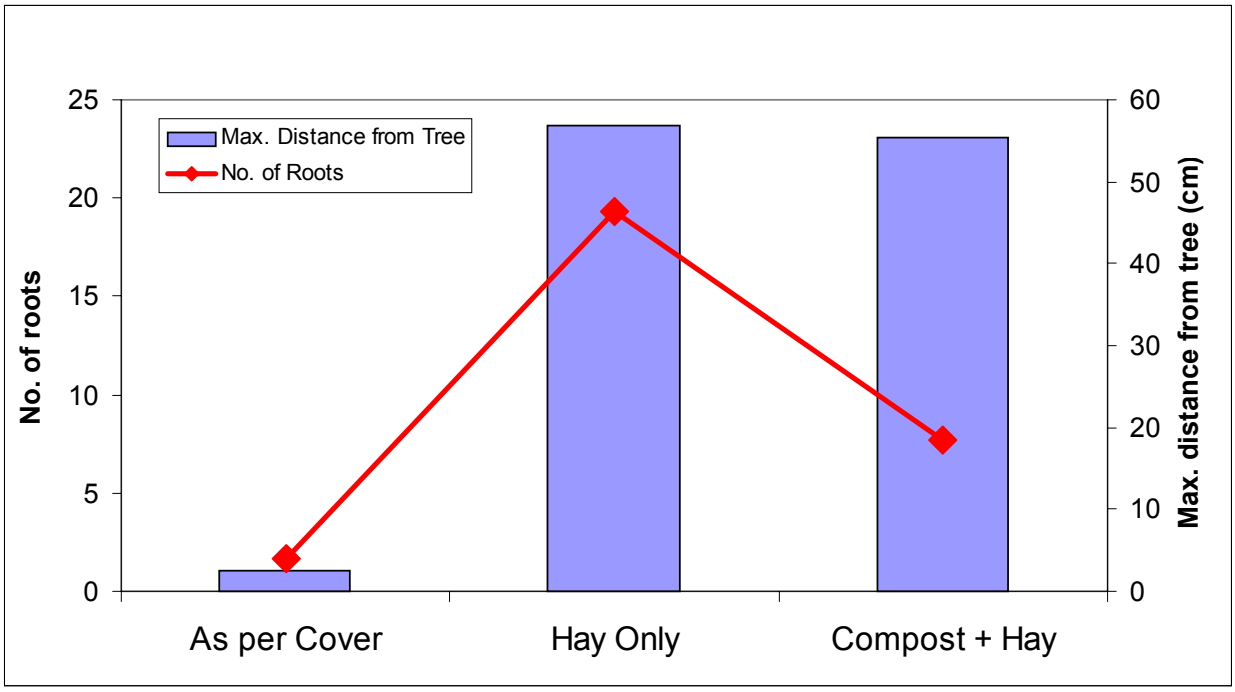


Figure 2. Durian tree response to mulching at Lambells Lagoon

This trial will need to continue for many years before any concrete conclusions can be made. However, it is already becoming clear that early competition from green mulching is detrimental and mulching aids root growth.

Mulch, fertiliser type and fertiliser and irrigation rate trial in pots
The aim of this trial is to quantitatively identify (with trees in large pots) various management factors that may influence the incidence of *Phytophthora* disease in the field. Various types of organic 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.

There are no results to report. Efforts to inoculate the pots with *Phytophthora* have been unsuccessful. Alterations to the methodology have been identified and will be trialled. The other problem with the trial is the crowding which is encouraging leaf disease and causes a large degree of competition for light. There has also been a large amount of longicorn damage, which is killing the stressed trees.

Screening, marcotting and grafting trials
The aim of this trial is to identify possible resistant varieties of durian and to test their compatibility as rootstocks with popular commercial scions. This is being done through two processes.

The first process involves testing as many as possible durian varieties (and other *Durio* species) with a number of *P. palmivora* isolates, from orchards in the Darwin rural area. The most resistant varieties or trees are then being vegetatively propagated to allow rootstock compatibility testing. Alongside that process is a rootstock trial using current commercial material. This trial will allow the identification of rootstock-scion interactions.

While a number of possibly resistant varieties/trees have been identified, more testing has to be done. The testing to date has been unsuccessful. The leaf bioassays being conducted have shown very little difference in either varietal resistance or isolate pathogenicity. This is due to poor cultures that, while producing sporangia, do not appear to effectively infect the plant tissue.

There has also been little success at vegetatively propagating the varieties/trees selected. Most success has come from work in north Queensland. The climate there appears to be better suited to marcotting though the number of live marcotts in the greenhouse is less than 10% of all the marcotts attempted. The total success rate from marcott-attempt to alive-in-pot is less that 3%. This low level of success has also been found in the major durian growing regions in SE Asia where grafting is the typical method of plant multiplication.

Antagonists of Phytophthora:

The aim of this trial is too identify and field-test fungi and bacteria that may inhibit (antagonise) *Phytophthora*. A large number of laboratory tests resulted in the identification of one fungus that inhibits the growth of *Phytophthora* on Petrie dishes. This fungus is yet to be tested in the field.

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

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

PROJECT: Irrigation/Nutrition Management Guidelines for Date Palms

Project Officers: A. Nesbitt and S. Nagarajah

Location: Alice Springs

Objective:

- ***To establish water use guidelines for date palms.***
- ***To establish leaf and soil nutrient guidelines for date palms.***

Very little information exists on detailed irrigation and nutrition for producing quality dates. This project aims to establish some tentative guidelines on water requirements for date palms grown in Central Australia, as well as suggest leaf and soil nutrient standards for date production.

Irrigation:

Tensiometers installed at 30 cm, 60 cm, and 90 cm in triplicate were recorded twice weekly throughout the season on one date palm plantation. The 30-cm tensiometer showed 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 27ML/ha of water per annum. However, it is not known whether these tensiometer values correspond with actual crop water requirements. Monitoring for at least one more season will continue with corresponding application rates, in order to establish general guidelines of crop water use for date palms in Central Australia.

Nutrition:

Leaf and soil samples were collected three times 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 some of the nutrients monitored in leaf and soil samples. Large fluctuations are seen in many of the soil samples due to seasonal timing of the sample as well as fertiliser applications, particularly for nitrogen and phosphorus.

Table 1. Ranges of nutrient levels found in leaf and soil samples (July 2000 – Jan 2001)

Nutrient	Soil range (Top 30 cm)	% Leaf range
Nitrogen (N)	2.6 – 13, mg/kg (Nitrate N)	0.98 – 1.2
Phosphorus (P)	12 – 29, mg/kg (Olsen P)	0.05 – 0.075
Potassium (K)	0.32 – 0.68, meq/100g	0.43 – 0.71
Calcium (Ca)	3.4 – 3.9, meq/100g	0.62 – 0.95
Magnesium (Mg)	1.8 – 2.3, meq/100g	0.14 – 0.24
Sodium (Na)	0.04 – 0.19, meq/100g	$2x10^{-3}$ – $5x10^{-3}$

A similar sampling regime is expected to continue for one more season, at which time modifications to the above values will allow us the make tentative recommendations for optimum soil and leaf nutrient status for date production.

PROJECT: Improving Rambutan Productivity

Project Officers: C. Wicks, G. McMahon and G. Dunker

Location: Various commercial Rambutan orchards and CPHRF

Objective:

- ***To develop rootstock/scion combinations and pruning strategies that control flowering and tree size.***
- ***To improve industry productivity by benchmarking nutrition standards.***
- ***To improve grower knowledge and use of irrigation monitoring.***

The main focus of this project is on the benchmarking of nutrition standards and the uptake of irrigation monitoring systems. A system to improve/control flowering has been developed and was published in 2000. The development of pruning strategies to control tree size is the basis for a project currently being conducted in Queensland. There is an opportunity to conduct similar work in the NT.

The development of rootstock/scion combinations was scheduled to finish after the 2000 season but an almost 100% fruit loss due to fertiliser burn in 2000 plus the death of trees resulting in poor replication has relegated this portion of the project to a minor priority. The flowering and tree size differences in 2000 were not significant.

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

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

The project is being run in conjunction with the NT Rambutan Growers Group, a subgroup of the NT Horticultural Association. Each grower is contributing financially to the project as well as providing complete details of fertiliser and irrigation regimes used and tree yields. The growers meet at least four times a year with DPIF staff to discuss results.

Method:

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

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

Results:

To date there have been 12 rounds of soil and leaf sampling with the first occurring in June 1998 while the latest round was completed in February 2001. Data from these observations show that soil and leaf nutrient levels do not always correspond. For example, high soil zinc levels do not necessarily show sufficient levels of zinc in the leaf. This is due to the use of foliar sprays by some growers to supply the required trace elements while others use soil application.

We have also found that the levels previously recommended for some elements are incorrect. An example of this is phosphorus. The recommended soil level (determined from a small sample size) does not correspond with the recommended leaf level. One of these levels will need to be adjusted. Figure 1 demonstrates this difference between the soil and leaf standards with the result of the earlier work.

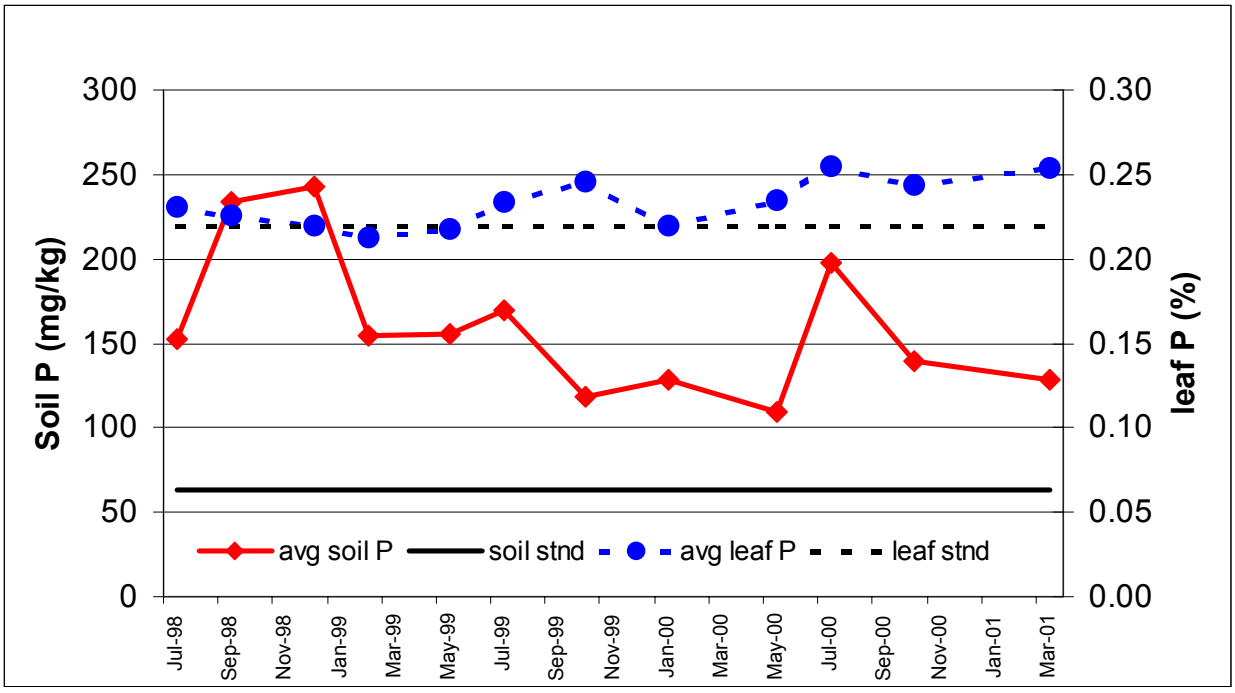


Figure 1. Rambutan phosphorus levels

One strong positive result from this nutrition work is the increase in soil pH seen across the industry. When the project began there were a number of orchards with low to extremely low soil pH. This was due to poor orchard management, which was remedied by the application of lime and gypsum. The result of this change in orchard management can be seen in Figure 2 where growers were divided onto three groups on the basis of soil and bore type with the majority (eight out of 15) belonging to the rest group. This change may have also brought about an improved balance in the soil chemistry but this needs further analysis.

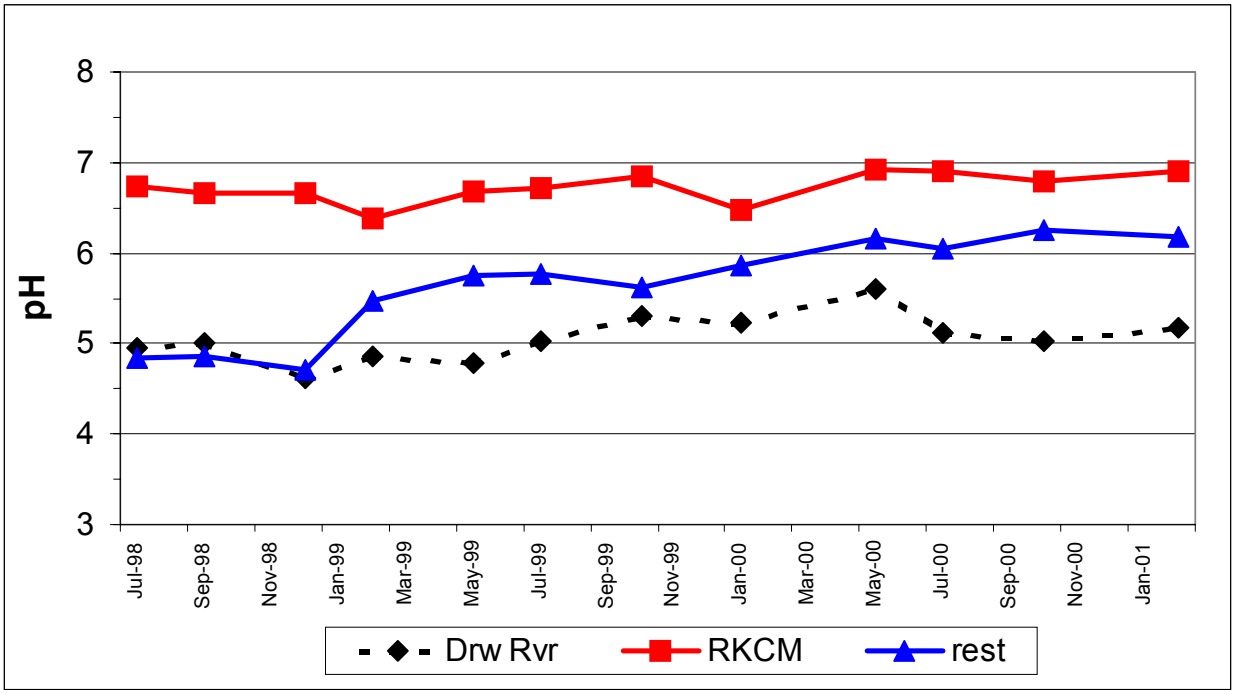


Figure 2. Rambutan soil pH

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

Hopefully the irrigation monitoring equipment will do the same. The next phase of the irrigation monitoring includes grower assessment with the hope that at the end of the project a large majority of the growers will be monitoring their irrigation themselves.

PROGRAM: Ornamental Industry

SUBPROGRAM: Nursery

PROJECT: Nursery Industry Accreditation Scheme Australia

Project Officer: M. Connelly

Location: Various nursery businesses

Objective:

To ensure the NGINT representative has acquired the knowledge to implement and monitor the NIASA scheme for the NT nursery industry and to conduct a survey of the industry yearly for at least two years.

Three nurseries retained their accreditation through the reported period. In addition to these, a fourth business attained full accreditation and two others continue to develop their nursery to the national "best practice" level that would warrant full accreditation.

A Nursery and Garden Industry – NT (NGINT) NIASA technical committee was successfully established and all administration and decisions are now undertaken by it. The appointment of a NIASA technical officer has yet to be resolved and is inhibiting the complete hand over of the NIASA scheme functions to industry; however this will take place in 2001.

PROJECT: Nursery Product Diversity and Promotion

Project Officers: M. Connelly, M. Hoult, J. Thomas, R. Aiton and C. Ford

Location: BARC Ornamental block

Objective:

To identify new nursery products and to produce required visual displays and associated printed material.

Palms
In collaboration with local palm producers a palm poster depicting the main commercial species and their cultural requirements was prepared for printing.

Euphorbia
Further bulking up of the Thai hybrids of *Euphorbia milii* occurred with *Erwinia chrysanthemi* -biotype IV, a bacterial "soft rot", which is proving troublesome in several accessions. This pathogen is prevalent during the Wet season and good nursery hygiene is essential in its management on *Euphorbia*. A bract spotting fungus, possibly *Corynespora cassicola*, was also prevalent during the Wet, particularly on white bracted cultivars exposed to rain. Selective use of fungicides and cover from rain should control this pathogen on susceptible accessions. The main insect pests have been mealy bug, white fly and scale, which are easily managed. Occasionally caterpillars have caused damage to foliage and flowers but can be easily managed.

Of the 47 accessions that were released from post–entry quarantine, three have been lost due to soft rots and four are duplicated, that is, EU 5 is the same cultivar as EU 22 and EU 17 is the same cultivar as EU 18. There may well be duplicated introductions with the later accessions as well. Release of material to the public will occur in 2001, now that sufficient numbers have been propagated.

Plumeria
Some promising open-pollinated seedlings from a *Plumeria* species have been selected and propagated. Prospects for true dwarfed frangipani types look good and may be suitable for courtyard/pot culture. These will be commercialised with local industry in the near future.

Acknowledgment:

We would like to acknowledge the enthusiastic assistance of Doug Walker in this project.

SUBPROGRAM: Cut Flowers

PROJECT: Improvement and Development of New and Locally Adapted Cut Flowers for the Top End

Project Officers: **D. Marcsik, M. Gosbee, P. Albano, M. Hoult, R. Aiton and M. Connelly**

Location: BARC and CPHRF

Objective:

- ***To provide industry with new, improved and locally adapted cut-flower cultivars.***
- ***To determine heritability for commercial traits in the genus Zingiber***

Curcuma

Introduction:

The genus *Curcuma* , within the large *Zingiberaceae* family, offers exciting prospects for cut-flower producers, as well as for the ornamental industry at large. Many new species have recently been introduced from South-East Asia, and significant interest is being shown in the Japanese and European markets for these unique and colourful products. Several species and cultivars have been sourced by DPIF over the past two years. The first screening of accessions resulted in some promising selections. A second screening trial was established in 2000 and included a much larger range of accessions.

Method:

Dormant rhizomes and non-dormant potted plants of *Curcuma* accessions were established at BARC Horticultural block in September 2000 on raised beds 1.2 m apart. Row spacing depended on species and/or cultivar and ranged from 30 cm, 60 cm to 120 cm. In many cases three plants per accession were established; however in some instances one or two plants per accession were planted due to limited planting material. Fertiliser was applied pre-plant at 500 kg/ha NPK at a ratio of 14:14:12 and 500 kg/ha dolomite. Side dressing occurred every six weeks at 100 g/m^2 of NPK at a ratio of 14:14:12 during the growing season (October to April) along with foliar application of micronutrients three times in the season. Irrigation was applied via drippers and at rates close to 100% of daily evaporation. Soil moisture was monitored with tensiometers. Observations were made on basic phenology, yield and vase-life. Some accessions were established under a full sun, others under 50% shade and some under shade only (see Table 1).

Results:

Table 1. Preliminary evaluation of *Curcuma* accessions, BARC 2000-01

***Species*/Common name**	**Cultivar**	**Acc No.**	**Plant No.**	**Yield [a]**		**Vase-life (n)[b]**	**Comments**
				Shade	**Sun**		
C. alismatifolia – Siam Tulip	"White"	CU 1	1	2	1	3(2)	-
C. alismatifolia – Siam Tulip	"Pink"	CU 2	3	7	6	7-14(5)	Poor form, reasonable yield
C. roscoeana –Jewel of Burma	-	CU 3	3	6	-	8-32(6)	Poor colour, reasonable form, short stem length,
C. roscoeana –Jewel of Burma	-	CU 4	3	4		21-30(2)	Good colour and stem length
C. cordata	-	CU 6	3	4		2-6(6)	Good form, average colour
C. parviflora.	-	CU 7	3	14		5-29(9)	Lacks stem length
C. elata ??	-	CU 8	3	-	-	-	No flowering 2000-01
C. australasica - Cape York Lily	-	CU 11	3	14	8	>40(7)	Best vase-life of all accessions and good yield. Release for industry evaluation?
C. australasica - Cape York Lily	-	CU 13	3	8	4	4-11(6)	Pale colour
C. elata ?	-	CU 18	3	-	-	-	No flowering 2000-01
C. alismatifolia – Siam tulip	“Green tip”	CU 20	3	5	5	7-19(8)	Good form but average colour
C. thorelli – Chiang Mai Snow	-	CU 21	3	4	-	13-21(5)	Short stem length
C. sumatrana - Olena curcuma	-	CU22	3	1	0	8(1)	Poor establishment
C. roscoeana – Jewel of Burma	-	CU24	3	4	-	30(1)	Good colour
C. cordata	-	CU 26	3	?	-	-	Two different clones in the one accessions – one has poor form and colour other has excellent colour and good form
C.australasica	-	CU 28	3	3	4	6-21(9)	-
C.australasica	-	CU 29	2	4	7	9-20(6)	-
C.australasica	-	CU 30	2	2	4	6-8(5)	-

Species/Common name	Cultivar	Acc No.	Plant No.	Yield [a]		Vase-life (n)[b]	Comments
				Shade	Sun		
C. australasica	-	CU 31	3	2	4	9-11(5)	-
C. alismatifolia –Siam tulip	“Red”	CU 32	2	5	5	-	Robust with good form and dark colour
C. thorelli -Chiang Mai Snow	-	CU 34	3	2	-	4-5(2)	-
C. alismatifolia –Siam tulip	"White"	CU 38	2	10	6	-	Late flowering?, average form
C. cordata	-	CU 41	1	0	-	-	-
C. aurantiaca-Rainbow curcuma	-	CU 42	1	14	-	4-9(6)	Good yield
C. aurantiaca-Rainbow curcuma	-	CU 43	1	2	-	-	Only average
C. aurantiaca-Rainbow curcuma	"White top"	CU 44	1	4	-	19(1)	Excellent form and colour, short stem length
Curcuma sp. –Ribbon curcuma	-	CU 47	3	1	-	-	Vigorous with interesting colour pale with pink tips to bracts
Curcuma sp.	-	CU 48	1	5	-	7-14(2)	Good form, dark purple, good stem length?

(Key: [a] = Average number of stems /plant, [b] = range of days to not saleable for all assessed stems/accession; (n) = number of stems assessed/accession

Zingiber
Zingiber is yet another genus within the large ginger botanical family that offers good commercial prospects for the local industry. DPIF has over the past decade introduced a number of accessions for evaluation as commercial cultivars. Several of these now form the basis for commercial production of *Zingiber* in the Northern Territory. Recently the cut-flower industry group identified *Alpinia*, *Zingiber* and *Etlingera* as the *Zingiberaceae* genera warranting more intensive development.

DPIF commenced a breeding project with *Zingiber* in 1998. Through a number of industry meetings, the following commercially important traits were identified: range of colours, stem length > 50 cm, vase-life of 10 days minimum, cultivars adapted to full sun, marketable yield> 100 stems/plant, cultivars easy and quick to harvest and an extension of the harvest season. Several crosses were undertaken and progeny and parents established in a fully replicated trial, so heritability of these important traits could be determined.

Data collection continues, with analysis and subsequent determination of heritability expected by 2002. Commercial evaluation and market testing of advanced selections is also to commence in 2002 and any release of material will be protected under plant breeder rights.

Heliconia

Introduction:

With a complete embargo on the importation of *Heliconia* vegetative material into Australia, new cultivar development is limited to open-pollinated (OP) seedling selection and induction of mutants from existing cultivars. Several species and cultivars were previously not introduced into the NT and were cultivated in Queensland for a number of years prior to the national embargo. Some Queensland suppliers have been actively selecting OP seedlings and some of this material is now publicly available.

Since 1998 a number of accessions have been sourced and established at CPHRF and basic evaluation of vase-life and yield has occurred over the past couple of years. In addition to this, 130 open pollinated seedlings from *Heliconia psittacorum, chartacea, platystachys, and rostrata* species have been evaluated and some preliminary selections have been made.

Method:

Clonal accessions
Bare-rooted rhizomes of 27 accessions were introduced from Queensland and planted at CPHRF. Inter-row spacing was 4 m and intra-row spacing varied from 2 to 4 m depending on species. Fertiliser was applied pre-plant at 500 kg/ha NPK at a ratio of 14:14:12 and 500 kg/ha dolomite. Side dressing occurred every six weeks at 100 g/m^2 of NPK at a ratio of 14:14:12, along with foliar application of micronutrients three times during the year. Irrigation was applied by under tree sprinklers and at rates for 100% of daily evaporation. Observations were made on establishment, vigour, productivity and vase-life (Table 2).

Table 2. Evaluation of *Heliconia* clonal accessions, CPHRF 2000/01

Species	Cultivar	DPIF Acc No.	Date planted	Plant No.	Yield [a]	Vase-life days to unsaleable (n)[b]	Comments
H. psittacorum	Lucille	HE1	10/98	2	Good	10-13(3)	Medium sized red, good dry season production?
H. psittacorum	Lillian syn. Rosi	HE2	4/00	1?	Low	3-8(3)	Lacks vigour, poor vase life
H. acuminatum	Peaches and Cream	HE3	1/00	1	Low	7-13(8)	Small, weak flower
H. caribaea x bihai ?	Freddy's Blue	HE 4	11/99	2	-	-	No flowering in 2000-01
H. bihai	Emerald Forest	HE5	I/00	2	-	-	No flowering in 2000-01
H. bihai	Emerald Forest	HE6	?	1	-	-	No flowering in 2000-01
H. bihai	Nappi Yellow	HE7	1/00	1	Good	12-17(5)	60% of assessed blooms lost turgor -drooped, strong grower.
H. bihai	Nappi	HE8	1/00	1	-	-	No flowering in 2000-01
H. bihai	Nappi Yellow	HE9	1/00	1	-	-	No flowering in 2000-01, same clone? As HE7 but different source.
H. solomonensis	-	HE 10	1/00	1	-	-	No flowering in 2000-01
H. chartaceae	Marisa?	HE11	1/00	2	Good	12-22(3)	Same as Sexy scarlet?
H. bihai	Yellow Dancer	HE 12	1/00	1	Moderate	?	Yellow bihai type, strong grower
H. angusta	Yellow Xmas	HE13	4/00	2	-	-	No flowering in 2000-01

Species	Cultivar	DPIF Acc No.	Date planted	Plant No.	Yield [a]	Vase-life days to unsaleable (n)[b]	Comments
H. steyermarkii?	-	HE 14	1/00?	1	-	-	No flowering in 2000-01
H. champneiana	Maya Blood	HE15	1/00	1	-	-	No flowering in 2000-01
H. orthotricha	Selection 1	HE16	12/98	1	Low	10-16(2)	Poor yield
H. orthotricha	Selection 2	HE17	12/98	1	Moderate	8-13(8)	
H. orthotricha	Imperialis	HE18	12/98	1	Moderate	9-13(9)	80% of assessed flowers lost turgor and drooped
H. orthotricha	Selection 4	HE19	12/98	1	Good	8-13(17)	Best of ortho. Accessions? 355 of assessed flowers lost turgor
H. orthotricha	Selection 5	HE20	12/98	1	Low	8(1)	Poor yield
H. orthotricha	Selection 6	HE 21	12/98	1	Low	8-12(5)	40% of assessed flowers lost turgor and drooped
H. orthotricha	Selection 7	HE 22	12/98	1	Moderate	3-12(10)	10% of assessed flowers lost turgor and drooped
H. orthotricha	Selection 8	HE23	12/98	1	Moderate	9-13(10)	
H. orthotricha	Selection 14	HE24	12/98	1	Moderate	8-20(6)	
H. orthotricha	Edge of Night	HE25	2/00	4	Low	12-13(3)	Very poor yield
H. orthotricha	She	HE26	12/98	1	Low	8-12(5)	60% of assessed flowers lost turgor and drooped
H. pogonatha x mariae	Dinosaur	HE27	1/00	1	Moderate	0(2)	Lip and tip necrosis of bracts, may interest niche markets

(Key: [a] = Good yield approximately > 50 stems/plant; moderate between 20 –50 stems; low < 20 stems; [b] = range of vase-live for all assessed stems/accession; (n) = Number of stems assessed/accession

OP seedlings
Open-pollinated seed was collected from mature plants at BARC and CPHRF. Fruits were soaked in water for a week and flesh removed and the cleaned seed air-dried and dusted with fungicide. Seed were then sown in trays into a steam pasteurised peat-perlite mix. Once seedlings had attained 2-3 leaves they were potted on into 2 litre poly bags containing steam pasteurised peat, sand and composted pine bark media.

Seedlings were planted out in December 1999 in rows 3 m apart and 2 m within the row. General management was as for the clonal accessions. Selection of better seedlings followed visual assessment where unattractive individuals were culled and vase-life assessments were undertaken on promising seedlings. This was followed by an industry field evaluation, where promising individuals were identified.

Results:

Clonal Accessions
Of the 27 accessions evaluated, “Lucille” psitt, “Nappi yellow”, “Yellow Dancer” and “Dinosaur” could be released. Of the *H. orthotricha* accessions, “She”, “Imperialis” and selections 2, 4, 7, 8 and 14, warrant release for industry evaluation. In all cases propagation material is limited.

OP seedlings
All *H. rostrata* seedlings tested for vase-life were very poor (less than four days) and all have been rejected. The *H. chartaceae* and *H. platystachys* seedlings have yet to flower. Of the *H. psittacorum* seedlings the industry project group have selected six which show promise. These will be further evaluated and market tested on commercial farms.

Conclusion:

With the rapid screening of both clonal accessions and OP seedlings, a number of promising, new cultivars could be commercialised by industry. For example, “Lucille” and two OP seedlings may provide industry with a large, productive, red psittacorum, locally, a product in great need. The *H. orthotricha* accessions represent a new product for industry and are increasing in demand from southern wholesale markets. Given that promising material has been derived within three years of commencing the project and total costs of the project to date are in the order of $15,000, the above strategy offers industry a viable alternative to developing a new product, which is crucial for a sustainable cut-flower industry.

Acknowledgment:

We would like to acknowledge the assistance of Patrick Lake and flower producers Kia Hanson, Jan Hintze, Ian Hennesy, Neal Witham, Margot Race and Peter Jettner in this project.

RESOURCE PROTECTION

PROGRAM: Resource Protection

SUBPROGRAM: Plant Pathology

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:

Ornamentals and tropical fruits usually make the bulk of imported plants in the Berrimah post-entry quarantine facility. The quarantine plant pathologist makes progress inspections and full-term inspections for release.

Method and Result:

As usual, tropical fruit and ornamental species predominated in post-entry quarantine in 2000-2001. Other species included snake beans.

Some problems were experienced when grafting imported mango and longan when some scions and rootstocks died. In mangoes, secondary *Aspergillus niger* and *Fusarium* sp. were isolated from the base of the rootstock, while *Botryodiplodia theobromae* was isolated from the scion where it was apparently acting as a weak or opportunistic pathogen. The problem appears to be due to the slowness of the scion to establish, for one reason or another, preventing the leafless grafted plant to take up water from the potting medium. The result is excess water in the medium with an associated oxygen deficit.

PROJECT: Assessments and Pathogen Testing for Nursery Industry Accreditation Scheme

Project Officers: A. Daly, M. Connelly and S. Bellgard (in conjunction with M. Hoult, Horticulture Division)

Location: Darwin/Katherine

Objective:

To assess nurseries for pathogen freedom for the purpose of accreditation under the Nursery Industry Accreditation Scheme.

Background:

A plant pathologist visits nurseries in the Darwin and Katherine areas to assess initial accreditation or to determine the continuation of accredited status. Samples of media and water are collected for pathogen testing at the Berrimah laboratory.

Method and Result:

Assessment of nurseries continued in 2000-2001.

Soil and potting mix samples from an already accredited nursery in Katherine were tested on 29 September for pathogens according to NIASA standards. *Phytophthora palmivora* was detected in a pot containing soil. Similarly, soil and potting mix samples from an already accredited nursery in the Darwin area were tested for pathogen on 6 February. *P. palmivora* was detected again in a compost heap used for potting mix.

Lupin baiting of soil and potting mix samples from a large accredited nursery in the outer Darwin area was carried out on 27 June as part of the NIASA assessment. A *Phytophthora* sp. was detected in a sample from the floor of a shadehouse. A follow-up visit will be made for more extensive testing of the shadehouse.

PROJECT: Survey for Banana Fusarium Wilt

Project Officers: A. Daly and I. Arao-Arao

Location: Darwin/Adelaide River

Objective:

To survey Fusarium wilt (Panama disease) in commercial banana plantations.

Background:

After the detection of tropical race 4 of Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense*) in a Northern Territory banana plantation in 1997, six-monthly surveys of all commercial plantations were established. Plant Pathology staff conducted surveys to achieve early detection. The surveys complemented the day-to-day surveillance by plantation owners and their workers. After assessing this arrangement with industry, it was decided to discontinue the bi-annual surveys and replace them with special surveys by Plant Pathology staff when requested by growers.

Method and Result:

A suspected case of Fusarium wilt at a second Lambells Lagoon property was reported previously. This was confirmed in all four affected plants on 10 July. There were six further detections and seven plants were affected.

Monthly surveys of a second Middle Point property, started in March of 2000, detected disease on 23 August. This was the first time the disease had been picked up in this type of survey. During a following survey a suspect sample was collected from which a saprophytic *Fusarium sp.* was isolated and confirmed by testing in Brisbane. The sample was affected by a bacterial 'rhizome rot'. These surveys were stopped in December 2000. Since the first detection on that property, the owner and/or staff reported three more, involving five plants.

A further six detections were made at the first property at Lambell's Lagoon, affecting six plants. Two of the suspects are yet to be confirmed.

Staff visited a rural block on 15 September to look for exotic diseases following a report of an unhealthy banana plant of an unknown variety, which possibly entered Darwin illegally. A follow-up visit on 31 October confirmed the plant was not infected.

PROJECT: Survey for Banana Sigatoka Diseases

Project Officer: A. Daly

Location: Darwin

Objective:

To survey Sigatoka-like diseases in bananas and submit samples to QDPI for detection of Black Sigatoka Disease.

Background:

As part of the national surveys for Sigatoka, samples showing Sigatoka symptoms were collected from commercial plantations and other sites and forwarded to QDPI Mareeba for identification. The survey aims to detect any black Sigatoka, which is not readily distinguishable from the common yellow Sigatoka in the field.

Method and Result:

Samples showing common yellow Sigatoka symptoms were collected from a Middle Point plantation in July 2000. Yellow Sigatoka and Speckle (a different species of the organism causing Sigatoka) were confirmed.

In August 2000 and again in February 2001 a survey of banana plants in the inner Darwin area was conducted as part of the ongoing Sigatoka survey. The aim is primarily to detect black Sigatoka disease. The inner Darwin area is considered susceptible because of the port and the airport as points of potential entry. The city area, Larrakeyah, Stuart Park, Fannie Bay, Nightcliff and Casuarina were surveyed. A sample was also collected from Berrimah. Yellow Sigatoka was only confirmed on the sample from Berrimah. All other samples were affected by Speckle except one, which was collected during the August survey and was affected by *Deightoniella* leaf spot. No symptoms resembling yellow or black Sigatoka were seen. Locations of plants in these areas were recorded for future visits.

Samples were collected again in March 2001 from the Middle Point plantation and from a property at Lambell's Lagoon and forwarded to QDPI Mareeba for checking. Results were not available for this report.

PROJECT: Northern Cotton Disease Survey

Project Officer: S. Bellgard

Location: Katherine Research Station

Objective:

Develop Sustainable Cotton Farming Systems.

Method and Result:

Northern Cotton Disease Survey
With the expected expansion of cotton cultivation in the NT and in the north of WA, it is essential to identify potential diseases that may threaten commercial production. Emphasis was placed on populations of naturalised and volunteer cotton on roadsides and riversides. Visits were made to trials of commercial cotton varieties in Katherine and Kununurra.

Tropical rust, caused by *Phakopsora gossypi,* was observed in all naturalised cotton populations, but not in the commercial cultivars in KRS. None of the cotton had symptoms of vascular wilts and/or black root-rot, which are caused by *Thielaviopsis basicola*.

Leaf Spot Research
Incidence of leaf spot disease, which is caused by *Alternaria* species, was compared between irrigation treatments and 20 cultivars. Leaf spot occurred early in the life of the crop in both drip-tape and overhead irrigation. However, in the long-term, leaf spot disease pressure was consistently greater in the overhead irrigated cotton. All commercial cultivars exhibited some susceptibility to leaf spot. The most susceptible lines were Sicot 51i and 53i.

Mycorrhizal Research
Cotton is a mycotrophic plant in which growth and nutrient uptake is usually increased by their mycorrhizal partnerships with beneficial soil fungi. Best Practice soil conservation management practices are part of our cotton farming system. Impacts of conventional tillage have begun to be investigated, as well as the variation in seasonal spore numbers of the beneficial soil fungi.

This work has been supported in part by a Cotton CRC scientific exchange, which made it possible to host Professor Stephen E. Williams from the Department of Renewable Resources, University of Wyoming.

PROJECT: Disease Diagnostic Service - Darwin

Project Officers: B. Condé, R. Pitkethley, A. Daly, L. Ulyatt and I. Arao-Arao

Location: Darwin

Objective:

To 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 Branch. The status of this service was elevated when DPIF became a core partner in the Cooperative Research Centre for Tropical Plant Protection and became involved in a major project initiative, the Northern Australian Diagnostic Network (NADN). The Darwin and Katherine plant disease diagnostic facilities together form a 'node' of this network.

Results:

In 2000-2001 a total of 733 diagnostic cases were handled in Darwin. Some interesting diseases were:

- Cavendish banana pseudostem with vascular discolouration from three plantations found during regular intensive surveys or submitted by growers. A Fusarium resembling *Fusarium oxysporum* f.sp. *cubense* was isolated and subsequently confirmed by PCR and VCG testing to be identical to the original tropical race 4.
- Bacterium recovered from a 'rhizome rot' affected banana plant at a commercial plantation was identified by Dr Steve Akiew at QDPI Mareeba as *Erwinia chrysanthemi,* the principal causal organism of the disease.
- Pawpaw from Daly River with leaf, fruit and stem spot caused by the fungus *Corynespora cassiicola*.
- Vietnamese basil wilt in the glasshouse caused by *Fusarium oxysporum* f.sp. *basilici*. Most likely the infection came from infected seed, as the seed was obtained from a submitted wilt specimen.
- Rot of mature yam bean (*Pachyrhizus erosus*) tubers due to *Sclerotium rolfsii*.
- Edible fig trees in a commercial plantation with rot of the lower trunk/branches. Caused by overly drastic pruning during wet conditions, leading to reduced transpiration with excess water retention in the root zone.
- Two rows of mango trees were affected by indirect lightning strike on a property at Lambells Lagoon/Humpty Doo. The orchard had underlying ironstone at the far end of the affected mango rows. Trees showed symptoms of fine cracking of the stem and yellowing of the branch. Internal necrosis was also visible when several affected branches were cut.
- Three samples of the macro bracket fungi were sent to Mr Jack Simpson at State Forests of NSW. He identified them as an undescribed species of Ganoderma. The common local Ganoderma had previously been believed to be *G. lucidum*.

Dr Natalie Moore, plant pathologist from QDPI Indooroopilly, visited Darwin from 18 to 22 September. During that visit Dr Moore trained plant pathology staff in techniques for vegetative compatibility group (VCG) analysis of the banana Fusarium wilt fungus *Fusarium oxysporum* f.sp. *cubense* (Foc). The setting up of VCG capability at Berrimah is an initiative under the NADN to provide rapid confirmation of Foc and to support the germplasm-testing program.

Since Dr Moore's visit, Darwin plant pathology personnel have worked on the VCG technique to get it fully functional. Tests on local banana Fusarium wilt suspects were done concurrently in Berrimah and at QDPI at Indooroopilly. Problems with the test at Berrimah were systematically investigated to find the cause. Mutant selection and media were found to be suitable. The integrity of tester cultures used will be investigated next.

PROJECT: Plant Disease Diagnostic Service - Katherine

Project Officer: S. Bellgard

Location: Katherine Research Station

Objective:

Maintain a plant disease diagnostic service for the Katherine region.

Background:

The plant disease diagnostic service is the core function of the Plant Pathology Branch at KRS. In 2000-2001, a total of 203 plant disease cases were handled in Katherine.

Method and Result:

New disease records on commercial crop-plant-hosts include:

- *Sesamum indicum* - *Phytophthora nicotianae* leaf blight and *Alternaria sesami* (tentatively identified) leaf spot
- *Arachis hypogea* - *Diplodia gossypina* leaf spot.

PROJECT: Plant Disease Reference Collection and Database

Project Officers: R. Pitkethley and L. Ulyatt

Location: Darwin

Objective:

To 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 developed further since then. The plant disease herbarium at Berrimah has been unofficially designated Darwin Northern Australia Phytopraphology (DNAP).

A functional database (Microsoft Access®) was set up in 1999-2000 allowing entry of plant disease accession records to be resumed after a pause of several years. A consultant had been engaged to refine the database, which had only limited functionality since data was transferred over from the old Q&A® database. Entry of plant disease accession records could be resumed after a pause of several years. With a Plant Pathology presence in Katherine, records from that region will be added to the database and to the Draft Host Index of the NT.

Results:

As the database was being used, staff identified the need for corrections of minor bugs and for further refinements. The programming consultant addressed these issues. A useful function of the new database is its ability to generate labels for the herbarium specimens, directly from the specimen records.

The Plant Pathology branch together with a national group developed and submitted a proposal for an initiative designated *National Network of Biological Collections for Plant Protection and Quarantine*. The initiative would protect national pathogen and insect collections and link their databases into a national network. The proposal sought funds from the Commonwealth Major National Research Facilities (MNRF) program.

Irrespective of the outcome of the above submission, there are plans to link the pathogen collection databases. In addition, DPIF is involved in a joint project with QDPI under the auspices of the CRC for Tropical Plant Protection, to develop and catalogue a database of plant pathogens in northern Australia. This project has commenced and will involve the linking of the NT and Queensland (Indooroopilly) databases.

PROJECT: Management System for Diseases of Bananas - Fusarium wilt

Project Officers: A. Daly, B. Condé, R. Pitkethley, L. Ulyatt and I. Arao-Arao

Location: Darwin/Adelaide River

Objective:

To identify sources of banana for possible testing for resistance to tropical race 4 of Fusarium wilt.

Background:

The detection of infections of tropical race 4 of *Fusarium oxysporum* f.sp. *cubense* in several localities since 1997 has highlighted the need to seek sources of resistance to the pathogen. These will be tested if a suitable testing site can be set up. Apart from plantation hygiene practices, there are no other means of control of this disease.

Method and Results:

Barry Condé obtained from Sharon Hamill of the Banana Tissue Culture laboratory at Nambour, Queensland, Lakatan/Pisang Berangan, a highly susceptible banana to tropical race 4 of *Fusarium oxysporum* f.sp. *cubense* (Foc – tr4) in Malaysia for multiplication of inoculum for a varietal testing site.

Barry Condé also arranged with Sharon Hamill, Natalie Moore and Madam Ho Yuk Wah of Malaysia to import through quarantine tissue cultures of selections of bananas with resistance/tolerance to tropical race 4. In October 2000, six lines of bananas with tolerance to Foc-tr4 were imported from United Plantations, Malaysia (Madam Ho Yuk Wah) to the AQIS Import Export Centre at Brisbane for post-entry quarantine testing. These are two lines of Grand Nain cv. Novaria, one line of Pisang Embun (Dwarf Cavendish), two lines of Pisang Rastali cv. Mutiara and one line of Pisang Jari Buaya, which Madam Ho Yuk Wah selected for somaclonal resistance to Foc-tr4. Due to contamination in one of the lines of Pisang Rastali cv. Mutiara in Post Entry Quarantine at Nambour, it was re-imported from Malaysia in June 2001.

The whole of Plant Pathology is involved in preparations for the inoculation, sampling, isolations and analysis of the Fusarium from a future testing site. Sorghum grain was inoculated in December with a culture of tropical race 4 of *Fusarium oxysporum* f.sp. *cubense* in preparation for the inoculation of the banana germplasm testing site at Coastal Plains Research Farm. Both the sterilisation of the sorghum and its inoculation were very time consuming processes. From time to time, the sorghum inoculum was tested for viability on agar plates.

PROJECT: Management System for Diseases of Asparagus

Project Officers: B. Condé, S. Bellgard, I. Arao-Arao, A. Daly, R. Pitkethley and L. Ulyatt

Location: Katherine/Darwin

Objective:

To develop a management system for diseases of asparagus, with initial emphasis on anthracnose.

Background:

The Darwin and Katherine sections of Plant Pathology aim to assess the infection cycle and tolerance of commercial asparagus cultivars and native asparagus (*Protasparagus racemosus*) to anthracnose (*Colletotrichum gloeosporioides*).

Method and Results:

Because of the precedence for screening snake bean lines for resisatance to Fusarium wilt and reduced interest in asparagus in Katherine, little work was done on asparagus anthracnose in 2000-2001. Spray inoculation in March 2001 of very young asparagus in polystyrene cups with spore suspension harvested from young cultures resulted in extensive lesions and sporulation on the very thin stems within four days. Previously symptoms and sporulation occurred in 10 days when older and stronger seedlings were inoculated with a spore suspension of *Colletotrichum gloeosporioides*. Anthracnose was recently found in north Queensland. Bob Davis in Queensland has reported an incubation time of seven days after inoculation before the appearance of symptoms and acervuli.

PROJECT: Management Systems for Diseases of Asian Vegetables – Fusarium Wilt of Snake Beans

Project Officers: B. Condé and I. Arao-Arao

Location: Darwin

Objective:

To develop a management system for diseases of snake beans, with current emphasis on the recently detected Fusarium wilt.

Background:

A Fusarium fungus was isolated from wilted snake beans in mid-1999 at Berrimah. Koch's postulates were fulfilled indicating that the Fusarium fungus was the cause of the disease. *Fusarium oxysporum* f.sp. *tracheiphilum* (Fot) is the name of the fungus causing Fusarium wilt of snake beans and cowpea. The fungus was plum-red coloured on PDA, aging to a dark purple colour. By the end of 1999 the Fusarium wilt was causing considerable damage to snake bean crops in the Buckley Road Humpty Doo area of Darwin.

Method and Results:

By 2000 and early 2001, Fusarium wilt caused severe disease in snake beans in most of the Darwin area. Some farms were no longer growing snake beans because of the disease. Production losses due to the disease reached approximately 50%.

An experiment showed that the causal fungus, *Fusarium oxysporum* f.sp. *tracheiphilum* (Fot) could be stored in sterilised (autoclaved) soil. The Fusarium stored in this sterilised soil was recovered on PDA and was found to be pathogenic on the standard commercial snake bean, Green Pod Kaohsiung (GPK).

The five Fot isolates from commercial farms in 1999 were single spore cultured and stored on filter paper using Natalie Moore's technique for banana Fusarium wilt. These filter paper stored cultures were shown to be virulent on the standard GPK snake bean and were the source of the fungus for all further tests.

In early tests this financial year, the variety Bat Kong sold by Mr Fothergill Seeds, showed a moderate level of resistance and a good level of tolerance to Fot compared with the standard GPK variety. Two rows of this variety were grown commercially without any plants showing disease. However, this Bat Kong variety was unacceptable commercially.

Seed of 29 lines of snake bean and three lines of cowpea indicators obtained from Merv. Rettke, Australian Tropical Crops Genetic Resource Centre, (ATCGRC) Biloela, Queensland together with the standard variety GPK were increased by Mark Traynor in Horticulture at CPHRF. Mark Traynor also increased seed of ten lines obtained from commercial companies. The pods were de-seeded by Plant Pathology staff with assistance from the Condé family. Albert Simonato stored the seed at the Seeds Section. A further six lines of cowpeas (Groit, Tvu298, Arlington, California Blackeye No 5, California Blackeye No 46 and California Blackeye No 27) were obtained from ATCGRC, Biloela to help sort out the race of Fot. Four lines of snake

beans were obtained from Sunland Seeds, a bean wholesaler, to include in the screening program. A dwarf line was obtained from the Darwin rural area. Malcolm Smith put us in contact with Dr. P. Umaharan, University of the West Indies, Trinidad-Tobago. After e-mail communication with Dr. Umaharan, six lines of snake beans (bodi) including one line with a high level of resistance in trials in Trinidad were imported and grown in Post Entry Quarantine (PEQ) at Berrimah. Seed will be released from plants inspected as healthy in PEQ. Plants grown from this released seed will be screened in the glasshouse for resistance to Fot. This will be reported in the Technical Annual Report for 2001-2002.

Four lines of snake beans assessed as having good pod characteristics were screened for resistance to the Fusarium wilt. All four lines tested susceptible. Seed from a line imported from Dr. Yi-Sheng Lin, National Chungshing University, Taichung, Taiwan called “White Skin” was released from PEQ. The “White Skin” line was reported to have a high level of resistance in tests against the Fusarium wilt in Taiwan. In the first Fusarium resistance screening in 2001, the “White Skin” line was found to have some resistance, but was highly tolerant to infection with a 1999 isolate of Fot (24946). The tolerance of the “White Skin” line was demonstrated when the Fusarium was isolated from 5/10 of the symptomless plants. Another line tested at the same time, Red Eye, obtained by Mark Traynor from a seed company, was found to be more susceptible than the standard commercial variety.

To conserve space, and so thereby screen the snake bean lines more rapidly, a composite screening of ten seedlings of each line in 6-inch pots rather than screening ten seedlings in individual small pots was devised. Each seedling was tagged with a price tag for recording purposes. Since an initial trial of a few lines indicated that this method was successful, it was adopted as the standard screening technique. Inoculations of the first two screenings of composite pots of snake bean lines of 26 and 28 lines respectively were commenced on 29/5/01 and 29/06/01 by inoculating them with a 1999 isolate of Fot (24946). Both tests included positive controls. Results are expected from these two screenings early in the next financial year.

Samples of wilted snake beans from a property in the Webb Road Humpty Doo area of Darwin in September 2000 yielded a *Fusarium oxysporum,* which was yellow-orange in colour in contrast to the plum red colour of all the Fot isolates in 1999. This yellow-orange-pale pink Fusarium was also isolated from some wilted snake beans collected in early 2001. We have not examined the relationship between these two types of isolates yet, nor have we done a survey to indicate the distribution of the two apparently different types of Fusarium.

Contacts were made with scientists in Queensland, Taiwan, Mississippi State University, South Carolina, USDA at Georgia, UC-Davis, UC-Riverside and Trinidad on snake bean and cowpea Fusarium wilt disease and management issues. Efforts to identify the cowpea differential lines used by previous researchers to enable us to determine the race of the Fot isolates were unsuccessful. An updated information paper on the snake bean Fusarium wilt was prepared and distributed as extension material for farmers.

PROJECT: Management Systems for Diseases of Asian vegetables – Fusarium Wilt of Basil

Project Officers: B. Condé and I. Arao-Arao

Location: Darwin

Objective:

To develop a management system for diseases of basil with present emphasis on Fusarium wilt and base rot.

Background:

Fusarium wilt of basil (*Fusarium oxysporum* f.sp. *basilici*) was identified in the Darwin rural area in 1997, probably introduced in infected seed some three years earlier. It again became a problem in May 2000 when Vietnamese farmers began to grow basil and submitted affected plant samples to Plant Pathology with typical external and internal symptoms.

Method and Results:

Fusarium oxysporum fsp. *basilici* (Fob) was isolated in culture on PDA and PDA plus lactic acid from sweet (white) basil from the Humpty Doo and Darwin River rural areas of Darwin with internal and external necrosis. Colonies were pale off-white colour when young, maturing to an orange colour, quite different from *Fusarium oxysporum* f.sp. *tracheiphilum* (Fot). The Fob cultures proved to be useful for Fusarium studies because they produce abundant spores of all three types, microconidia, macroconidia and clamydospores after only a few days and without any special cultural conditions. In July, 10 seedlings of conventional sweet basil were inoculated with 10 isolates of *Fusarium oxysporum* fsp. *basilici* (Fob) from basil specimens using the direct PDA plate root inoculation technique developed and used in the Fot inoculations by the authors. Plants showed wilt, tip necrosis and stem necrosis in 13 days. A second pathogenicity test was started on Sunday 13 August. On 25 August, 12 days later, two plants were beginning to wilt. By the end of August, after 18 days, 80% of plants showed symptoms of wilt or more advanced symptoms of necrosis of tips, stems or base rot. Some necrotic plants showed sporulation of the fungus. The sequential symptoms included plants ceasing to grow, leaves becoming chlorotic, plants beginning to wilt, leaves dropping off, followed by necrosis of tips and stems. When plants were necrotic, a white or pink fungal growth with abundant sporulation was often visible. The Fob could be re-isolated from an experimentally infected sweet basil plant in the glasshouse. Infested soil was also used to successfully inoculate a further two sweet basil plants. Fob was found to be widespread in most of the basil growing areas of Darwin, introduced through infested seed. With the rapid development of sweet basil and Vietnamese basil cropping by Vietnamese farmers, most soils became infected and Fusarium free seed was no longer a management option for control of this disease.

Observations in 2000-2001 indicate that Vietnamese basil is more resistant to and tolerant of infection by Fob. In one instance, the Fob fungus was isolated (one colony) from a wilted specimen of Vietnamese/Thai/Asian basil without obvious necrosis but which had root knot nematode. It may well be that Fob can be present in Vietnamese/Thai/Asian basil without causing wilt symptoms. A Vietnamese basil plant in the glasshouse grown from seed collected from an infected plant in July, and transplanted on 10 August began to show initial minor symptoms of Fusarium infection by 23 September. Some side shoots had stopped growing and the new growth was distorted and then chlorotic. Later these shoots showed tip dieback. There was internal necrosis, but this was initially unevenly distributed. There was internal necrosis, but this was initially unevenly distributed. Isolations were made onto PDAL from the necrotic side shoot tissue. Colonies of a *Fusarium* typical of *Fusarium oxysporum* f.sp. *basilici* (Fob) were obtained in culture. This infection appeared to have originated from the seed. Observations on this infected plant indicate that Vietnamese basil is more resistant and tolerant to the Fusarium disease than sweet basil. The infected plant took longer for any infection to appear and lasted much longer than sweet (white) basil before symptoms became severe. Two months later, another Vietnamese basil plant in the glasshouse was observed to be apparently healthy except for one small dead branch. Isolations were made from the dead branch, and the sweet basil Fusarium wilt fungus, *Fusarium oxysporum* f.sp. *basilici* (Fob) was obtained in culture. The plant was then stressed by withholding water for several days. The whole plant developed typical Fusarium wilt symptoms with permanent wilt and leaf drop; the plant did not recover when re-watered. Stressing caused the wilt fungus to move through the plant and the plant to develop severe wilt symptoms. Again, this plant was not experimentally inoculated; the infection either originated from infected seed or else from contamination in the glasshouse.

UH sweet basil, a line of sweet basil selected for tolerance to Fusarium wilt was imported from Hawaii. UH sweet basil seed was given to growers through Kim Bui to trial for resistance to Fob together with the Nufar F1 seed purchased from interstate in 1999-2000. Nufar F1 is a sweet basil selected for resistance to Fob in Israel. A sweet basil called "5170" was also trialled by growers. A grower in the Darwin River area found "5170" and UH sweet basil unsuitable for the market. He reported that the leaves of the Hawaiian basil were too small for commercial acceptance. He also reported that one third of the "resistant" Nufar F1 plants died early in their growth compared with total death of the normally susceptible sweet basil variety. The market prefers the normal susceptible sweet basil variety but will accept the Nufar F1 at a lower price if there is a scarcity of the normal variety. An uninoculated plant of Nufar F1 sweet basil was observed with wilt and leaf drop in the Plant Pathology glasshouse in December - January. *Fusarium oxysporum* f.sp. basilici, the cause of basil Fusarium wilt and base rot, was isolated from this plant. This infection in this instance was due to contamination in the glasshouse. This demonstrated that while the Nufar F1 has resistance to Fob, the hybrid is not totally resistant to infection by Fob. The practice of removing and destroying obviously infected Nufar F1 plants should reduce the build up of Fob inoculum and so allow the remaining Nufar F1 plants to last longer before they succumb to the disease.

In summary, Fusarium wilt free sweet basil seed can be used where the soil is not known to be contaminated with the disease. The disease can affect Vietnamese basil, but observations suggest that this basil is both more resistant and tolerant to Fob infections. Nufar F1 sweet basil is more resistant to Fob than conventional sweet basil and is also acceptable to the market, but at a lower price than conventional basil when this is available.

PROJECT: Management System for Major Diseases of Asian Vegetables - Cucurbit Mosaic Viruses

Project Officers: B. Condé and I. Arao-Arao

Location: Darwin

Objective:

To identify the viruses affecting cucurbit crops in the Darwin area and to elucidate their epidemiology so that an effective management system can be developed.

Background:

Mosaic virus caused serious damage to cucurbit crops last year and this year. Until 1989, PRSV-W (papaya ringspot virus – cucurbit strain, an aphid transmitted potyvirus) was the only virus of importance in cucurbit crops. SqMV (squash mosaic virus, a beetle transmitted virus) was recorded from one crop having been transmitted to the plants through the seed. The SqMV did not spread. Unlike the situation in Queensland, WMV-2 (watermelon mosaic virus – strain 2, a potyvirus) has not been found in the NT. In 1989, ZYMV (zucchini yellow mosaic virus, a potyvirus) was found for the first time in the NT in a crop of zucchini at Berry Springs and gramma (*Cucurbita moschata*) in a home garden at Nightcliff. ZYMV has been recorded from the NT several times since 1989. With the increase in cucurbit crop production among Vietnamese and other growers, there has been a dramatic increase in the incidence of mosaic viruses of cucurbits over the past few years.

Method and Results:

Severe mosaic was found on a farm in Humpty Doo in July 2000 in which 100% of the Blackjack zucchini and at least 50% of a Sunburst squash crop were infected. Owners estimated a 50% loss. The zucchini had bubbled fruit and the golden squash had fruit with colour break, and so could not be sold. Samples were taken for virus identification. Discussions were held with the owners on the virus, its spread, its epidemiology and some suggestions for management. Because of this severe outbreak, an information sheet and photographs were produced and presented to an NT Horticultural Association - Asian Vegetables Group meeting on 7 August. Initial herbaceous indicator tests again indicated that this virus was ZYMV and not PRSV-W.

Another farm at Webb Road Humpty Doo had serious problems with mosaic viruses in September 2000. A zucchini crop was 100% infected. Squash and a new cucumber crop were 80% and 60% infected, respectively. Again, the virus responsible appears to be ZYMV; differential herbaceous indicators will be used to confirm its identity. The farmer had not undertaken any aphid control; aphids (*Aphis gossypii*) were free to build-up on infected plants, picking up the virus to transmit to uninfected plants.

Greg Owens of Horticulture brought to our attention a suspected incidence of mosaic virus on bitter melon in November 2000. The vines were very old at the end of their production life but leaves displayed a vague light and dark green mottle. Samples were taken and inoculated onto Jap gramma indicators. Symptoms on the indicators were not positive for virus. One bitter melon plant was experimentally inoculated with a ZYMV culture and failed to show symptoms. Thus it appears that the symptoms on the bitter melon leaves were nutritional rather than due to virus infection.

A farm in Darwin River Road lost several thousand dollars worth of crops of yellow squash and Lebanese cucumbers in June 2001. Fruit production was reduced and yellow squash had colour break and Lebanese

cucumbers had blisters. The growers were advised to remove infected plants and to control aphids. However, the virus was traced to a long-standing mosaic virus infected long melon crop in a neighbouring farm.

Inoculation work with herbaceous indicators on some samples was commenced late last financial year and completed early this financial year. The samples indexed as ZYMV rather than PRSV-W or WMV2. The critical reactions were severe systemic mosaic rather than local lesions on Kiwano (*Cucumis metuliferus*) and *Cucumis melo* cv. 633-3, absence of chlorotic lesions and failure to recover virus from inoculated leaves of okra (*Hibiscus esculentus*), and strong chlorosis of new growth leaves of inoculated sinqua (*Luffa acutangula*).

Work last year and this year demonstrated that both Jap gramma (*Cucurbita moschata*) and long melon (*Lagenaria siceraria*) are important hosts in the epidemiology of virus spread onto commercial farms. These two hosts act as long term reservoirs of the virus, and are particularly important in the epidemiology of the disease where they are grown and on nearby farms. It would be beneficial to replace these two plants with resistant lines in the Asian vegetable production system to eradicate serious cucurbit virus problems.

PROJECT: Management System for Diseases of Peanuts

Project Officer: S. Bellgard

Location: Katherine Research Station

Objective:

Sustainable peanut farming systems

Background:

Leaf spot and Rhizoctonia limb blight are the two major disease problems in commercial peanut production. Two commercial peanut farms were visited fortnightly since planting to monitor the incidence of leaf spot. Additionally, an on-farm trial at Early Storms, Douglas Daly Region, is testing the efficacy of tebuconazole on Rhizoctonia limb blight.

Results:

The observation is continuing to investigate wet-season rotation cover-crop options that will aid in the reduction of soil borne leaf and limb disease inoculum.

PROJECT: Management System for Diseases of Sesame

Project Officer: S. Bellgard

Location: Katherine Research Station

Objective:

Sustainable sesame farming systems.

Background:

Together with the *Sesame Industry Development project* we have started an investigation of disease tolerance in commercial sesame cultivars.

Results:

As part of our preliminary survey work, we identified two new pathogens causing leaf blights, *Phytophthora nicotianae* and an *Alternaria* species (tentatively identified as *A. sesami*).

SUBPROGRAM: Entomology

PROJECT: Insect Pests of *Acacia mangium* Plantations on Melville Island

Project Officer: **G.R. Brown**

Location: Melville Island

Objective:

To sample and identify insect species found on Acacia mangium, and to determine their pest status.

Background:

Acacia mangium is a fast-growing New Guinean species of wattle tree that has potential as a source of wood chip. It has been grown commercially on Melville Island since 1998, with the size of plantations being increased each year. It is expected that these will expand to 32,000 ha by 2005.

There are over 700 species of Australian a*cacia*. These are attacked by a wide variety of insects. However, little is known of the Northern Territory's wattle fauna, especially under plantation conditions. However, in 1999 these plantations were severely attacked by longicorn beetles (Coleoptera: Cerambycidae) and in 2000 by three species of caterpillar, an undescribed species of *Adoxyphyes* (Lepidoptera: Tortricidae), *Donuca orbigera* (Guérin) (Lepidoptera: Noctuidae) and an unknown species but probably another species of noctuid.

Because of the severity of these infestations, as well as the increasing size of the plantations and the increasing range of ages of the plantation trees, it was planned to monitor the plantations regularly during 2000/2001.

Results:

Four visits were made to Melville Island as summarised below. Based on previous years' problems, damage by caterpillars was expected to be the most important in March, but this did not happen.

9 August 2000
Insect activity was less than during previous visits and damage was slight. *Myllocerus* weevils (Coleoptera: Curculionidae) and tortricid caterpillars (Lepidoptera: Tortricidae) were present only in small numbers. Long soft scale, *Coccus longulus* (Douglas) (Hemiptera: Coccidae) and a small black and white moth were both common, but the latter had not been recorded on previous visits. The moth was subsequently reared from a bright pink tortricid like caterpillar but has not been identified at this stage.

4 October 2000
Very few insects were active on the trees. The only caterpillars found were of an unknown species. This species cuts small sections from the leaf margins, and then folds them over the leaf to form a covering for itself. These larvae were present less than one per tree. The small black and white spotted moth, previously present in higher numbers was rarely seen during this trip. Dead branches from previous prunings were collected for boring insects. These contained bostrichid (Coleoptera: Bostrichidae) and cerambycid (Coleoptera: Cerambycidae) larvae, and may also contain buprestid larvae as an adult specimen of *Melobasis* sp. (Coleoptera: Buprestidae) was collected in flight. The cerambycid may be *Platyomopsis* (Coleoptera: Cerambycidae) which had caused ringbarking and death of young trees last year. If this is the case, prunings will have to be removed to prevent a buildup of *Platyomopsis* populations.

29 March 2001
Few insects were present, and few were found due to rain. Although it was expected that the large noctuids (as yet unidentified) would be present as they had been last year, they were not detected during this visit.

Two caterpillar species were present – one which leaf-mines and another which chews the edges of the leaves, as observed in October. Both are as yet unidentified, but are not of economic importance.

13 June 2001
The trees were looking healthy. Plants were just beginning to produce new shoots but there was little insect activity. Almost no caterpillars were found although there was some insignificant damage from weevils, *Polyphrades* sp. and *Myllocerus* sp. (Coleoptera: Curculiondae). The bostrichid borer, *Sinoxylon anale* Lesne (Coleoptera: Bostrichidae) was active in dead and severed branches, and three examples of the cerambycid, *Platyomopsis* sp. (Coleoptera: Cerambycidae) were also found in dead branches.

Discussion:

Unlike previous years, there were no pest outbreaks this year. *Platyomopsis* was observed on a number of occasions, but was not considered to be a pest. Similarly the caterpillars *Adoxophyes* sp. (Lepidoptera: Tortricidae) were rare, and no noctuids (Lepidoptera: Noctuidae) were found.

PROJECT: Arthropod Identification and Control Service

Project Officers: D. Chin, G.R. Brown, E.S.C. Smith, G. R. Young, M. Hoskins and H. Brown

Location: Territory wide

Objective:

To 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 Branch provides an advisory service on entomological matters pertaining to agricultural, horticultural or domestic situations. Over the past few years, the demand for this service has increased dramatically as the number of horticultural producers has increased and as fruit trees in suburban gardens mature.

The extension services provided by the Branch include phone enquiries on identification and advice on control of insects, grower visits, examination of specimens delivered to DPIF offices; talks provided to industry organisations, schools and the university; and presentations at departmental field days, rural, horticultural and agricultural shows.

Results:

The nature of the enquiry and the recommendations provided are recorded and entered into a database. The information recorded may be used for future planning of research and allocation of resources.

During the year, the Branch received 2,215 enquiries (including 224 from the Katherine Branch). This represents an overall increase of 44.6% compared with the previous year. The proportion of the various client groups and the differences to the 1999/2000 period are shown in Table 1.

Table 1. The proportion of services provided to different groups in 2000/2001

		% Difference to 1999/2000
Government:	34.9%	(-6.7)
Primary producers:	24.6%	(+1.6)
Householders:	20.3%	(-4.1)
NTQIB:	4.8%	new category
AQIS:	0.8%	new category
Pest control operators:	1.6%	(+1.6)
Others:	13.0%	(+3.6)

Most of the extension enquiries were concerned with insect identification and pest control recommendations for growers provided directly or through Horticulture Extension Officers, Quarantine staff and other staff within DPIF (decrease from 41.6 to 34.9%). Direct advice to primary producers accounted for 24.6% (an increase of 1.6%) and householders 20.3% (a decrease of 4.1%) of the total. There was a slight decrease in enquiries from departmental officers (government) because Quarantine enquiries were placed in a separate category and a slight increase in the enquiries from primary producers. Household and backyard enquiries decreased by 4.1% due probably to fewer problems from mango leafhoppers this year. There was an increase in enquiries from pest control operators from 0.7 to 1.6 %, mostly related to termite identifications. The increase in the “Others” category included a greater number of enquiries from schools, universities and private agricultural consultants.

The promotion of integrated pest management through demonstrations on grower properties and displays at open days and rural shows has continued to generate interest amongst growers. In particular, mango, rambutan, citrus, Asian vegetables and cucurbit growers have been provided with insect monitoring and insect identification workshops, assistance in regular monitoring of pests and natural enemies, the use of commercially reared beneficials and chemical control options.

Diagnostic identifications were provided to all outstations of the Department and extension visits were carried out at Coastal Plains, Katherine, Douglas Daly and Ti Tree Research Stations to discuss pest problems on fruit, vegetables and field crops.

Commercial Crops:

Fruit Trees

The majority of enquiries from fruit growers concerned the control of redbanded thrips, *Selenothrips rubrocinctus* (Giard) (Thysanoptera: Thripidae); mango leafhopper, *Idioscopus nitidulus* (Walker) (Hemiptera: Cicadellidae); flatids (*Colgaroides* spp.) (Hemiptera: Flatidae); fruit fly *Bactrocera tryoni* (Froggatt), (Diptera: Tephritidae); longicorn beetle, *Acalolepta mixtus* (Hope) (Coleoptera: Cerambycidae); giant termite, *Mastotermes darwiniensis* Froggatt (Isoptera: Mastotermitidae); fruit spotting bug *Amblypelta lutescens lutescens* (Hemiptera: Coreidae) and fruitpiercing moth *Eudocima fullonia* (Clerck) (Lepidoptera: Noctuidae). The main tree crops included mangoes, citrus, rambutan, carambola, guava and pawpaw. Further details are shown in the project: “Control of Arthropods and Development of IPM in Tropical Tree Crops”.

Mango leafhopper, *I. nitidulus* continued to spread throughout Darwin and the rural areas. It has been confirmed from most Darwin suburbs, Howard Springs, Humpty Doo, Berry Springs, Noonamah, Darwin River, Tipperary Station and as far as Adelaide River. In the rural areas, growers have been advised to use carbaryl (but not at flowering) or trichlorfon. Carbaryl seems to be more effective when there is a large infestation. Two organic growers have shown interest in treating their mango trees with canola oil and pyrethrum. Although the Branch received many enquiries from the Darwin suburbs on the control of *I. nitidulus* on backyard mango trees, control with insecticides was not recommended as the trees were generally too tall to treat effectively and had potential problems of spray drift into houses.

A commercial citrus grower submitted branches and twigs with numerous small cracks and lesions. The damage was inspected by Plant Pathology and Entomology and was determined to be from last Dry season and caused by red scale, *Aonidiella aurantii* (Newstead) (Hemiptera: Diaspididae).

Growers of carambola and other fruits in Humpty Doo who had problems with damage to flowers were advised after inspection that the damage had not been caused by insects but by possums. The NT Wildlife Park provided advice on control measures.

Cucurbits and Asian Vegetables
The most common advice requested by growers was for the control of *Thrips palmi* Karny (Thysanoptera: Thripidae), Poinsettia whitefly, *Bemisia tabaci* (Gennadius) Type B (Hemiptera: Aleyrodidae) and mites. This included the control of *T. palmi* on cucurbits, hairy melon, bitter melon, button squash, eggplant and loofa. *B. tabaci* may affect okra, snake bean and bitter melon. The current recommendation for both *T. palmi* and whitefly is the regular use of potassium soap such as Natra Soap®.

Broad mite *Polyphagotarsonemus latus* (Banks) (Acarina: Tarsonemidae) was recorded as a severe pest on chillies on one property. The grower preferred not to use conventional miticides and instead persisted with weekly applications of petroleum oil sprays (DC Tron Oil®). After three applications, the crop appeared healthy and suffered very little damage to new leaves from mites

A commercial rockmelon property encountered significant plant damage and yield loss from *Solenopsis geminata* (Fabricius) (Hymenoptera: Formicidae) which removed the seeds and attacked the seedlings. This and other properties followed advice to regularly monitor and treat for cucumber moth based on the results of sampling. A series of insect specimens from two properties were identified for compiling a species list for the growers.

Ornamentals and Nursery Plants
Several flower growers had caterpillar damage to flowers and stems of *Alpinia purpurata* causing the flowers to be unmarketable. Horticulture and Entomology Staff inspected the affected properties. Larvae were collected and reared to adults. The specimens were identified as *Conogethes* near *pluto*. Other similar specimens have been recorded from Queensland and northern NSW but had no host records. Information on the control of this moth was supplied to Horticulture Extension Officers for distribution to growers.

Plantings of ornamental sweet potato (*Ipomoea batatus*) on nature strips were inspected as requested by the Department of Transport and Works. The plants had suffered from leaf defoliation over a few months. Although most of the damage was old, moderate numbers of grasshoppers (Orthoptera: Pyrgomorphidae) and a chrysomelid beetle, *Metriona* sp. (Coleoptera: Chrysomelidae) were present. Insecticides were not recommended since the numbers were low but it was advised that fertiliser be applied and watering increased. At the end of the month the plants were reported to have recovered and were looking healthy after the advice was followed.

Other common enquiries concerned mealybugs causing distortion to new shoots of palms and thrips in nursery plants. Two thrips species (Thysanoptera: Thripidae) also caused significant damage to Vanda orchid flowers owned by a hobby grower and *Hymenocallis,* a lily, in a nursery. The causal agents were *Dichromothrips corbetti* (Priesner) and *Astrothrips* sp., respectively.

The following insect swarms were recorded from the Darwin and Darwin Rural Area during the year;

- *Monolepta australis* (Jacoby) (Coleoptera: Chrysomelidae) - in orchards.
- *Agetinus* sp. (Coleoptera: Chrysomelidae) - on young mango trees.
- Scarab beetles (Coleoptera: Scarabaeidae) - on ornamentals.
- Flea beetles (Coleoptera: Chrysomelidae) - in orchards.
- *Graptostethus* sp. (Hemiptera: Lygaeidae) - in orchards.

Ginger Ants
Many enquiries and associated specimens were received due to media publicity following the detection of the red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae) in Queensland. Specimens that were collected or supplied were generally ginger ant, *Solenopsis geminata* (Fabricius), *Odontomachus turneri* Forel or *Iridomyrmex* sp (a brown species). *S. geminata* which is well established in the Darwin area was found at Katherine and in nursery stock that was sent to Alice Springs from Darwin. A local man in Katherine was admitted to hospital after ants, confirmed as *S. geminata,* had stung him.

Ants that were killing birds in an aviary at the Territory Wildlife Park were identified as *Pheidologeton* sp. This ant comes in raiding swarms and attacks small vertebrates. Information was provided on the management and control of the ants. *S. geminata* was also found in an area outside the aviary.

Household and Backyard Enquiries
Popular household enquiries included information and/or control of the following:

- ants (Hymenoptera: Formicidae) - *Tapinoma melanocephalum* (Fabricius), *Monomorium* spp., *Pheidole megacephala* (Fabricius), *Paratrechina longicornis* (Latreille), *Solenopsis geminata* (Fabricius);
- spiders (huntsman (Araneida: Heteropodidae); mouse, *Missulena pruinosa* Levitt-Gregg (Araneida: Actinopodidae); orb-weavers, (Araneida: Araneidae); redback, *Latrodectus hasselti* Thorell (Araneida: Theridiidae); brown widow, *Latrodectus geometricus* Koch (Araneida: Theridiidae) and wolf, (Araneida: Lycosidae)) - spiders were more commonly seen during September and May;
- mango pests from backyard trees;
- lawn grubs (Hymenoptera: Scarabaeidae);
- papernest wasps (Hymenoptera: Vespidae);
- psocids in hotels, houses and a herbarium;
- Carpenter bees - *Xylocopa aruana* (Hymenoptera: Anthophoridae);
- bush bee (*Trigona* sp.) (Hymenoptera: Apidae) nesting in wall cavities.

Other Public Enquiries
Five separate Aboriginal communities requested information from the Katherine branch during the year. These ranged from IPM and crop monitoring to specific requests on mango and citrus pests and dung beetle releases.

Huge numbers of brown widow spiders were of concern at a community care centre. The spiders were found on children's toys in this new complex.

In the northern suburbs, the coastal brown ant, *Pheidole megacephala* (Hymenoptera: Formicidae) caused acid corrosion to an aluminium door frame of a house. Trails of the green ant *Oecophylla smaragdina* Fabricius (Hymenoptera: Formicidae), possibly from different colonies, travelled along an aluminium tubular fence and sprayed acid onto the fence which stripped the top layer of paint.

Host information on witchety grubs (*Xyleutes* sp.) (Lepidoptera: Cossidae) was provided to a vendor who sold witchety grub satays to tourists at Mindil Beach Markets for $10 each (one grub to a stick).

Two sandgropers, *Cylindracheta* sp. (Orthoptera: Cylindrachetidae) were delivered to the Branch. These insects which are not often encountered were collected from soil near cocoa roots and from soil in a backyard.

Colletid bees, *Hylaeus ruficeps* (Smith) (Hymenoptera: Colletidae) which have nested in the polystyrene walls (with concrete rendering) of a motel in Tennant Creek in previous years, have once again re-invaded. Chemical control was not effective in controlling the bees after they started nesting. To prevent further problems next year, recommendations were made on preventing the entry of the bees rather than attempting control after entry.

PROJECT: Development of IPM Strategies for Citrus

Project Officers: G.R. Brown, M. Hoskins and E.S.C. Smith

Location: Katherine and Mataranka

Objective:

Identify potential arthropod problems in citrus tree crops and devise appropriate control measures.

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. A recent survey conducted by DPIF in conjunction with the NT Citrus Growers' Association estimated there were 70,000 planted trees, with the majority of large plantings now situated near Katherine. However most planted trees in the Top End are still young and over 80% are yet to come into production.

Several of the main citrus insect pests have now been identified and ongoing advice and assistance is provided to all growers consistent with the aim of developing integrated Pest Management (IPM) systems for all tropical tree crops including citrus. New problems appear each year as this relatively new crop continues to expand in area and value, and new growers enter the industry.

Method:

Regular monitoring of citrus plantings in the Katherine region began in December 1999. Fortnightly surveys were conducted at the experimental cultivar plots located at KRS. A further nine private properties in the Katherine region have been monitored at irregular intervals. It is envisaged that regular monitoring will continue until at least May 2003 when collected data will show definitive population trends and allow publication of various extension materials required by growers.

Results:

A great deal of beneficial information was collected dealing with insect pest distribution, seasonal occurrence, life cycles and their pest potential. Beneficial insects such as generalist predators and parasites were also collected and identified. Feedback was given to property owners in regard to the insect pests found but growers do not rely on this service to manage their orchards.

The following is a brief summary of various activities and key results obtained through crop monitoring and field trials up to 30 June 2001.

Citrus leafminer *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillaridae)
The larvae of this moth mine leaves and cause leaf curling and distortion. Severe infestations can retard the growth of young trees. Damage is thought to occur throughout the year when suitable new flush growth is available. Results monitored to date show that citrus leafminer (CLM) is most damaging to immature trees which flush continually, whilst mature trees carrying heavy fruit loads tend to flush less through the months of September to April when CLM is most active.

Monitoring included the collection of CLM pupae to breed out parasitic wasps. One hundred and sixty nine wasp specimens were reared including at least 12 species of parasites. Levels of parasitism were normally low, (< 10 %) but a collection in February at KRS yielded 44 % parasitism.

An interesting finding, yet to be confirmed by DNA analysis, was that CLM were collected from two native tree species (*Terminalia platyphylla* (Combretaceae) and *Clerodendrum floribundum* (Verbenaceae)), and possibly more, in at least the Katherine region.

Ants (especially) *Iridomyrmex* spp. (Hymenoptera: Formicidae)
Some species of ants at high densities can severely disrupt IPM programs, particularly those directed towards the control of red scale, honeydew-producing insects such as mealybugs, planthoppers and sooty mould. Honeydew is a favourite food source for several common ant species and ants entering the tree canopy in search of honeydew can interfere with predators and parasites seeking out pest species. Ants act to defend such pests, which are then able to rapidly build up to damaging levels, causing sooty mould stains on fruit or damaging the structure of trees.

Observations have been made of some species of meat ant, *Iridomyrmex* spp., physically chewing the edges of citrus leaves. This behaviour is not understood and occurs only sporadically resulting sometimes in severe damage to new flush tissue. Meat ants give a nasty bite and are a nuisance to people pruning trees.

Meat ant activity has been monitored at KRS to establish when ants are most active and damaging to tree crops. From November to March it is necessary to monitor and control meat ants. Bare soil under rows appears to encourage ants to nest because full sun and warm conditions are most suited to tropical ant species. Mulching beneath trees can increase soil organic matter, improve soil structure, reduce root temperature fluctuations and increase soil water retention. Mulching may also deter ants to some extent. Mulch was laid at KRS during July 2001 and ants will be monitored from November to assess the impact on ant numbers.

Oriental spider mite *Eutetranychus orientalis* (Klein) (Acarina: Tetranychidae)
Oriental spider mite (OSM) feed on plant tissue including leaves, fruits and green twigs of many host plants. OSM are distributed widely within Australia and are also found in South-East Asia and Africa. In the NT, OSM is found on citrus and other tree crops in the Katherine and Darwin areas.

Eggs are deposited on the upper surface of leaves, commonly near the midrib and the life cycle can take as little as 10 days in warm weather.

OSM feeds on the upper surface of leaves and exposed surfaces of fruit. Symptoms of mite activity are most obvious on mature leaves, giving them a white, mottled appearance (chlorosis) which then turns yellow and leaves may drop. Fruit is damaged when mite populations are heavy, causing chlorosis and dull patches at ripening.

Monitoring results showed that infestations began to build at the onset of the Dry season, around May and remained active through the cooler months. Feeding activity is thought to be interrupted by heavy rains and excessively hot conditions over our Wet season so mites are less common in the tree canopy. Further studies into population dynamics are continuing.

Predatory mites are not yet found commonly on citrus in the Katherine area but further studies may reveal these valuable predators. *Stethorus sp*. (Coleoptera: Coccinellidae) has been common at times and increases in numbers over the Dry season, thereby keeping mite populations in check. Adult beetles and their larvae feed on all mite life stages and especially mite eggs.

Other common insects found to be pests on citrus are:

- red scale *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae);
- spherical mealybug *Nipaecoccus viridis* (Newstead) (Hemiptera: Pseudococcidae);
- fruitpiercing moth *Othreis materna* (Linnaeus) (Lepidoptera: Noctuidae)
- cicadas (Hemiptera:Cicadidae);
- aphids *Aphis gossypii* Glover (Hemiptera: Aphididae);
- sap sucking bugs *Oncocoris* sp*., Nezara viridula* (Linnaeus) *Mictis profana* (Fabricius) etc. (Hemiptera: Pentatomidae);
- citrus butterflies *Papilio* spp*.* (Lepidoptera: Papilionidae);
- grasshoppers, katydids and crickets various species (Orthoptera).

PROJECT: Taxonomy of Scale Insects and Mealybugs (Hemiptera: Coccoidea) and White Flies (Hemiptera: Aleyrodidae)

Project Officers: G.R. Brown and L. Zhang

Location: Territory wide

Objective:

To reliably identify scale insects and mealybugs and to recognise new occurrences particularly those of agricultural importance.

Background:

Many scale insects, mealybugs (Hemiptera: Coccoidea) and whiteflies (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 last year's Technical Annual Report.

A list of species identified microscopically is given together with host and location where collected. Numbers given are “C” for quarantine interception numbers or “T” for the taxonomy catalogue or “K” for Katherine. Other numbers refer to the database of the Entomology Branch.

HEMIPTERA:

Asterolecaniidae (Pit Scales)
Three species of *Bambusapis* were found on bamboo in large numbers on stems or causing discolouration of leaves. All are new records for the Northern Territory, and one may be a new species. Material examined is as follows:

Bambusaspis bambusae (Boisduval)
(T148) on bamboo at Marlows Lagoon (New NT).

Bambusaspis robusta (Green)
(T149) on bamboo at Marlows Lagoon (New NT).

Bambusaspis sp.
(T110) on bamboo at Berrimah Agricultural Research Centre (New NT).

Coccidae (Soft Scales)
At least 16 species are recorded from the NT of which the majority are introduced and widespread polyphagous pests of commercial crops. These belong to the genera *Ceroplastes, Coccus, Eucalymnatus, Parasaissetia, Pulvinaria, Saissetia* and *Vinsonia,* as well as *Megapulvinaria* and *Milviscutulus* although the status of the latter two genera needs to be confirmed. Only three native species are recorded, *Cryptes baccatus* (Maskell) on *Acacia*, *Paralecanium pseudexpansum* (Green) on pandanus, and an unidentified species on *Melaleuca*.

Ceroplastes rusci (Linnaeus) is a new record for the establishment of this species in Australia. *Cryptes baccatus, Eucalymnatus tessellatus* (Signoret)*, Milviscutulus, Pulvinaria psidii* Maskell, *Pulvinaria urbicola* (Cockerell) and the unknown and possibly new species *Pulvinaria* are new species records for the NT. Additionally, many of these are new host records for the Entomology Branch database. Examined material is as follows:

Ceroplastes rusci (Linnaeus)
(T57) on Cluster fig, *Ficus* racemosa and Banyan, *Ficus virens* at Casuarina (New hosts).

Coccus hesperidum Linnaeus
(T108) on rambutan, Nephelium lappaceum at Humpty Doo (New host).

Coccus ?hesperidum Linnaeus
(T42) on mango fruit peduncle, *Mangifera indica* at Katherine;
(T88) on ? Hibiscus at Berrimah Agricultural Research Centre (New host);
(EXT) Darwin area, no other data.

Coccus longulus (Douglas)
(T19) on *Acacia mangium* at Melville Island (New NT);
(T51) on *Exocarpus latifolius* at Black Point Ranger Station (New host)
(T89) on Citrus at Nakara (New host);
(T136) on Acacia at Berrimah Agricultural Research Centre;
(T37) on *Dalbergia* sp. at NTU, Casuarina (New NT).

Coccus sp.
(T107) on chilli plants, Capsicum annuum at Virginia (New host);
(T124) on mango, *Mangifera indica* at Katherine Research Station;
(T125) on grapefruit, Citrus paradisi at Katherine;
(Unnumbered) on Ficus benjamina at Darwin (New host);
(Unnumbered) on Foxtail palm, Wodyetia bifurcata at Berrimah Agricultural Research Centre (New host).

Cryptes baccatus (Maskell)
(Unnumbered) on Acacia ?stipuligera seedlings at Julalikari Karguru Nursery, Tennant Creek (New NT).

Eucalymnatus tessellatus (Signoret)
(T73A) on *Alstonia scholaris* at Tiwi (New NT).

Milviscutulus sp.
(T73B) on *Alstonia scholaris* at Tiwi (New NT).

Parasaissetia nigra (Neitner)
(T54) on *Ficus microcarpa hilli* at Berrimah Agricultural Research Centre (New host).

Pulvinaria psidii Maskell
(T43) on frangipani, *Plumeria rubra* at Katherine (New NT);
(T53) on *Alstonia actinophylla* at Rapid Creek (New host);
(T66) on frangipani, *Plumeria rubra* at Karama (New NT);
(T72) on *Alstonia scholaris* at Tiwi (New NT);
(unnumbered) on *Minusops* (New host).

Pulvinaria urbicola (Cockerell)
(T25) on fiddlewood, *Citharexylum spinosum* at NTU, Casuarina (New host);
(T98) on an unknown host at Katherine.

Pulvinaria sp. (unknown - ?new sp.)
(T81) on frangipani near Rapid Ck, Darwin airport (New NT).

Saisettia coffeae (Walker)
(T49) on *Mangifera indica* fruit spikes at Katherine (New host);
(K1) on unknown plant at Katherine.

?Saisettia sp.
(T45) on guava, *Psidium guajava* at Katherine Research Station (New host).

Unknown genus, tribe Paralecaniini
(T86, T96) on *Melaleuca* at Nakara.

Diaspididae (Armoured Scales)
At least 24 species are recorded from the NT; many of them introduced polyphagous pests. The native species are poorly known and most cannot be identified because they are not in the literature. These may include new species as well as new host records.

Aspidiella ?hartii (Cockerell), *Aspidiotus/Mytilaspis* sp. *sensu* Froggatt, *Chionaspis* sp. and *Pseudaonidia* sp. are new records from the NT. There are also many new host records for the NT as listed below.

Aonidiella aurantii (Maskell)
(T39) on *Citrus* sp. at Leaning Tree Lagoon;
(T47) on avocado, *Persea americana* at Katherine Research Station (New host);
(Unnumbered) on cumquat, *Fortunella japonica* at Acacia Hills (New host).

Aonidiella orientalis (Newstead)
(T30A) on *Alstonia scholaris* at Fort Hill Wharf (New host);
(T36) on *Carica papaya* (Pawpaw) at Alawa;
(T105) on papaya, *Carica papaya* at Alawa;
(T112A) on Melaleuca at Tiwi;
(T115A) on heliconias at Parap (New host);
(T141) on papaya, *Carica papaya* at Berrimah Agricultural Research Centre;
(Unnumbered) on milkwood, *Alstonia actinophylla* at Tiwi.

?Aonidiella orientalis (Newstead)
(T115B) on heliconias at Parap (New host).

Aonidiella near *orientalis* (Newstead)
(T112A) on Acacia at Tiwi. This may possibly be *A. simplex* (Grandpré & Charmoy) (New NT).

?Aonidiella sp.
(T117) on iron wood, *Eryrophleum chloros* at Katherine (New host).

Aspidiella ?hartii (Cockerell)
(T126) on sandalwood, *Santalum lanceolatum* and *Alternathera* sp. host at Batchelor. (New NT).

Aspidiotus destructor Signoret
(T50) on avocado, *Persea americana* at Berrimah (New host).

Aspidiotus sp.
(T31) on *Philodendron scandens* at Mirambeena Resort, Darwin (New NT).

Aspidiotus sensu Froggatt
(T40) on *Eucalyptus* sp. at Katherine (New NT);
(T84) on *Melaleuca* at Nakara;
(ETX) on an unknown host from the East Timor survey of Darwin.

Chionaspis sp.
(T103) on lemon grass, *Elionurus citreus* at Tiwi (New NT).

Chrysomphalus aonidum (Linnaeus)
(T75) on dwarf variegated *Draceana* at Katherine;
(39513) on *Antherium* sp. previously in collection as *?Hemiberlesia lantaniae* (Diaspididae) (New host).

near *Chrysomphalus* sp.
(T70) on *Ficus microcarpa hilli* at Nakara (New host).

Lepidosaphes gloverii (Packard)
(T77, T78A) on lemon trees, *Citrus limon* at Nakara (2 samples).

Lepidosaphes sp.

(T30B) on *Alstonia scholaris* at Fort Hill Wharf (New host);
(T58) on *Alstonia actinophylla* at Rapid Creek (New host);
(T112B) on *Acacia* at Tiwi (New host).

Genus 1 near *Lepidosaphes*
(T59) on *Polyalthia* sp. at Alawa (New host).

Genus 2 near *Lepidosaphes*
(T60) on *Acacia* sp. at Berrimah Agricultural Research Centre (New host).

Mytilaspis sp. *sensu* Froggatt
(T121) on *Eucalyptus ?papuana* at Aileron roadhouse (New NT).

Pinnaspis strachani (Cooley)
(T82) on *Brachychiton paradoxus* in shadehouse at Berrimah Agricultural Research Centre (New host);
(T93) on frangipani, *Plumeria rubra* at Tiwi;
(T114) on eggplant, *Solanum melongena* in glasshouse at Berrimah Agricultural Research Centre (New host);
(T118) on cycad leaf at Katherine (New host);
(T123) on the base of spring onion bulbs *Allium* sp. at Humpty Doo. This sample is a different form from all other samples of the species seen, and may be of a different origin for this variable species (New host).

Pseudaonidia sp.
(T71) on oleander, *Nerium oleander* at Tiwi (New NT).

Pseudaulacaspis cockerelli (Cooley)
(T56) on Golden cane palm, *Chrysalidocarpus lutescens* at Berrimah (new host record);
(T64) on *Pandanus spiralis* at Karama (New host);
(T65) on desert rose, *Gossypium sturtianum* at Karama (New host);
(T68) on *Plumeria* sp. at Karama (New host);
(T83A) on *Alstonia scholaris* at Tiwi (New host);
(T130) on mango, *Mangifera indica* at Berrimah Agricultural Research Centre;
(T131) on mango, *Mangifera indica* at Berrimah Agricultural Research Centre.

Unaspis citri (Comstock)
(T78B) on *Citrus limon* tree at Nakara;
(T138) (ET83) on lemon leaves, *Citrus limon* at Berrimah Agricultural Research Centre.

Unknown
(T128) (C1564) on grapefruit, *Citrus maxima* intercepted in quarantine ex East Timor;
(T129) (also C1564) on , *Citrus maxima* intercepted in quarantine ex East Timor;
(T132) (ET53) on quinine tree, *Petalostigma pubescens* at Berrimah (new record NT);
(T135) (ET5) unknown on *Acacia* at Northlakes.

Margarodidae (Fluted Scales)
Only three species are recorded, two widespread, introduced, polyphagous pest species *Icerya aegyptiaca* (Douglas) and *Icerya seychellarum* (Westwood); and an undescribed species of *Icerya.*

The undescribed species of *Icerya* has not been previously recorded. It occurs on the grass *Bothriochloa pertusa*. There are also two new host records for *Icerya aegyptiaca.* Material examined is as follows:

Icerya aegyptiaca (Douglas)
(T32) on fruit of cluster fig, *Ficus racemosa* at NTU, Casuarina (New host);
(T44) on *Melaleuca* sp. at Katherine (New host);
(T119) on palm, *Chamaedorea elegans* at Katherine (New host).

Icerya n.sp.
(T106, T111) on grass, Bothriochloa pertusa at Alawa (undescribed and newly discovered, New NT).

Pseudococcidae (Mealybugs)
There are 25 species recorded from the NT. The most commonly collected species are introduced and widespread polyphagous species. Although comprehensive data is available on the Australian fauna, accurate identification is impossible without well-prepared microscope slides.

The only new species record for the NT is *?Crisicoccus* sp., although there are numerous new host records among the other species listed. The presence of *Pseudococcus affinis* needs to be confirmed. The most common pest species encountered during the year were *Ferrisia virgata* (Cockerell), *Maconellicoccus hirsutus* (Green), *Nipaecoccus viridis* (Newstead) and *Planococcus citri* (Risso). Examined material is as follows:

?Crisicoccus sp.
(T61) on *Acacia* at Berrimah Agricultural Research Centre (New NT).

Ferrisia virgata (Cockerell)
(T99) on cocoa, *Theobroma cacao* in the quarantine glasshouse Berrimah Agricultural Research Centre (New host);
(T163) on *Durantia*, Berrimah (New host).

Maconellicoccus hirsutus (Green)
(T62) on *Pongamia pinnata* at RAAF Darwin (New host);
(T63) on *Alpinia purpurata* at Elizabeth Valley Farm (New host);
(T79) on variegated hibiscus at Darwin city (New host).

Near *Melanococcus* sp.
(T85) on *Eucalyptus bigalerita* at Berrimah Agricultural Research Centre (New host);
(T97A) on quinine tree, *Petalostgma pubsecens* at Holmes Jungle (different from T85 and T109) (New host);
(T109) on *Eucalyptus* sp. at Berrimah Agricultural Research Centre.

Nipaecoccus viridis (Newstead)
(T41)on *Citrus paradisi* (Grapefruit) at Katherine Research Station;
(T46) on *Albizzia lebbeck* (Indian Siris) at Katherine Research Station (New host);
(T48) on *Feronia limonia* at Katherine Research Station (New host);
(T76) on *Philanthus multifolia* at Nakara (New host);
(T100) on cocoa in quarantine glasshouse at Berrimah Agricultural Research Centre (New host).

Planococcus citri (Risso)
(T26) on cocoa seedlings, *Theobroma cacao* in quarantine glasshouse at Berrimah Agricultural Research Centre (New host);
(T55) on mango, *Mangifera indica* at Berrimah Agricultural Research Centre.

Planococcus sp.
T104 (C1438) on a pineapple, *Ananas comosus* intercepted in quarantine ex East Timor.

Pseudococcus affinis
(T20, T21) on roots of palm trees at a nursery, Girraween (New NT).

Aleyrodidae (Whiteflies)
There are 39 species recorded from the NT. Most are introduced and feed on a variety of plants.

Neomaskellia bergii (Signoret) is a new record for Australia, while *Aleurolobus marlatti* (Quaintance), *Siphoninus phillyreae* (Haliday) and *Tetraleurodes sulcistriatus* Martin are new records from the NT. *Siphoninus phillyreae* is now well established in the Alice Springs area and is particularly abundant on pomegranate, *Punica granatum*. Several new host records were also discovered. Examined material is as follows:

Aleurocanthus near *spiniferus* (Quaintance)
(ET84) First East Timor Survey at Darwin.

Aleurodicus destructor Mackie
(Unnumbered) on *Syzygium bamagense* at a nursery, Humpty Doo (New host).

Aleurolobus marlatti (Quaintance)
(Unnumbered) on river red gum, *Eucalyptus camaldulensis* at Anula (New NT).

Dialeurodes kirkaldyi (Kotinsky)
(T163) on *Durantia* sp. at Berrimah (New NT).

?Dialeurolonga sp.
(ET5) First East Timor Survey at Darwin (New NT).

Neomaskellia bergii (Signoret)
(T33) on Dutch millet, Paspalum scorbuclata at Darwin (New NT and New host Australia).

Siphoninus phillyreae (Haliday)
(unnumbered) on pomegranate (*Punica granatum*), ?nashi pear, and possibly *Lagerstroemia indica* (eggs only) from numerous localities at Alice Springs including Arid Zone Research Institute (New NT).

Tetraleurodes sulcistriatus Martin
(T80) on *Alstonia actinophylla* at Rapid Ck, Jingili (2 samples) (New NT).

PROJECT: Detection and Eradication of Arthropod Pests of Quarantine Importance in the Northern Territory

Project Officers: All Branch Officers

Location: Territory wide

Objective:

To detect, identify and assess the feasibility of eradicating or controlling arthropod species of quarantine significance, which are new to the NT.

Background:

When previously unrecorded species in the NT have penetrated the Quarantine barrier, one of the responsibilities of the Entomology Branch is to detect, identify and assess the feasibility of eradicating or controlling them. The civil unrest in the former Indonesian province of East Timor and the subsequent large military and civilian involvement of Australian and other personnel created a significant increase in the potential for exotic organisms to enter the Darwin area. Surveys were conducted of high-risk areas in Darwin to detect potential quarantine pests and diseases originating in East Timor.

Results:

Following the detection and subsequent successful eradication program mounted against the Asian honeybee *Apis cerana* Fabricius (Hymenoptera: Apidae) from June 1998 to June 1999, samples of feral honeybees continued to be submitted for testing during 2000/2001. Asian honeybees were not discovered, nor were mites detected on any of the *A. mellifera* examined. The port surveillance program, which was initiated by the Animal Health Branch, continued to monitor artificial coconut traps and sentinel and feral honeybee hives. The Entomology Branch conducted all testing for bee and parasitic mite species.

Several other species were assessed for their quarantine importance and official notification made on detections during consultative committee teleconferences. These included the fig wax scale *Ceroplastes rusci* (Linnaeus) (Hemiptera: Coccidae) on mango in both Darwin and Katherine and a species very similar to the Indian cotton leafhopper *Amrasca devastans* (Distant) (Hemiptera: Cicadellidae). The former had

possibly been confused with the pink wax scale *C. rubens* Maskell, a common pest on mangoes, citrus, avocados, rambutans and numerous other tree and ornamental crops but is regarded as less damaging than pink wax scale. After intensive field searching in the NT and further detections at Nhulunbuy and Townsville, the leafhopper appears to be a new species distinct from *A. devastans* and possibly confined to beach hibiscus *Hibiscus tiliaceus*. Insectary and limited field host preference trials appear to corroborate this hypothesis.

A further "post-East Timor" survey was conducted during the 12 month period, at the end of the Wet season in May-June. No important detections were made although several hundred specimens were collected and many hundreds of others examined in the field without collection.

Trapping for melon thrips (*Thrips palmi* Karny (Thysanoptera: Thripidae)), Poinsettia whitefly (*Bemisia tabaci* type-B) and Western flower thrips (*Frankliniella occidentalis* Pergande (Thysanoptera: Thripidae)), continued in 17 nurseries in the Darwin region and four nurseries in the Alice Springs area during the year. Poinsettia white fly was detected in Alice Springs, but after treatment, appears to have been eradicated.

The ash white fly *Siphonius phillyreae* (Haliday) (Hemiptera: Aleyrodidae) was detected on Alice Springs properties. This species had first been recorded in Australia several years earlier.

Following detection of Queensland fruit fly *Bactrocera tryoni* (Froggatt) (Diptera: Tephritidae) in the Ti Tree area during late December, an eradication program was mounted on three Accredited Production Areas (APA) to regain area freedom. At 30 June 2001, one area encompassing nine properties had regained area freedom and the other two APAs were expected to regain that advantage within several months.

PROJECT: Dissemination of Information

Project Officers: All Branch Officers

Location: Territory wide

Objective:

Provide relevant agricultural entomology information to a range of clients.

Background:

The Branch is the main provider of information on agricultural entomology relevant to the Northern Territory. All primary producers, government employees and the general public may request information on a wide range of insect pest problems. This information is normally provided in the form of telephone discussions, on-farm visits, examination of submitted specimens, original or annotated Departmental Agnotes, extracts from published works or illustrated talks, media interviews and lectures. The provision of advice occurs through the Entomology Branch offices in Darwin and Katherine.

In addition, the Branch provides data on arthropod occurrence and distribution to national and international organisations which is frequently used for pest management or trade purposes. In conjunction with the NT Parks and Wildlife Commission, all applications for the introduction into, or release from quarantine, of biological control agents used against agricultural pests, diseases and weeds are reviewed by the Branch as part of an Australia- wide assessment.

Results:

In providing a pest and disease identification and advisory service to primary producers, government departments and the public, the Entomology Branch processed more than 2,200 enquiries during the year. In addition, Branch Officers attended eight technical or scientific conferences/workshops, presented 11 publications and conference papers and provided display material for 14 events during the year. Numerous radio interviews were conducted and 14 articles on entomological matters were provided to local newspapers. Talks were also presented to visiting groups of primary and high school students and project information made available for universities in the NT and interstate. Insect display materials were provided

for field days, local shows and various student groups. Other input was provided at the many conferences, workshops and seminars attended during the year.

During the year, separate reports were provided to the Australian Quarantine and Inspection Service on host and distribution data of both quarantine and non-quarantine organisms in the Northern Territory. These included NT records of arthropods on a range of crops that will assist negotiations for potential market exports.

Many submissions were prepared on plant health and quarantine topics for use by DPIF and other organisations.

PROJECT: Control of Arthropods and Development of IPM in Tropical Tree Crops

Project Officers: D. Chin, E.S.C. Smith, M. Hoskins and H. Brown

Location: Top End properties

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 Branch's resources. New problems appear each year as this relatively new crop continues to expand in area and value, and new growers enter the production phase. Other tree crops such as citrus, rambutan, durian, mangosteen, jackfruit, carambola, guava and cashew are becoming more commonly planted. Horticulture officers, commercial growers and urban backyard producers frequently refer pest problems to the Branch for advice or comment and these referrals may detect new or potentially damaging insect problems. The Branch is committed to providing advice and assistance to all growers consistent with the aim of developing Integrated Pest Management (IPM) systems for all tropical tree crops.

Results:

Table 1. Common enquiries on insects and mites on mango, citrus, rambutan and carambola (from July 2000 to June 2001)

Mango	**Citrus**	**Rambutan**	**Carambola**
Mango leafhopper	Citrus leafminer	Brevipalpid mites	Fruit fly
Fruit fly	Oriental spider mite	Mealybugs/fluted scales	Aphids
Redbanded thrips	Citrus rust mite	Caterpillars	Flower caterpillar
Flatid planthopper	Citrus redscale	**Gralliclava**	Fruit piercing moth
Mastotermes	Fruit fly	Ants	
Graptostethus	Flatids		
Mango scale	Fruit piercing moth		
Amblypelta	Ginger ants		
Flower caterpillars	White louse scale		
Longicorn			
Mites			
Mango seed weevil			
Helopeltis			
Mango stem miner			
Monolepta			
Agetinus			

Arthropods are listed in the order of the most common to the least common enquiry.

Identification and advice on arthropods were provided to growers, hobby growers and backyard growers on a range of tropical tree crops. The main enquiries were on insect identification and pest control on mangoes, citrus, rambutan and carambolas. Where possible integrated pest management strategies were encouraged. These included regular monitoring of pests and natural beneficials, the use of softer chemicals and biological control. Table 1 shows the common insects and mites recorded on mango, citrus, rambutan and carambola.

Rambutan IPM Workshop
A two part Rambutan IPM workshop was held for growers in March and April 2001. The workshops concentrated on IPM strategies and insect identification.

The first part of the workshop was held on 17 March. Growers were introduced to IPM and provided with information on the identification of pests and beneficials. Twenty growers and a few staff members from Horticulture attended the workshop.

The second part of the workshop was held on the 7 April. The workshop provided a “hands-on” experience with identifications of pests and beneficials and broad suggestions on monitoring orchards. There was a good turnout of about 30 growers and most of them showed enthusiasm in the practical sessions.

Citrus
Life cycle of the fruit piercing moth Eudocima *materna* (June-November 2000)
A culture of the fruit piercing moth *Eudocima materna* (Linnaeus) (Lepidoptera: Noctuidae) was established from larvae collected from *Tinospora smilacina*. The moths were reared through three generations in the insectary and shade house.

The colony used for the studies contained 40 adult moths reared from eggs. The female moths started laying eggs 7-10 days after emergence from pupae. Eggs were deposited indiscriminately and in large numbers on potted host plants (*Tinospora smilacina*) and over the shadecloth walls. Eggs hatched within one to two days and the larval period had a mean of 12.5 days. The growth rate of the larvae was monitored with regular measurements taken of their head capsules. The mean pupal period was 9.7 days. Adults survived for a maximum of four months in the insectary, which was kept at a temperature of between 19-28° C and 50-70% relative humidity.

Distribution of the larval host plant *Tinospora smilacina* in the Darwin area
A brief survey of the Darwin area was carried out to record the distribution of the larval host plant *Tinospora smilacina*. Known sites recorded for *T. smilicina* were Darwin CBD, Casuarina Coastal Reserve, Holmes Jungle, Yarrawonga, corner of Howard Springs Road and Stuart Highway, along Stuart Highway from Amy Johnson Avenue to Palmerston and in the suburbs of Leanyer and Wulagi.

PROJECT: Management and Control of *Mastotermes* in Northern Australia

Project Officers: G.R. Young, M.J. Neal, and H. Wallace

Location: Darwin, Gunn Point, Kowandi Radio Station - Dept of Defence, CPHRS, and selected growers properties on the Venn Blocks Katherine

Objective:

- ***To develop effective environmentally sustainable control methods against Mastotermes darwiniensis that can be applied in horticultural crops by growers or other persons not experienced in termite biology.***
- ***Studies of the biology of the species are being carried out in conjunction with development and testing of control methods so that their effectiveness can be fully assessed.***

Background:

Mastotermes darwiniensis Froggatt (Isoptera: Mastotermitidae) is the most destructive species of termite in tropical Australia. In the NT this species accounts for substantial annual production losses in horticultural tree crops and is also responsible for losses in vegetable and agricultural crops. *Mastotermes* can cause major damage to buildings, wooden structures, electrical cables and a variety of other materials. The main chemical registered for use in horticulture against this pest is an organochlorine, mirex. Mirex is the active ingredient of the product Mirant®. As organochlorines are being phased out, it is necessary that alternative pesticides be tested against *Mastotermes.*

Method:

A successful management strategy for the giant termite was developed from research and experimentation conducted during a joint project for the control of *Mastotermes* and reported previously (TAR 1996, 1997 and 1998). The method involves aggregating the termites in 20 litre 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 (DPIF *Agnote* No. A26 Management of Giant Termites in Rural Blocks).

Field testing of several promising insecticides to replace mirex commenced at CPHRS during 1999. Chemicals are tested using aggregation drums, the object being to aggregate *Mastotermes* in pine billets in drums before applying the pesticide. The drums have been placed on soil beside infested trees, over the cut stumps of dead trees, or attached to the trunks of infested trees. New pesticides are tested by placing a bait containing the toxicant on top of the infested billets or by removing the infested billets from the drums, placing several layers of cardboard coated with the new compound in the drum and then replacing the infested billets on top of the cardboard. The method is consistent with that currently used with Mirant®.

In addition, other methods of chemical application involving soil treatment around infested drums or trees have been extensively examined over the past twelve months.

A wood consumption trial to look at the feeding behaviour of *Mastotermes* over an extended period of time was commenced at the beginning of March 2001. An area of native bush at Kowandi Radio Station on the Stuart Highway was used as the site for this trial. Information gained during this trial will be used to better understand *Mastotermes* biology and the effect of seasonal changes on their behaviour.

Results:

1. A trial using the chemical mixed into a bait matrix and placed into aggregation drums was completed during 1999–2000 on properties in Katherine. In that trial, the toxicant was transferred to the *Mastotermes* colony by termites that had fed on the bait. Results were promising but the chemical company supplying the toxicant was not prepared to embrace the recommendation on rates and bait matrices resulting from that trial. Negotiations are continuing.

2. A soil injection trial at CPHRS conducted between December 2000 and April 2001 used aggregation drums over tree stumps in an ailing cashew plantation. Initial assessment of the trial area revealed a high level of *Mastotermes* activity. The chemical was injected into the soil under the drums. Termite activity was assessed on a weekly basis and showed complete eradication in all treated drums within two to three weeks. After eight weeks, re-infestation started to occur in some drums and after three months all drums displayed high termite activity.

3. A second soil injection trial using the same chemical at the same rate but a greatly increased volume was applied to mature mango trees infested with *Mastotermes.* This trial commenced at the beginning of June 2001 on a property at Humpty Doo. The trial was assessed four times during the month. During the first two assessments, sick termites were found in both treated and adjacent trees, indicating probable effect of the chemical. By the end of June no termite activity was evident in any of the trees within the trial area. This trial will continue to be assessed over the following 12 months.

4. During the year there were no signs of the epizootic that affected aggregated termites last year (TAR 2000). There is the possibility that the condition causing mass death to *Mastotermes* is physiological. The occurrence of an epizootic is most likely to be a natural phenomenon under certain conditions. A possible explanation for the occurrence of the epizootic last year was a rise in the water table at the trial site.

PROJECT: Northern Territory Economic Insect Reference Collection

Project Officers: H. Brown, D. Chin, E.S.C. Smith, G.R. Brown and M. Connolly

Location: BARC

Objective:

To develop, curate and maintain a reference collection of economically important arthropods of the various NT agricultural and horticultural industries and to develop and maintain a suitable, retrievable database of all specimens held in the collection.

Background:

The insect reference collection was initiated in 1970 and rapidly became the main insect reference collection in the NT. Over the years, the collection expanded to include economically important arthropods from agricultural, horticultural and domestic situations as well as general collections. In 1992, the majority of the non-economic insect specimens were donated and transferred to the NT Museum.

Results:

During 2000/2001 the Branch forwarded 55 specimens for species confirmation or identification. Most specimens were of economic significance.

Computerisation of museum specimens onto the network *ACCESS* database is continuing. To date, over 26,800 specimens have been recorded on the database, constituting about 89% of the entire collection. The museum database has been upgraded to make it easier to use and enable more efficient entry of records.

The number of specimens in the collection is ever increasing and there is now a catalogued sub-collection maintained at Katherine Research Station. This collection has 1,225 specimens of which 351 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 in the main Darwin collection.

The following were new records determined during the year 2000/2001. These are indicated as a new regional or country locality (New NT, New Aust.) or new host records for the NT (New host).

Acarina

Eriophyidae

Aceria sp. nov.
- ex. *Persoonia falcata*, causing pink lesions on leaves. (New Aust.)

Tetranychidae

Eutetranychus orientalis (Klein)
- ex. *Azadirachta indica* (neem tree). (New host)

Tetranychus marianae McGregor
- ex. *Merremia aegyptia* and *Macroptilium atropurpureum.* (New NT)

Tetranychus neocaledonicus André
- ex. leaves of *Arachis hypogaea* (peanut). (New host)

Tetranychus sp. nov.
- ex. *Desmodium tortuosum* leaves. (New Aust.)

Hemiptera

Aleyrodidae

Aleurolobus marlatti
- on river red gum, *Eucalyptus camaldulensis*. (New NT)

Aleurodicus destructor Mackie
- ex. *Syzgium bamagense.* (New host)

Bemisia tabaci (Gennadius)
- on *Colocasia esculenta* (taro). (New host)
- ex. leaves of *Momordica charantia* (bitter melon). (New host)

Bemisia tabaci Type-B
- on leaves of *Abelmoschus esculentus* (okra). (New host)
- on leaves of *Vigna unguiculata* (snake bean). (New host)
- ex. *Abelmoschus esculentus* (okra). (New host)
- ex. *Vigna unguiculata* (snake bean). (New host)
- ex. *Colocaisia esculenta* (taro). (New host)
- ex. leaves of *Momordica charantia* (bitter melon). (New host)

Dialeurodes kirkaldyi (Kotinsky)
- on *Durantia* sp. (New NT)

?*Dialeurolonga* sp. (New NT)

Neomaskellia bergii (Signoret), sugarcane white fly
- ex *Paspalum scorbuclata.* (New NT and new host Aust.)

Tetraleurodes sulcistriatus Martin
- from *Alstonia actinophylla* (milkwood). (New NT)

Trialeurodes vaporariorum (Westwood)
- ex. *Sonchus oleraceus* (Milkthistle). (New host)

Siphoninus phillyreae (Haliday)
- on pomegranate, ?nashi pear, and possibly *Lagerstroemia indica* (eggs only). (New NT)

Asterolecaniidae

Bambusaspis bambusae (Boisduval)
- on bamboo. (New NT)

Bambusaspis robusta (Green)
- on bamboo. (New NT)

Bambusaspis sp.
- on bamboo. (New NT)

Coccidae

Ceroplastes rusci (Linnaeus)
- on *Ficus racemosa* (Cluster fig) and *Ficus virens* (Banyan). (New host)
- ex. *Alstonia scholaris* (Cheesewood). (New Aust.)

Coccus hesperidum Linnaeus
- from *Nephelium lappaceum* (rambutan). (New host record)
- on ?hibiscus. (New host)

Coccus longulus (Douglas)
- on *Acacia mangium*. (New NT),
- on ornamental tree, *Dalbergia* and *Acacia mangium.* (New NT)
- on *Exocarpus latifolius.* (New host)
- on Citrus at Nakara. (New host)

Coccus sp.
- on *Wodyetia bifurcata* (Foxtail palm). (New host)
- from chilli plants, *Capsicum annum*. (New host)

?*Coccus* sp.
- on *Ficus benjamina*. (New host)

?Crisicoccus sp.
- ex. Acacia. (New NT)

Cryptes baccatus (Maskell)
- on *Acacia ?stipuligera* seedlings. (New NT)

Eucalymnatus tessellatus (Signoret)
- on *Alstonia scholaris* (cheesewood). (New NT)

Near *Melanococcus* sp.
- ex. *Eucalyptus bigalerita* and from *Petalostgma pubsecens.* (New hosts)

Nipaecoccus viridis (Newstead)
- from *Philanthus multifolia* and from *Theobroma cacao* (cocoa). (New host)

Parasaissetia nigra (Neitner)
- on *Ficus microcarpa hilli* (New host)

Pulvinaria psidii Maskell
- on frangipani, *Plumeria* sp. (New NT)
- on *Alstonia actinophylla* (milkwood). (New host)
- on *Minusops*. (New host)
- on *Plumeria* sp. and *Alstonia scholaris* (cheesewood). (New NT)

Pulvinaria urbicola (Cockerell)
- on an unknown host. (New host)

Pulvinaria sp.
- on fiddlewood, *Citharexylum spinosum.* (New host)
- (unknown) on frangipani, *Plumeria* sp. (New NT)

Saissetia coffeae (Walker)
- on *Mangifera indica* fruit peduncle, Katherine. (New host)

?Saisettia sp.
- on *Psidium guajava*. (New host)

Diaspididae

Aonidiella aurantii (Maskell)
- on cumquat, *Fortunella japonica*. (New host)
- on *Persea amerciana* (avocado). (New host)

Aonidiella orientalis (Newstead)
- on heliconias. (New host)
- on *Alstonia scholaris* (cheesewood). (New NT)

?Aonidiella orientalis (Newstead)
- from heliconias. (New host)

Aonidiella near *orientalis* (Newstead)
- from Acacia. This may possibly be *A. simplex* (Grandpré and Charmoy). (New NT)

?Aonidiella sp.
- from iron wood (*Eryrophleum chloros*). (New host)

Aspidiella ?hartii (Cockerell)
- from Alternathera and sandalwood. (New NT)

Aspidiotus destructor Signoret (Diaspididae)
- on *Persea americana* (Avocado) (New host)

New genus (*Aspidiotus sensu* Froggatt)
- on *Eucalyptus* sp. (New NT)

Aspidiotus sp.
- on *Philodendron scandens*. (New record)

Chionaspis sp.
- from lemon grass. (New NT)

Chrysomphalus aonidum (Linnaeus)
- on *Antherium* sp. previously in collection as *?Hemiberlesia lantaniae*. (New host)

near *Chrysomphalus* sp. (Diaspididae)
- on *Ficus microcarpa hilli*. (New host)

Lepidosaphes sp.
- on *Alstonia scholaris* (cheesewood). (New host)
- on *Alstonia actinophylla* (milkwood). (New host)
- from Acacia. (New host)

Genus 1 near *Lepidosaphes*
- on *Polyalthia* sp. (New host)

Genus 2 near *Lepidosaphes*
- on *Acacia* sp.(New host)

?Milviscutlus sp.
- on *Alstonia scholaris*. (New NT)

Mytilaspis sp. *sensu* Froggatt
- from *Eucalyptus ?papuana*. (New NT)

Pinnaspis strachani (Cooley)
- on *Brachychiton paradoxus*. (New host)
- on shallots. (New host)
- from eggplant, cycad leaf and from the base of spring onion bulbs (this sample is a different form from all other samples of the species seen, and may be of a different origin for this variable species). (New hosts)

Pseudaonidia sp.
- on *Nerium*. (New NT)

Pseudaulacaspis cockerelli (Cooley)
- on *Chrysalidocarpus lutescens* (Golden cane palm). (New host)
- on *Plumeria* and *Alstonia scholaris* (cheesewood). (New host)
- on *Pandanus spiralis* and desert rose. (New hosts)

Margarodidae

Icerya aegyptiaca (Douglas)
- on fruit of clustering fig, *Ficus racemosa.* (New host)
- on *Melaleuca* sp. (New host)
- from *Chamaedorea elegans.* (New host)

Icerya n.sp.
- from grass (*Bothriochloa pertusa*). (New NT)

Phacopteronidae

Pseudophacopteron sp.
- ex. *Alstonia actinophylla* (milkwood). (New NT)

Pseudococcidae

Ferrisia virgata (Cockerell)
- on *Durantia*, Berrimah (New host)
- ex. *Theobroma cacao* cocoa. (New host)

Maconellicoccus hirsutus (Green)
- on *Pongamia pinnata*. (New host)

- on *Alpinia purpurata*. (New host)
- on variegated hibiscus. (New host)

Nipaeococcus viridis (Newstead)

- on *Albizzia lebbeck.* (Indian Siris). (New host)
- *Feronia limonia.* (New host)

Planococcus citri (Risso)

- on cocoa *Theobroma cacao* seedlings. (New host)

Pseudococcus affinis (Maskell)

- on roots of palm trees in nursery. (New NT)

Lepidoptera

Geometridae

Prasinocyma sp. probably *flavicosta* Warren

- reared from pupa ex. *Acacia mangium.* (New NT)

Gracillariidae

Phyllocnistis ?citrella Stainton

- ex. *Clerodendrum floribundum.* (New host)

Immidae

Imma sp. nr. *tetrascia* Meyrick

- reared from larva ex. *Acacia mangium* leaves. (New NT)

Noctuidae

?*Anomis* sp.

- on *Citrus reticulata* fruit. (New host)

Eudocima materna Linnaeus

- feeding on *Citrus reticulata* fruit. (New host)

Mocis frugalis (Fabricius)

- on *Citrus reticulata* fruit. (New host)

Ophiusa tirhaca (Cramer)

- on *Citrus reticulata* fruit. (New NT)

Pyralidae

Parotis marginata (Hampson)

- reared from larvae feeding on bark of *Alstonia scholaris* (cheesewood). (New NT)

Pleuroptya sp.

- reared from larvae feeding on *Buchanania* leaves. (New NT)

Thysanoptera

Thripidae

Scirtothrips sp.

- on leaves of *Alstonia actinophylla* (milkwood). (New host)

Thrips parvispinus Karny

- on leaves of *Alstonia actinophylla* (milkwood*).* (New host)

PROJECT: The Entomofauna of Peanuts *(Arachis hypogaea)*

Project Officers: G.R. Brown and M. Hoskins

Location: Katherine and Douglas Daly

Objective:

- ***To sample and identify insect species found on Arachis hypogaea, and to determine their pest status.***
- ***To expand on existing data in order to assess those insect species of greatest threat to the development of a peanut industry in the Top End.***

Background:

Peanuts are a high value, high input legume crop. Dryland yields range from 1.3-3.2 t/ha, but supplementary irrigation is recommended for optimum production and quality. Recent crops have been grown under full irrigation in the Dry season.

From the time of crop emergence in April 2001, two peanut crops were visited to obtain data. One property is located in the Douglas Daly Basin and the other near Katherine. Both properties use overhead, pivot irrigation and plant one half of each pivot at a time. The Douglas property has two working pivots both being planted to peanuts for four years consecutively. The Katherine property, which has only recently been developed, has grown a first crop of maize and peanuts side-by-side.

Method:

Beginning in April and continuing until harvest, the Katherine property was sampled each fortnight and the Douglas Daly property once per month. The method of crop sampling has been standardised and is used at various times of crop development to ensure consistency of results. During each field visit samples were taken from five random locations and included vacuum sampling 10 m of crop, visually checking 2 m of crop to especially check for lepidopteran pests and digging at least five whole plants to check for pod damage. Vacuum samples were sorted into pest and beneficial species. Any new insect pests or live specimens that have been collected or reared were lodged in the NT Economic Insect Reference Collection.

Results:

As the cropping season does not conclude until October partial results are currently available. Complete results, together with a consecutive year of data will be published in 2003. The following is a brief overview of insect pests or potential pests found to date.

Sucking bugs (Hemiptera: Pentatomidae) which may be of importance and were seen on the crop, sometimes in large numbers, included the green vegetable bug, *Nezara viridula* (Linnaeus) and the red-banded shield bug *Piezodorus hybneri* (Gmelin). Several species of leafhoppers (Hemiptera: Cicadellidae) were also collected. The Brown mirid, *Creontiades pacificus* (Stal) (Hemiptera: Miridae) and its nymphs were collected but not considered to be at levels capable of causing any damage.

Helicoverpa spp. (Lepidoptera: Noctuidae) larvae were present for most of the crop's cycle and can be especially damaging at flowering when they tended to feed on flowers instead of foliage. One grower chose to spray on one occasion for *Helicoverpa*. *Spodoptera litura* (Lepidoptera: Noctuidae) larvae became damaging at one time in the crop's development, as they began chewing off pegs before they could reach the soil to form nuts. One grower chose to spray for *Spodoptera*.

A number of geometrid and other noctuid moths were found in the crop, the larvae of which had been found feeding amongst peanut foliage or on the ground. No lucerne seed web moths, *Etiella behrii* (Zeller) (Lepidoptera: Pyralidae) were seen in any samples from either property, however a small amount of damage was found characteristic of internal feeding by a caterpillar leaving only an exit hole.

Since growers had noted some pod damage in previous years, particular attention was directed at soil-borne pests, and in particular, adult or immature beetles, which could cause such damage. False wireworm larvae have proved damaging at the germinating stages of various other horticultural and field crops.

The adult false wireworm beetle, *Gonocephalum carpentariae* Blackburn (Coleoptera: Tenebrionidae) was commonly seen at the Douglas Daly property, whilst *Caedius sphaeroides Hope*, also a false wireworm were more common at the edges of the field in the Katherine crop. Damage to immature peanut pods was characterised by 'scarifying' on the outer shell of the peanut and in some cases holes formed in the shell causing the nuts to rot. Larvae of at least one of these species were suspected of causing this type of 'scarifying' damage and several instances of damage occurred during the growing season.

PROJECT: Pest Management in Tropical Vegetables

Project Officers: L. Zhang, E.S.C. Smith and G.R. Young

Location: Darwin area

Objective:

To advise on resistance management for the major pests of tropical vegetables and to conduct research using natural enemies and lower toxicity pesticides to enhance control.

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 use of persistent chemicals. Other pests are more specific to particular crops (e.g. bean fly *Ophiomyia phaseoli* (Tryon) (Diptera: Agromyzidae on snake beans) or can be controlled with more specific pesticides (e.g. melon and cowpea aphid control with pirimicarb).

There is a range of natural parasites and predators which are effective against these pests, provided that non-disruptive chemicals are used to prevent excessive mortality of the 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.

As indicated in the 2000 TAR, bean fly exhibited resistance to dimethoate during the 1998 Dry season. The proposed trials with relatively soft chemicals such as spinosad and confidor which were planned for subsequent Dry seasons did not eventuate but work on parasitoids of bean flies continued throughout the year.

Results:

In the second half of 2000, growers reported severe outbreaks of *B. tabaci* Type B on a range of crops. It was suspected that the damaging populations were induced by the use of synthetic pyrethroids. In addition, the poinsettia white fly was detected at an Alice Springs nursery, having probably been introduced from infected Darwin properties. This pest now has the potential to damage vegetables and other crops in the arid zone.

By attending several grower meetings and working through extension officers, the message was conveyed to growers that they should use potassium soaps applied at high volumes for control of *B. tabaci* Type B. Where these recommendations were carried out, good results were achieved. Various strategies were discussed with extension officers. In particular, growers were asked to:

- utilise the softer options such as high volume potassium soaps;
- coordinate the applications of chemicals across the growing areas to maximise population decline;

- apply treatments in response to their picking and packing schedules;
- consider hiring equipment or contractors which/who could apply large volumes of carrier under appropriate pressures; and
- if required, use recommended chemicals in "clean-up" treatments.

Detailed parasitism studies on commercial blocks of snake beans at Humpty Doo indicated that eight species of parasitoid were active against bean fly in the rural area. These records represent at least four families of Hymenoptera and in one large sampling program, the rate of parasitism varied from 8 – 57% with a mean of 22%. This data again emphasised the importance of disruptive chemicals affecting pest control in tropical vegetables in the Top End.

PROJECT: Quarantine Entomology

Project Officer: G.R. Brown

Location: Darwin

Objective:

To identify insects and other organisms intercepted in Quarantine, to provide advice on the quarantine significance of these organisms, and to facilitate putting these records on a database.

Background:

AQIS provides partial funding for the Quarantine Entomologist to provide identifications on insects intercepted by quarantine in the Northern Territory.

Method:

Insect and other animal samples collected by Quarantine Inspectors are submitted with Insect Interception Record sheets to Quarantine Entomology for identification and advice. These are provided and Insect Interception Identification record sheets completed. Copies of both the sheets are forwarded to the relevant inspectors, and to AQIS, Canberra for putting on a database.

Interceptions considered to be of quarantine significance were investigated further.

Results:

During the year, 296 insect interceptions totalling 350 samples were received. Most were collected at Perkins Wharf (86), Rooney's Shipping (30), Darwin Airport (99), Darwin Wharf (33) and at the Quarantine Inspection Depot (11). The remainder were collected from seven other sites, although 51 were listed as miscellaneous. The latter included ships' galleys and on board insectacutors.

Species found:

The following is a list of taxa and the number of samples examined:

Acarina....4
algae....10
Amphibia....2
Aranaea....19
Blattodea....6
Coleoptera....131
Collembola....2
Decapoda....1
Diplopoda....1
Diptera....66
Mantodea....1
Mollusca....11
Hemiptera....16
Hymenoptera....34
Isoptera....2
Lepidoptera....18
Orthoptera....2
Passeriformes....1
Pseudoscorpiones....4
Psocoptera....17
Squamata....8
Thysanoptera....1
Thysanura....1
unknown eggs....1

Counties of origin:

The following is the number of samples examined from each country:

Africa....1
Australia....6
Bangladesh....2
Kampochea....4
East Timor....140
Hong Kong....1
India....1
Indonesia....89
Iran....2
Italy....2
Jordan....1
Malaysia....8
Malawi....1
Pakistan....2
Papua New Guinea....4
Philippines....1
Singapore....9
Taiwan....10
Thailand....8
USA....2
Vietnam....6

In addition, 36 were collected on ships and the origin of a further 13 was unknown.

Interesting records:

The majority of specimens received were either stored product pests or borers. Records of interest included:

- one record of *Cryptotermes* frass (Isoptera: Kalotermitidae)
- nine records of brown widow spider, *Latrodectus geometricus* Koch (Araneida: Theridiidae)
- one record of the freshwater shrimp, *Cardina longirostris* (Decapoda: Aytidae) in the water barrel on an illegal fishing boat.
- 11 records of *Aedes aegypti* (Linnaeus) and 1 of *Aedes longirostris* (Leicester) (Diptera: Culicidae)
- six records of giant African snail, *Achatina fulica* (Bowdich) (Eupulmonata: Achatinidae) as well as five records of other exotic molluscs.
- four records of giant honey bee, *Apis dorsata* Fabricius (Hymenoptera: Apidae)
- five records of *Hemidactylus frenatus* Duméril and Bibron (Squamata: Gekkonidae) as well as three other reptiles and two frogs.

PROJECT: Sesame Entomology

Project Officers: G.R. Brown and M. Hoskins

Location: Katherine

Objective:

To survey insects found on sesame crops and to identify pest and beneficial species.

Background:

Sesame, *Sesamum indicum* L. (Pedaliaceae) is well adapted to the semi-arid tropical regions of the world and is cultivated for use in confectionery, culinary items and cosmetics. Although it has the potential, sesame has been grown only irregularly as a commercial crop in the Northern Territory.

There are no native species of sesame present in the Northern Territory, although there are stands of roadside feral sesame in the Katherine and Douglas Daly regions. These are a potential source of insect pests that may spread to commercial crops.

Trial plots were grown at Douglas Daly Research Station in 1999, Katherine Research Station in 2000 and a commercial crop at Taylor Park in 1999-2000.

Method:

Feral sesame was vacuum sampled at five sites in the Katherine area on 19 January 2001 and 2 February 2001.

Results:

The results are summarised in Table 1, which lists the numbers of insects and other organisms, by family.

Table 1. Numbers of insects, collembolans (springtails) and arachnids (spiders) collected at five Katherine sites as listed in January (J) and February (F) 2001

	Site 1		Site 2a		Site 2b		Site 2c		Site 3		Site 4		Site 5	
	J	F	J	F	J	F	J	F	J	F	J	F	J	F
COLLEMBOLA												2		
BLATTODEA														
Blattellidae	1			1		1							1	
MANTODEA														
Mantidae					1								1	1
ORTHOPTERA														
Acrididae	1			2					1		2	1		
Gryllidae		2									1			
Pyrgomorphidae		4												
Tettigoniidae		1												
HEMIPTERA														
Aleyrodidae	1													
Aphididae														
Berytidae					1						2			
Cicadellidae	4	13	38	8	13	15	12	3		3	14	10		5
Coccoidea		1						1		1				
Colobathristidae											2	2		
Coreidae											1			
Fulgoroidea	1		1	1	3	2		2	2		2	4	8	
Lygaeidae	1					1								
Miridae	1	12	1	1	1	2	1				1	1	1	
Pentatomidae	1		1	1		1			3		1	1		2
Psyllidae											1			
Scutelleridae							1							
THYSANOPTERA														
Phlaeothripidae										1	2			
Thripidae														1
COLEOPTERA														
Anisotomidae								1						
Anthicidae					1									
Apionidae	6	3	2	2	5	3	7				1	1		1
Chrysomelidae		1			1	2	1	1			2	1		
Coccinellidae					2	1	2	1			9	5	1	
Curculionidae	1				1								1	
Elateridae			3											
Lathridiidae	1													
Silvanidae	1			1		3					4	2		
DIPTERA														
Acalyptrata	2	3	2	1	3	5		2		3	9	10	2	4
Empididae				1										
Nematocera	5	3	69	4	68	15	30	8	9	8	14	28	2	21
LEPIDOPTERA														
moths	1	2		2			1	1		2	2	3		
caterpillars		5	2	1						2	5		1	1
butterflies			1								1			
HYMENOPTERA														
Apidae	3		1	1	1		1	1	1		1		3	1
Braconidae		2												2
Chalcidoidea	3	3	3	2	4	2	2	1	3	2	9	6	3	4
Formicidae	9	2	5	10	8	5	17	8	21	7	10	4	8	7
Proctotrupoid														1
Pompilidae			1											
Scelionidae	2	1		1		1			1		2		1	4
ARACHNIDA														
spiders	33	13	11	15	25	15	27	10	22	19	38	17	16	32
mites										1	3	1		
UNKNOWN														
egg	1													

The most abundant pest species were leafhoppers (Hemiptera: Cicadellidae), mirids (Hemiptera: Miridae) and plant hoppers (Hemiptera: Fulgoroidea), and the high number of nymphs for these groups indicated that they were breeding on sesame. The most common species were *Orosius argentatus* (Evans), *Austroasca viridigrisea* (Paoli)*, Austroagallia torrida* (Evans)*, Balclutha rubrostriata* (Melichar) and *Nesoclutha pallida*

(Evans) (Cicadellidae); *Campylomma* sp. and *Nesidiocoris? tenuis* (Reuter) (Miridae); and *Siphanta* sp. (Fulgoroidea: Flatidae).

The majority of insects found were not pests, but are presumed to be attracted to the flowers. These include a wide range of beetles (Coleoptera), flies (Diptera) and ants, bees and wasps (Hymenoptera), although some of the latter could also be predators or parasites of pest species. The major group of predators were the spiders, and these were usually the most abundant animals apart from the flies.

RESOURCE MANAGEMENT

PROGRAM: Resource Management

SUBPROGRAM: Weeds Management

PROJECT: Eradication of Class A Noxious Weeds (to be eradicated) in the Darwin Region

Project Officers: **S. Wingrave, O. Sutter, J. Ross, M. Ashley, M Schmid, G. Flanagan, B. Hitchins and N. Ostermeyer**

Location: Darwin Region

Objective:

To eradicate infestations of all class A weeds in the region.

Background:

Class A noxious weeds pose a particular threat to the Northern Territory community and industries. The Weeds Branch coordinates the management of these species to initially limit their spread and achieve eradication in the longer term.

Method:

Class A noxious weeds are controlled and eradicated through cooperative efforts by the Weeds Branch and landholders using chemicals, fire, mechanical or other physical means, combined with surveys to monitor for regrowth.

Darwin City Council continues to coordinate the regulatory control of the weed barleria, *Barleria prionitis* through the application of relevant Bylaws. Darwin Weeds Branch staff continue to liaise with Darwin City Council staff and assist through the provision of technical advice and surveys. Barleria continues to be found in urban areas and Weeds Branch staff will continue to provide management advice.

The Territory's first field infestation of the aquatic weed cabomba, *(Cabomba caroliniana)* at Marlow Lagoon, Palmerston, is the subject of an eradication program. No cabomba was found in 2000/2001.Monthly monitoring continues.

The Territory's first infestations of alligator weed (*Alternanthera philoxeroides*) continue to be inspected for re-shooting rhizomes. Surveys in 2000/2001 found no Alligator weed at the two sites in suburban Darwin. These properties have not been sold and the current owners are familiar with the plant and are aware of the importance of its eradication and have changed their gardening practices to assist its eradication. Prospects for the eradication of Alligator weed are good.

Reports of new infestations of Class A noxious weeds will continue to receive priority to prevent further expansion and to minimise long term expenditure requirements.

PROJECT: Survey And Control Of Class B Noxious Weeds (growth and spread to be controlled) in the Darwin Region

Project Officers: **S. Wingrave, M. Schmid, O. Sutter, J. Ross, M. Ashley, B. Lukitsch and B. Hitchins**

Location: Darwin Region

Objective:

To protect the NT economy, community, industries and the environment from the adverse impacts of Class B noxious weeds.

Method:

Extension services and weed management planning services are provided to landholders in the region for control of Class B weeds. The Minister continues to provide assistance through the Weeds Management Assistance Scheme (WMAS) and the Herbicide Subsidy Scheme. These schemes are designed to provide a financial incentive to landholders to integrate a range of control options to control mimosa and other noxious weeds.

A Mimosa Management Plan has been developed for the Mary River catchment to improve strategic management of this species in the longer term. The Mimosa Management Plan has been circulated to landholders for input and its launching was planned for October 2001.

Control of key infestations of mimosa along the lower Mary River continued on Melaleuca, Opium Creek, and Marrakai Stations. Strategic control of mimosa in the lower Mary River catchment is essential to prevent rapid expansion of the current mimosa problem.

Other key infestations of mimosa were treated in the upper Adelaide River, Reynolds River, Finniss River and Daly River catchments. Control of isolated mimosa in the upper catchments of these river systems will ensure that mimosa management in the lower catchment of these river systems is not undermined by the reintroduction of seed in floodwaters.

PROJECT: Integrated Control of Salvinia on Mission Hole

Project Officers: **J. Ross, G. Flanagan and B. Hitchins**

Location: Elizabeth Downs Station

Objective:

To integrate biological and chemical control in the management of Salvinia molesta on Mission Hole.

Method:

The bud and stem -boring weevil, *Cyrtobagous salviniae*, was released in 1997. The area is monitored to determine if herbicide application is necessary to provide more effective control.

During 2000/2001 Salvinia molesta populations were restricted to several small isolated mats on the fringe of the billabong. Insect activity was high on the edges of the mats preventing their expansion. A small trial found that the herbicide AF101 was able to kill plants within two weeks. However, biological control agent activity meant that no herbicide applications were necessary. Wet season flushing of the billabong appears to have continued to reduce salvinia populations further.

PROJECT: Survey and Control of Mimosa on Aboriginal Land

Project Officers: S. Wingrave, O. Sutter, J. Ross, M. Ashley and B. Hitchins

Location: Darwin Region

Objective:

Management of mimosa (Mimosa pigra) on Aboriginal Land.

Method:

The services and funding agreement signed in 1998 between the Department of Primary Industry and Fisheries, the Northern Land Council, the Indigenous Land Corporation and the White Eagle Aboriginal Corporation continued throughout 2000/2001. The agreement has permitted control of mimosa at Oenpelli, Ngukurr, lower Daly River area, the southern Daly River Region, at Acacia Larrakeyah, and in areas of the Finniss River floodplain.

The management of mimosa in these areas has been complemented by the provision of training and strategic planning advice to different communities across the Top End. The training component of this agreement will enable community members to improve the capacity to manage mimosa in the longer term.

PROJECT: Survey and Control of Class A Declared Weeds in the Katherine Region

Project Officers: S. Wingrave, M. Fuller, R. Freeman, L. Johns, R. Maloney and J. Begley

Location: Katherine Region

Objective:

To protect the Northern Territory economy, community, industries and environment from the adverse impacts of Class A weeds. In the Katherine region these include prickly acacia, parthenium weed, Devil's claw, chinee apple, Mimosa pigra and ornamental rubbervine.

Background:

These weeds pose a particular threat to the NT. Eradication will prevent their spread.

Method:

Class A declared weeds are managed through cooperative efforts by DPIF Weeds Branch, landholders and the community using chemical, mechanical and biological control methods, an extension program and weed management planning processes.

Results:

All prickly acacia plants at Bulman and Manbulloo have been surveyed, mapped and treated, with no known mature plants remaining.

Ground surveys continued for parthenium weed infestations at Elsey Creek and Katherine town with no plants being found.

Survey, mapping and control of strategically important infestations of Devil's Claw continued on Willeroo Station, Camfield Station and Victoria River Downs as a cooperative effort between Weeds Branch and landholders

Monitoring of past chinee apple control efforts in the Katherine town area indicates that landholders have failed to meet commitments given during previous assistance programs. This has resulted in further spread of this species in the region. A follow-up program will be put in place using NT noxious weeds legislation.

Survey, mapping and control of Mimosa pigra continued on Scott Creek Station, Jindare Station, MCN 191 and the Phelp River in conjunction with landholders. Minimal numbers of mature seed producing plants were found, however survey and control will continue in the future due to the extended viability of the seed.

A number of infestations of ornamental rubbervine were found in the region during 2000/2001. These were located in the Mataranka town area, Katherine town, Numbulwar community and Bringun community. Extension and control programs have been put in place to minimse the risk from this species.

PROJECT: Survey and Control of Class B Noxious Weeds in the Katherine Region

Project Officers: S. Wingrave, M. Fuller, R. Freeman, L. Johns, R. Maloney and J. Begley

Location: Katherine Region

Objective:

To protect the Northern Territory economy, community, industries and environment from the adverse impacts of Class B weeds. In the Katherine region these species include bellyache bush, parkinsonia, lion's tail, candle bush, lantana and mesquite.

Background:

This project involves the survey and integrated management of Class B weeds in the Katherine Region.

Method:

Class B weeds are managed through a cooperative effort by DPIF Weeds Branch, landholders and the community using chemical, mechanical and biological control methods, an extension program and weed management planning processes.

Results:

Strategically important infestations of bellyache bush were surveyed, mapped and controlled in the Roper River and Victoria River catchments. A weed management plan for the extensive infestation at Willeroo Station was developed and is being managed by the landholder with input from DPIF staff.

The management of parkinsonia using chemical, fire and biological control methods continued in the Roper River catchment and the Victoria River catchment. This was done through a cooperative effort between the Weeds Branch, the NT Parks and Wildlife Commission, Aboriginal communities and landholders.

The control of lion's tail continued in high use areas of the Timber Creek district and on Humbert River Station, Yarralin and Victoria River Downs.

The survey, mapping and control of candle bush commenced at Bulman in association with the Bulman CDEP program and the NLC Caring for Country unit. This program forms part of the NTU Land Management program.

The survey, mapping and control of Lantana at Elsey Station were completed. It is expected this program will continue as more plants are found and a review of herbicide treatments is completed in the future.

Mapping and control of several mesquite plants was completed at Elsey Station. This is an important satellite infestation for this species. Survey continues in this area.

The survey, mapping and control of other Class B species such as hyptis, coffee senna, sicklepod, Sida acuta, Sida rhombifolia and Noogoora burr continued in the region. This program involved the use of stocking rate management, biological control agents and herbicide.

PROJECT: Eradication of Class A Noxious Weeds in the Barkly Region

Project Officers: J. McMahon and J. Peart

Location: Barkly Tableland

Objective:

To eradicate prickly acacia (Acacia nilotica) in the Barkly Region and improve the awareness of landholders of the species.

Background:

Prickly acacia is a major weed in north Queensland, but only isolated infestations occur in the NT. It is a Class A noxious weed (to be eradicated). On the Barkly Tableland, infestations are confined to two properties, but there is a potential for the weed to spread across the entire region.

Method:

The management of prickly acacia involved the removal of mature plants and the continued control of seedlings.

Results:

Ongoing programs have reduced the number of seedlings emerging at both Barkly locations and reduced its potential damage to the cattle industry.

PROJECT: Survey and Control of Class B Noxious Weeds in the Barkly Region

Project Officers: J. McMahon and J. Peart

Location: Barkly Tableland

Objective:

Improved management of Class B noxious weeds in the Barkly Region

Background:

This program involves the effective management of strategic Class B noxious weed infestations.

Method:

The management of Class B noxious weeds involved ground based surveys, mapping and monitoring of infestations and liaison with land managers.

Results:

The integrated management of parkinsonia *(Parkinsonia aculeata)* continued at strategic locations across the Barkly Region.

Ground management of Noogoora burr (*Xanthium occidentale)* continued on Helen Springs, Alexandria, Epenarra and Rocklands Stations.

Rubber bush (*Calotropis procera)* was controlled and contained at various locations throughout the Barkly Region.

Integrated mesquite (*Prosopis pallida)* control on Brunette Downs, Austral Downs Alroy Downs and Lake Nash has reduced the number of plants significantly.

PROJECT: Survey and Control of Class C (not to be introduced) Noxious Weeds

Project Officers: **J. McMahon, E. Conway, in collaboration with the Queensland Department of Natural Resources**

Location: 100 km Buffer Zone east of the Northern Territory and Queensland border.

Objective:

To stop the introduction of noxious weeds into the Northern Territory.

Background:

The project was developed when noxious weeds in Queensland were rapidly approaching the Northern Territory border. Projects involving personnel from the Northern Territory and Queensland Governments have reduced plant numbers in the buffer zone.

Method:

Yearly aerial surveys involving Queensland and Territory officers continue to map the movement of rubber vine (*Cryptostegia grandiflora)* and other noxious weeds towards the Northern Territory.

Results:

Isolated infestations were found this year along the Gulf coastline within 130 km of the Northern Territory border. Control programs involving Northern Territory and Queensland officers have restored the buffer zone to more than a 100 km.

Weed officers continue the management of prickly acacia, mesquite and parkinsonia within the buffer zone region.

PROJECT: Survey and Control of Declared Weeds in the Alice Springs Region

Project Officers: J. Gavin, B. O'Hanlon and A. O'Farrell

Location: Alice Springs Region

Objective:

To protect the NT economy, community, industries and environment from the adverse impacts of declared weeds.

Background:

This project involves the production of individual weed management plans for each property and the integrated strategic control of declared weed infestations in the southern region.

Method:

Declared weeds in the southern region are managed through cooperative efforts by the Weeds Branch, landholders and the community, using extension tools, weed management planning and control methods.

Results:

Progress in the Finke River Athel Pine project was slowed this year because of an unusually high rainfall during the Wet season. A national and an NT strategy for the management of Athel Pine was completed.

A variety of species were managed on a number of properties and in communities, with community education playing a major role in the process.

PROJECT: Biological Control of Mimosa

Project Officers: B. Hennecke, G.Flanagan, M. Paskins, S. Gall, B. Hitchins, N. Ostermeyer and N. Graham

Location: Darwin Region

Objective:

To protect the NT economy, community, industries and environment from the effects of Mimosa pigra

Background:

This joint program with CSIRO Entomology commenced in 1979/80. Since then a total of nine insect species and two fungal pathogens have been released. Seven of the insect species and the fungal pathogens have established on river systems across the Top End.

Method:

Carmenta mimosa, a stem-boring moth, has expanded its area of distribution in the Finniss, lower Mary, Reynolds, Daly and Adelaide River catchments in the last 12 months.

A bud-feeding weevil, *Coelocephalapion pigrae*, has continued to spread through the entire lower Finniss, Adelaide River and Daly River catchments.

Two species of seed feeding weevils continue to be released on the Finniss River. Field recovery of *Chalcodermus serripes* occurred and the laboratory-rearing program of adults has increased.

The molecular analysis of a Wet season fungal pathogen, *Phloeospora mimosae-pigrae* is continuing to determine a more suitable isolate for further field releases. Closely related fungi are also identified by phylogentic studies that will support the prediction of potential behaviour pattern of *Phloeospora* in the field.

The Dry season rust fungus, *Diabole* has reappeared at release sites after the initial inoculation in 1998. The rust has gone dormant in liquid nitrogen storage, and trials to break the dormancy have commenced. Studies on efficient culturing technique and further field releases will resume after a viable culture has been re-established.

Mass rearing for the new mimosa root and leaf-feeding beetle, *Malacorhinus*, has commenced. The first newly emerged adults have been collected and a release program is being developed.

PROJECT: The Integration of Biological Control of Mimosa and Other Control Options

Project Officers: **B. Hennecke, G.Flanagan, M. Paskins, S. Gall, B. Hitchins, N. Ostermeyer and N. Graham**

Location: Darwin Region

Objective:

To determine the most cost-effective method of integrating biological control, herbicides, mechanical control, fire and revegetation into a mimosa management program

Method:

The integrated control research aims to determine the impact on mimosa of various mechanical and chemical control methods, individually and in combination. In particular, the interaction of these control methods with biological control is being investigated. A significant result from this year's program is the finding that the abundance of key biological control agents on mimosa is greater in plots that have received prior chemical or mechanical control treatments. This is an exciting result, and augurs well for the development of a sustainable integrated management strategy for mimosa.

PROJECT: Biological Control of Sida

Project Officers: **N. Ostermeyer, S. Gall, M. Paskins, B. Hennecke and G. Flanagan**

Location: Darwin Region

Objective:

To protect the NT economy, community, industries and environment from the adverse impacts of Sida acuta.

Background:

Three insects have been released for the biological control of *Sida acuta:* the leaf feeding beetle, *Calligrapha pantherina*, in 1989; the stem-boring weevil *Eutinobothrus* sp. in 1994; and another stem boring weevil *E.*

pilosellus in 1997. Calligrapha established rapidly in the coastal Top End, and by the 1996/97 Wet season it had established as far inland as Katherine.

Method:

Over 11,000 stem boring weevils, *Eutinobothrus pilosellus*, and *Eutinobothrus* sp. were released at two sites in the Daly region during last year. Both species have been recovered from releases at Douglas Daly and Tipperary Station. The rearing colony for the two species at DPIF Darwin is running well with over 15,000 insects reared since the colony was established. Calligrapha is well established and was found on sida in isolated areas of the Reynolds River, more than 20 km from the nearest release site. Calligrapha continued to be redistributed at the request of land owners.

PROJECT: Biological Control of Parkinsonia

Project Officers: N. Ostermeyer, B. Lukitsch, G. Flanagan, and S. Wingrave

Location: Katherine and Barkly Regions

Objective:

To protect NT industries and the environment from the effects of Parkinsonia aculeata

Method:

Two species of pod-feeding beetles have established on *Parkinsonia aculeata* in the Roper River catchment, the Barkly Region and the Victoria River District. Surveys show these agents are spreading up to 99 km from release sites and destroying up to 87% of seeds.

PROJECT: Biological Control of Mexican poppy, Bellyache bush, Mesquite and Hyptis

Project Officers: N. Ostermeyer, B. Lukitsch, B. Hennecke, G. Flanagan and J. McMahon

Location: Katherine, Alice and Barkly Regions

Objective:

To protect the NT economy, community, industries and environment from the adverse impacts of Mexican poppy, bellyache bush, mesquite and hyptis.

Method:

The host specificity tests for the potential biological control agents against *Jatropha gossypifolia* (bellyache bush), are continuing at the CSIRO Quarantine Laboratories in Brisbane. The leaf feeding beetle *Colaspis* sp. and the longicorn beetle *Lagocheirus* spp. are being reared in quarantine. Plant material to feed the potential biological control agents was sent weekly from Darwin to the laboratories in Brisbane. The surveys for phytophagous insects on infestations of bellyache bush in Darwin, on Tipperary and Willeroo Stations have been completed. Exploration for biocontrol agents, and preliminary studies in Mexico for both Mexican poppy and bellyache bush, continue in Central America and the Caribbean.

The mass-rearing and releases program for two biocontrol agents of mesquite continued. The biological control agent, *Evippe* sp. # 1 has established at three release sites with the best results at Alroy Downs with plant damage between 50-80% within 5 km of release sites. The agent was redistributed from Alroy Downs to new releases sites. Difficulties in successfully establishing a sap sucking psyllid, *Prosopidopsylla flava*,

have been encountered following mass releases of 17,000 insects in the Alroy Downs area in March, April and May 2000.

Work into potential biological control agents for hyptis was restarted during the last year. Information obtained during earlier survey work in Brazil and Central American countries from 1979 to 1991 was collated and partly entered into a database. Two surveys were conducted this year and a promising insect, a weevil from Venezuela, has been sent away for identification.

PROJECT: Biological Control of Noogoora Burr

Project Officers: B. Hennecke and G. Flanagan

Location: Northern Territory

Objective:

To protect NT industries and the environment from the effects of Noogoora Burr.

Method:

At the request of DPIF, a report was prepared by CSIRO to assess the potential for biological control of Noogoora burr in the Northern Territory. The report examines if any avenues exist for the successful biological control of Noogoora burr in northern Australia, by summarising essential aspects of the weed, critically reviewing past efforts at biological control and exploring prospects for successful biological control in the future.

PROJECT: Biological Control of Senna

Project Officers: N. Ostermeyer and B. Hennecke

Location: Katherine, Alice and Barkly Regions

Objective:

To protect the NT economy, community, industries and environment from the adverse impacts of Senna.

Method:

Two sites for biological control for Senna have been set up to carry out ecology studies prior to the release of biological control agents. Currently, one potential biological control agent is undergoing host testing in quarantine at Alan Fletcher Research Station in Brisbane (QDNR). A second potential biological control agent for Senna has failed the host specificity testing and was rejected.

PROJECT: Weed Mapping and Management System

Project Officers: **K. Sanford-Readhead and Weed Management System Project Committee**

Location: Administered from Berrimah Farm

Objective:

To manage spatial information and provide tools to use that information for weed management planning.

Introduction:

The Northern Territory Weeds Management Strategy 1996-2005 provides a framework for weed management in the NT. A primary requisite for success is the establishment, maintenance and analysis of a database for the distribution of weeds and control measures adopted. The Weeds Branch is the agency responsible for implementing the strategy. In addition this Department was nominated the custodian of spatial weed data in the NTG under the NT Land Information Strategy. A major responsibility of the data custodian is to provide and maintain storage of and access to spatial weed data collected by all government agencies in the NT. Spatial data has sufficiently defined location coordinates to be plotted on a map.

This project is an ongoing program to manage the provision and improvement of weed distribution data and computer programs. The goal is for weed managers to access or collect weed population and management data, analyse the information and produce reports and maps independently of a GIS technician.

To meet this challenge the program has the following components:

1. Provision of a simple mapping and map production system.
2. Development of a new system.
3. Management of spatial weed population and management data.
4. Coordination of research and development of weed population mapping techniques and spatial analyses.

Progress has been made with each of these components in the last year. A brief description is given below:

1. The current simple mapping and map production system
In September 1999 the Department began to use a simple system using Trimble GPS (global positioning system) and off-the-shelf software with central data management and map production by GIS technical staff. Trimble GeoExplorer II and III GPs units were used because of their ability to record a list of attributes with point, line or polygon features and export this information from the GPS software in ArcView shapefile format. This format is read directly by the GIS geographic information system ArcView. Maps are produced with the GIS.

Officers collect weed population data to prepare a weed management plan for a land owner or group of land owners. Officers visit the property, survey for the presence of weeds and discuss weed management issues with the land owner or manager. Knowledge of weed habitat preferences is used to stratify the survey for weeds. Location and a small set of core attributes including weed name, date, density and population size are recorded on the GPS. The officer transfers the GPS to his/her computer and sends the file by electronic mail to a central data management facility in Darwin. Maps are produced on request in Darwin and Katherine.

Over 40 weed management programs addressing single or multiple species and focusing on properties, catchments or regions have benefited from the current system. These programs are located all over the NT. The DPIF Weeds Branch and the landowners it assists are the clients of the current simple system. Depending on interest and support, the new system services will be extended to other stakeholders including councils, non- government organisations and landowners.

A project committee administers the current system and the development of the new system. The committee was established in August 1999 to steer the development and management of this system so that it meets the information needs of the Department and other stakeholders. The committee includes representatives from Parks and Wildlife Commission and the Department of Lands Planning and Environment. The system is being developed in accordance with Government policy on the management of information systems and the NT Land Information Systems Strategy.

2. Development of a new system

Information in the current system can only be accessed by a person proficient in the operation of a GIS. A new system is required to provide officers direct access to weed distribution and management data. Figure 1 compares features of the current and new systems.

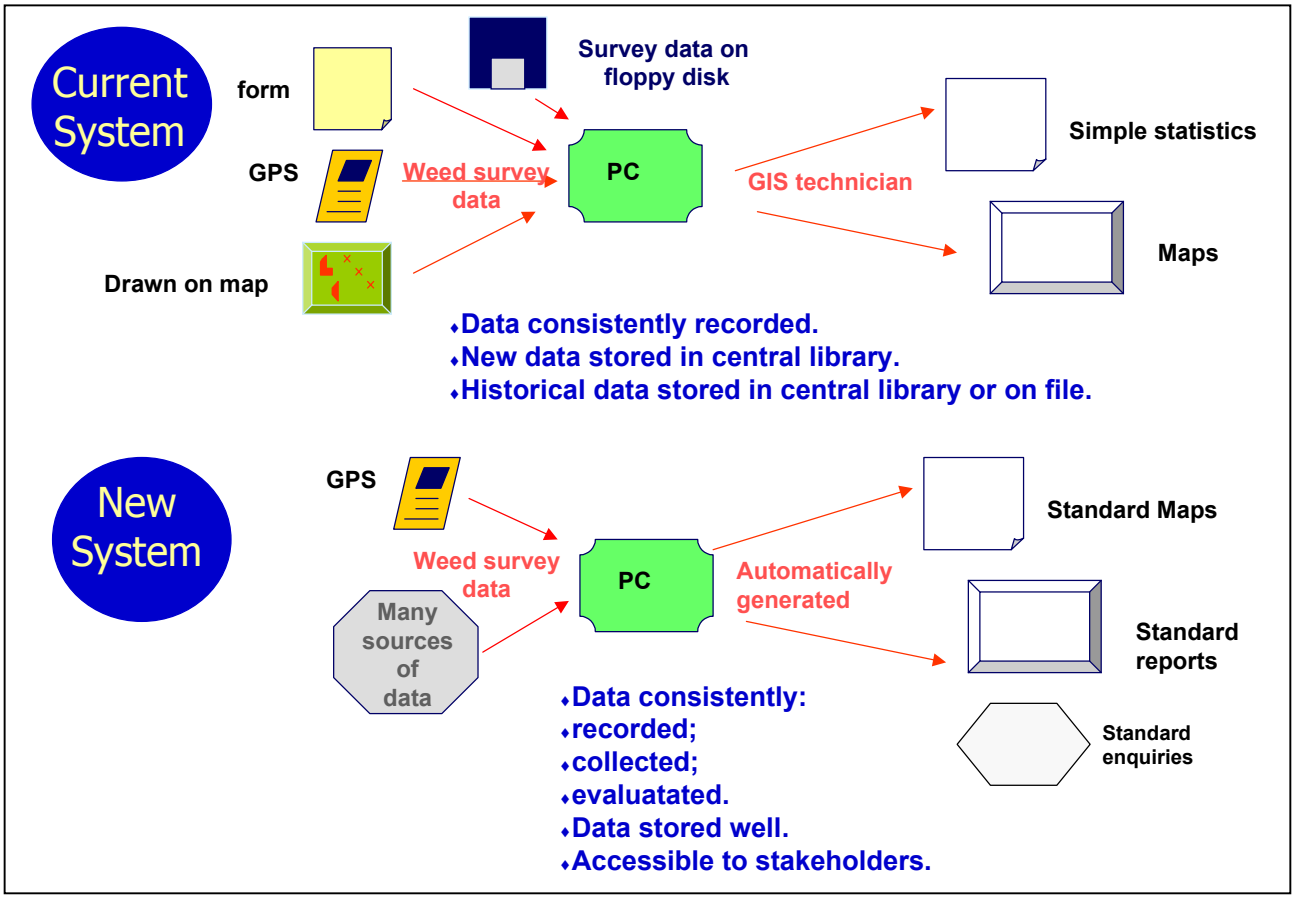


Figure 1. Comparison of features in the current and new systems

The process for developing the new system is to define stakeholder information needs and develop options for a practical approach. The steps are outlined in Figure 2.

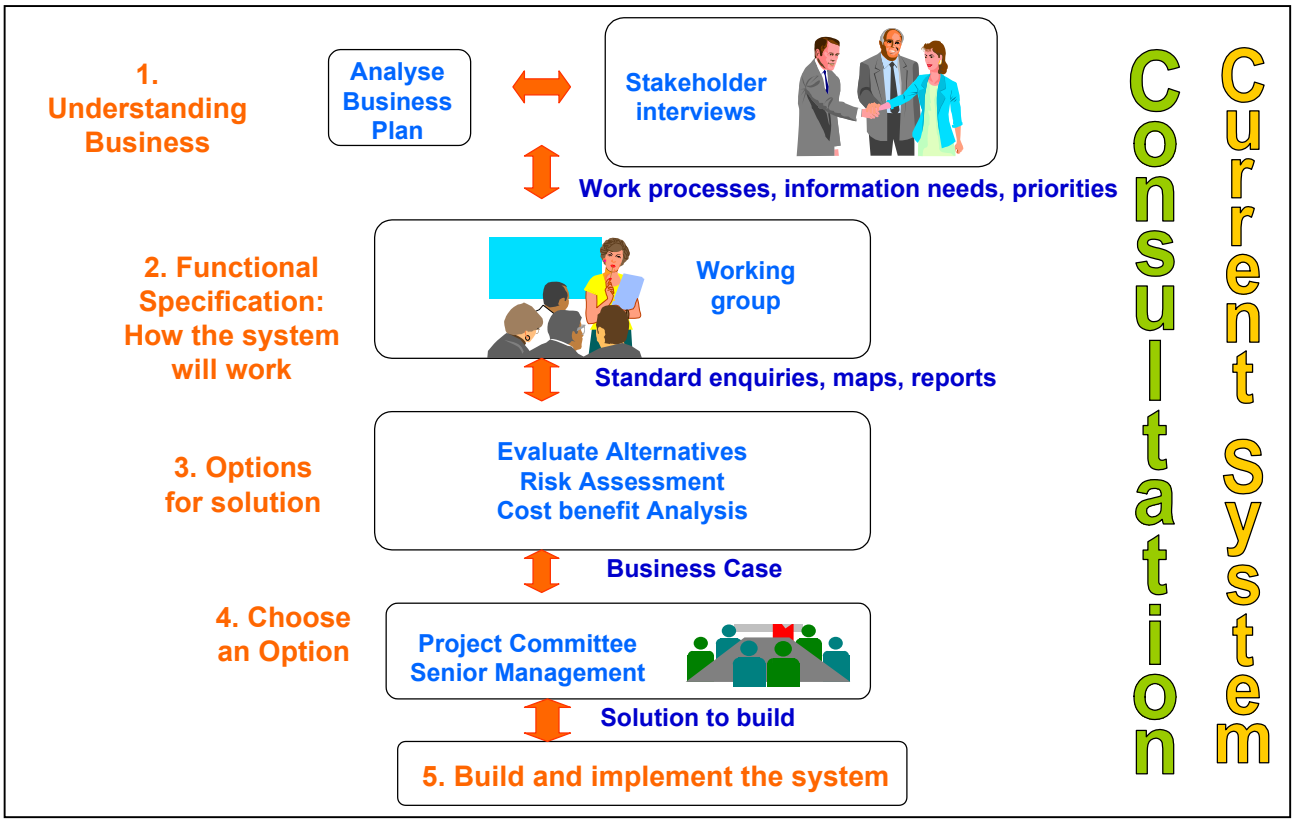


Figure 2. Steps to the new system

Progress with the new system

A synthesis of stakeholder information needs was drawn from interviews with over 30 potential users of the system. The resultant document “Analysis of Broad Requirements” was circulated for comment across three NTG and eight outside agencies. A brief summary of the themes in the 'Broad Requirements' is provided below:

- Capture weed distribution at the regional, property and paddock levels.
- Use this information to plan weed management at all scales and produce maps.
- Show changes in weed populations for making management decisions at each level.
- Record management history to evaluate weed management programs.
- Monitor effectiveness of various control methods.

The format of standard map products has been prototyped while producing maps with the current system. Figure 3 is an example. This map is displayed with kind permission from White Eagle.

At the time of writing this report the period for comment on the 'Analysis of Broad Requirements' document had not expired. Recipients were asked to rank the priority and usefulness of features proposed for the new system. The next step will be to analyse the results which will be titled “Statement of Broad Requirements”.

3. Management of spatial weed population and management data
Like the contents of a library, spatial data on weed populations and management activities has to be managed. All the digital data on weed population locations are stored in the Weeds Branch GIS Data Library on computer disk. This includes all the digital data on weed locations collected prior to the current system. Management of the data involves:

- converting incoming data to GIS format;
- maintaining a catalogue of data sets;
- providing data to other agencies under a data licence agreement if necessary; and
- ensuring the data is secure with regular backup and access security.

The data catalogue conforms to the ANZLIC spatial metadata standard.

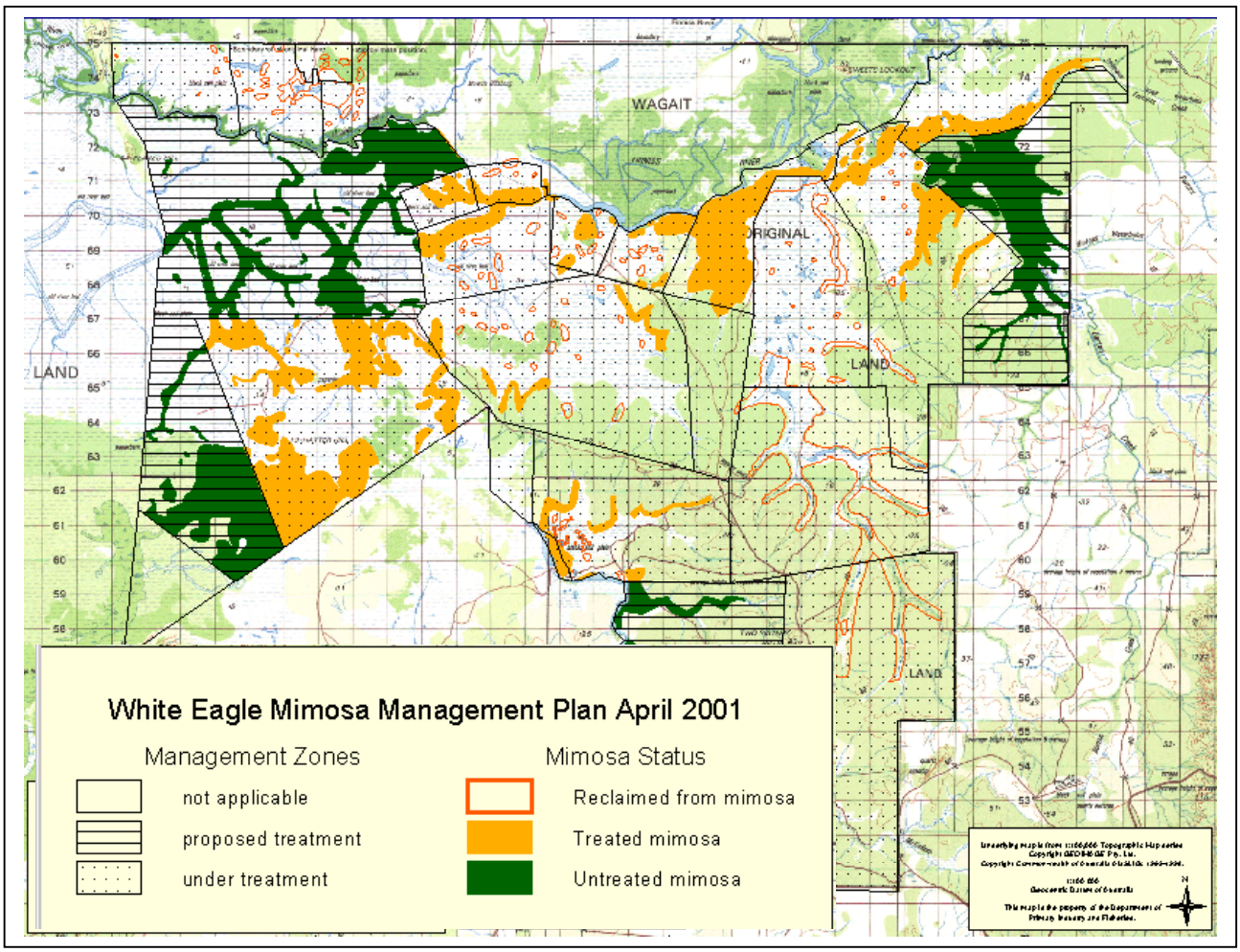


Figure 3. Sample map produced from the current system

4. Coordination of the research and development of weed population mapping techniques and spatial analyses

In addition to a computer system there will need to be guidelines and techniques for the collection of information on weed distribution. Joint projects to design standard tools for mapping weed distribution at the regional and local scale have been designed in conjunction with the Western Australian Department of Agriculture and the Queensland Department of Natural Resources and Mines. This and the development of modelling tools are also being pursued with the Northern Territory University and as part of the Weeds Cooperative Research Centre.

Conclusions:

DPIF has developed the capacity to collect and analyse weed distribution data for weed management planning. This has already provided maps for weed management plans for over 40 areas. The system will provide mapping techniques and computer tools to produce the essential spatial information for weed management. The system is well under way with the most consuming task of developing the broad requirements near completion. The system will be developed with the cooperation of clients, state agencies and the Weeds CRC in accordance with requirements.

SUBPROGRAM: Sustainable Rangeland Management

PROJECT: Conservation Strategy for Pastoral Land in the Alice Springs Region

Project Officer: **A. Lane**

Location: Darwin

Objective:

To implement property and regional conservation plans to protect biodiversity and benefit sustainable pastoralism.

Background:

About 50% of the NT is pastoral land. The pastoral land is generally used for extensive cattle grazing. Stocking rates are generally low and most pastoral land is considered to be in good condition.

Pastoralists in the Northern Territory recognise that, unlike many other areas of Australia, their industry is in a unique position to take proactive steps to protect natural resources on their land. Management for the conservation of species and ecosystems will provide benefits to landholders that could not otherwise be achieved.

Pastoralists in the Alice Springs region have expressed a desire to develop conservation plans for their properties. Thus, a strategy is being developed for the region in a partnership between the pastoral industry (represented by the Northern Territory Cattlemen's Association) and Government. It is envisaged that strategies will also be developed for other pastoral regions of the NT, namely Barkly, Katherine and Darwin.

Benefits:

A conservation strategy will assist pastoralists to:

- demonstrate to the wider community that pastoral land is managed in an environmentally responsible way;
- conserve and enhance biodiversity on pastoral land because it is important for the maintenance of ecological processes and for pastoral production;
- provide an integrated regional approach to environmental threats and to conservation because neighbours working together will be more effective and efficient than individual enterprises working alone;
- ensure that we leave a legacy of healthy, productive and profitable pastoral land for future generations; and
- enhance marketing opportunities - 'clean, green' land management practices are becoming increasingly important for marketing primary produce, conservation planning will assist the industry to attain accreditation to quality standards (e.g. ISO 14001) through implementation of an EMS and subsequently to maintain and expand into markets which require 'clean, green' certification.

Progress:

Pastoral groups in the Alice Springs region are working with NTCA, DPIF, DLPE and PWCNT to develop the strategy through publication of a strategy document and implementation of on-ground projects.

PROJECT: Green Cover Reporting

Project Officers: R. Dance and C. Allan

Location: Alice Springs

Objective:

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

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.

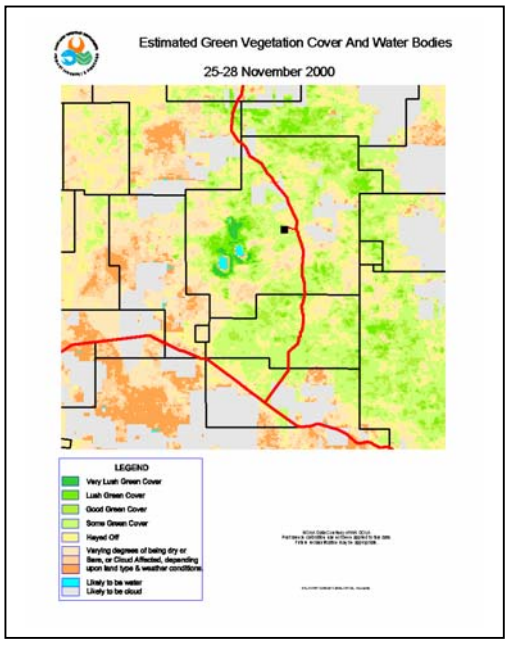
The use of satellite based indices of plant growth provides an opportunity to record production on a regional scale at the "grass roots" stage. This project has previously demonstrated the potential of this approach for Central Australia. Other States, and the Commonwealth, have also developed expertise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

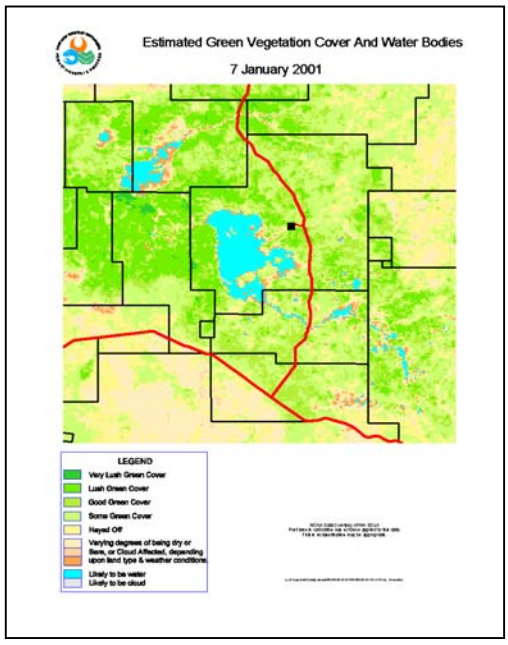
Results:

Fortnightly data continues to be acquired from the WA Department of Land Administration. It is used qualitatively in near real within the Department from time to time to clarify the extent of seasonal responses.

Images continue to be made available for public use through the Departmental Internet web presence. Over 100 images were added to this information source during the year.

Supplementary images were obtained to monitor flooding on the Barkly Tableland commencing in December 2000. On one station alone, in November 2000, prior to the big rains there was estimated to be less than 80 km^2 of free water surface in the lakes on the station. By 7 January 2001 well in excess of 2,000 km^2 was detectable in satellite imagery, with larger areas of shallow water less well defined.





PROJECT: Needlebush Rabbit Control

Project Officer: R. Dance

Location: Alice Springs District

Objective:

To undertake an evaluation of the effect of rabbit eradication on vegetation in the CLMA Needlebush Rabbit Eradication Project.

Background:

The Centralian Land Management Association (CLMA) has established a 300 km^2 rabbit eradication area on Erldunda, Lyndavale and Mt Ebenezer stations. The overall objective of the CLMA program is to show, by establishing a demonstration at the 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 of the Department is to measure the vegetation responses over the project period following the removal of the rabbits and to calculate the costs and benefits of the control operation.

Results:

Field assessment was completed, and the dismantling of infrastructure commenced. A final project report is being prepared.

PROJECT: Cograzing of Camels - Pasture Impacts

Project Officer: G. O'Reilly

Location: Waite River station

Objective:

To compare the impacts of cograzing camels and cattle on key pasture attributes including quantity of important species, botanical composition, and percentage of ground covered by plants and litter.

Background:

With funding from RIRDC, the Animal Production Section DPIF, Alice Springs initiated the project, "Co-grazing of camels and cattle for commercial production" in 1997. The Rangeland Management Section took responsibility for investigating the impact of cograzing on key ground pasture attributes.

Results:

Pasture quantity, by species, and by functional groupings, as well as botanical composition and percentage ground cover of plants and litter, were estimated at a series of sites within three treatment paddocks. Pasture assessments were undertaken during both drought and very good seasonal conditions. There were no significant differences ($p<0.05$) between the cograzed and cattle-only paddocks, for pasture quantities including total pasture, annual grasses, perennial grasses, and for *Enneapogon* sp. (a key grass species for fattening cattle in central Australia).

There was a significantly smaller quantity of forbs available in the cograzed paddock during all pasture assessments. Cograzing had no lasting impact on percentage of ground covered by plants and plant litter. It was concluded that cograzing would cause little impact on grass pasture attributes important for cattle production in central Australia.

Table 1. Camel Cograzing Project, Waite River (1998-2000)

Analysis of variance for averaged yields (kg/ha) of key pasture attributes (significant if p<0.05; rep=15, df=42) at each sampling date. Treatment averages with the symbol (*) in any one sampling event were not different from each other based on comparison to LSD values

Date	Cograzed	Cattle only	Control (ungrazed)	p value
Total pasture (all species)				
Month 14	145*	140*	293	<0.001
Month 20	32	77	150	<0.001
Month 24	403*	460*	511*	0.038
Month 27	930*	940*	1487	<0.001
All forb species				
Month 14	8	24	70	<0.001
Month 24	60	115*	141*	<0.001
Month 27	162	287*	335*	<0.001
Perennial grasses				
Month 14	130*	105*	146*	0.291
Month 24	193*	208*	178*	0.881
Month 27	433*	272*	522*	0.069
Annual grasses				
Month 14	7*	10*	77	<0.001
Month 24	117*	122*	175	<0.001
Month 27	335*	381*	630	<0.001
***Enneapogon* spp. grasses**				
Month 14	1*	3*	44	<0.001
Month 24	28*	25*	101	<0.001
Month 27	54*	71*	355	<0.001

The results of each aspect of the project, including pasture impacts, were compiled and published by RIRDC.

Phillips, A., Heucke J., Dörges, B. and O'Reilly, G. (2001) Co-grazing Cattle and Camels. Report for the Rural Industries Research and Development Corporation. RIRDC Project No. DNT-20A. Publ. No. 01/092. June 2001.

PROJECT: Grazing Impacts at Exclosed Sites

Project Officer: G. O'Reilly

Location: Alice Springs district

Objective:

Enhanced documentation of existing grazing impacts, and an improved basis for assessing them in the future.

Background:

After the drought of the 1960s, 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 (now 128 ha) constructed in 1968 on Mt. Riddock station in a sandy open woodland. Treatment differences in the first 11 years of the exclosure (1968-1979), were published in 1982 (Foran et al. 1982). Limited measurements taken by DPIF between 1993 and 1997 suggested that differences between the grazed and ungrazed areas existed, and justified closer scrutiny. Permanently marked sampling sites from the 1970s had been removed so new sites were established in April 1998, and were reassessed in May 2000 following very good seasonal conditions.

Results:

Thirty years or so of cattle exclosure changed pasture botanical composition dramatically. Species that significantly benefited in terms of biomass from exclosure include buckbush *Salsola kali*, woollyoats

Enneapogon polyphyllus, mulga grass *Aristida contorta*, blue parsnip *Trachymene glaucifolia*, sandhill grey vine *Bonamia media* and feathertop spinifex *Triodia schinzii*. Species which have significantly more biomass by not being exclosed include woollybutt *Eragrostis eriopoda*, sticky indigo *Indigofera colutea*, shrub sida *Sida rohlenae,* 3-awn wanderrie *Eriachne aristidea,* potato weed *Solanum ellipticum* and button grass *Dactyloctenium radulans*. Some species such as kerosene grass *Aristida holathera*, serrated goodenia *Goodenia cycloptera*, and speedwell *Evolvulus alsinioides*, were largely unaffected by exclosure.

Good seasonal conditions continued after the May 2000 pasture sampling and it remains to collect another set of pasture data in 2001, as well as to further investigate the age/size class structure of the key topfeed and shade species, *Ventilago viminalis*. It is planned to publish a final report for this project by December 2001.

PROJECT: Fire as a Pastoral Management Tool

Project Officer: G. O'Reilly

Location: Alice Springs district

Objective:

To quantify the short term (one to three years) and medium term (three to five years) effects of prescribed fire and management practices on key pasture species and designated tree and shrub species, and to make recommendations regarding the potential use of fire and its likely outcomes.

Background:

The northern Alice Springs district has had large increases in native woody species since the 1970s, which can hinder station operations and compete with more useful pasture species. Many stations recognise that the reduced frequency of fire when woody plants are still small is an important reason why this woodland thickening has occurred. DPIF has been advocating the general use of fire as a pasture management tool but this has been based on limited factual information for specific land types in central Australia and minimal direct experience within the Department. The recommendation to use fire cannot be more specific until more factual information can be gathered.

Results:

Burning for Profit

Technical Bulletin No. 290 “Fire as a Pastoral Management Tool in Central Australia” has been produced and can be obtained from the Publications Section. This literature review gathers together all known information on using fire as a pastoral management tool in Central Australia. It provides a basis for developing extension materials and will be used to help assess the success of the project and plan future research of fire issues in central Australia.

An extension guidebook “Burning for Profit” has been developed. It will be produced ‘in-house’ at this stage and distributed to pastoralists in central Australia for comment and feedback. Included with the guidebook is a questionnaire, which will hopefully provide some objective feedback for future research directions when the project finishes in June 2002.

Field studies

Cool winter burning in mulga (EJs fires - Narwietooma station)

- Fire significantly ($p<0.001$) reduced the quantity of cartwheel burr (*Sclerolaena cornishiana*) as a component in the pasture.
- All annual and perennial grasses had returned to pre-fire yields eight months after being burnt.
- There was no increase in grass production as a result of burning (as yet).

- The annual grass, *Aristida contorta*, was significantly more frequent in the burnt mulga compared to the unburnt mulga, but individual plants in the burnt mulga were smaller than those from the unburnt treatment. Even so there was almost a significantly greater quantity of *Aristida contorta* in the burnt treatment ($p=0.06$).
- The annual grass, *Enneapogon polyphyllus* was significantly more common in the unburnt mulga, but where it did germinate or regrow in the burnt mulga, individual plants were much larger, so that there was no difference in overall quantity of this species between the burnt and unburnt treatments.
- The forbs, *Boerhavia* sp. and *Euphorbia drummondii*, were significantly more frequent ($p<0.05$) in the burnt mulga. Other forbs (*Sida platycalyx*, *Indigofera linnaei*, and *Evolvulus alsinioides*) were unaffected by fire treatment.
- The shrub *Eremophila gilesii* had 100% mortality from 170 shrubs recorded as being burnt. Unburnt individuals of this shrub grew strongly in the eight-month period after the fire. There were 13 new seedlings recorded in unburnt sampling sites, with three new seedlings being recorded from burnt sampling sites.
- Mulga (*Acacia aneura*) had 80% mortality of shrubs under 2.75 m in height ($n = 273$). Mulga shrubs taller than this had only 20% mortality ($n = 46$). Unburnt mulga shrubs made spectacular vertical growth during the eight months after the fire.
- *Eremophila latrobei* was largely unaffected by burning, there being more of these shrubs eight months after the fire. Seedling germination was noted for this species, but there was no difference ($p>0.05$) in the number of seedlings germinating on burnt or unburnt sites.

Mulga/witchetty bush (Dodgy paddock, Narwietooma)

Pre-burn data continues to be collected and shows remarkable growth of shrubs as well as significant shrub seedling germination since the first data collected in 1999. A partial burn of the paddock was undertaken in January 2001 during warm windy conditions. The fire burnt only one of six transects where data had been collected since 1999. The area had approximately 200 mm of rainfall two months after the fire in March, and the burnt area responded with a predominance of forbs, mostly the unpalatable *Cleome viscosa*. It is too soon to confirm that summer burning has been unfavourable for grass pasture production. Further fires are planned during winter 2001.

Acacia farnesiana (Ambalindum station)

This burn was in March 1999. By March 2000 all burnt shrubs had recovered most of their canopy but then subsequently died back. Unburnt shrubs remained healthy during this time. Native perennial creek-grasses were even taller and thicker in 2001 than in 2000. All target shrubs, regardless of whether they were burnt or not, were suffering severe defoliation and dieback from insects and/or pathogens. Within the confines of the data collected, it must be concluded that the fire, two years earlier, had no effect whatsoever on the survival of shrubs or on pasture attributes. It is hard to even tell where the fire occurred. However, there was a period during 2000 when the burnt shrubs were suffering dieback and the unburnt shrubs were not. It may be possible that predators built-up their numbers on these susceptible (burnt) shrubs before moving onto the adjacent healthier unburnt shrubs (fire as a primary control treatment leading to secondary effects). A second fire is still being planned by the property for winter 2001.

PROJECT: Benefits and Costs of Water Ponding Banks

Project Officer: C. Ballenger

Location: Alice Springs region

Objective:

To record the potential benefits and associated costs of water ponding banks for increased pastoral production in central Australia.

Background:

Water ponding has been promoted as a means of land rehabilitation in central Australia. While there is anecdotal evidence of the benefits, there is little data on the value of these benefits compared to the cost of building the ponding banks. With the current financial squeeze that some central Australian stations find themselves in, it is important to have a clear idea of the costs and likely returns before committing time and money.

Results:

The Influence of Waterponding on the Pasture

The pasture at the ponding bank site at Hamilton Downs was assessed in 1998 and then again in 2001 after the above average rainfall conditions. Figures 1 and 2 demonstrate that the response of pasture to ponding will vary with seasonal conditions. Total pasture biomass in 2001 was similar for ponded and unponded sites whereas in 1998 total pasture biomass was much greater at the ponded site compared with the unponded site. This suggests that during drier periods (e.g. 1998 survey) the response of the ponded pasture will be more noticeable than that of the unponded pasture. During wetter periods (e.g. 2001 survey) the greater amount of annual grasses present in the unponded pastures means that total pasture yields may be similar. Although the grazing value of the pasture in 2001 was greater in the unponded area than the ponded area, the greater amount of perennial grasses present at the ponded sites suggests that the ponding banks have created a more stable pasture condition.

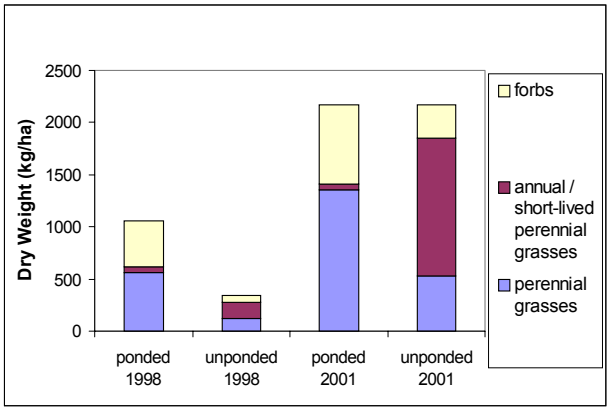


Figure 1. Comparison of plant groups – 1998 and 2001

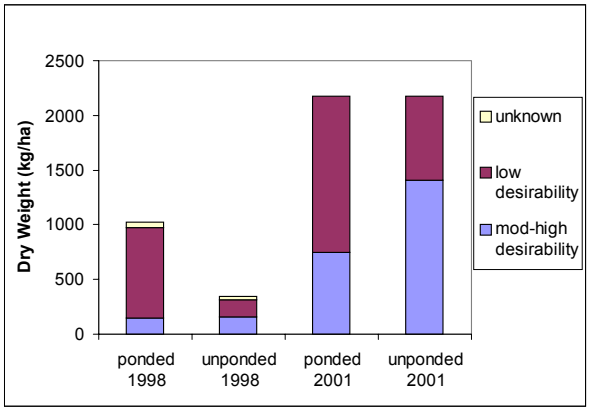


Figure 2. Comparison of grazing value – 1998 and 2001

Ponded and unponded pasture was also assessed at Murray Downs (July 2000) and results were compared with prior pasture assessments undertaken in 1990, 1991 and 1994. After 11 years the ponding banks were producing higher pasture yields than non-ponded areas. At sites that were ponded, ripped, seeded with buffel grass (*Cenchrus ciliaris*) and grazed, total pasture biomass was over three times higher than sites without reclamation and at spelled sites with the same treatment, total pasture biomass was over 13 times higher than without reclamation. The results demonstrate that spelling greatly increased pasture biomass

and desirability of pasture for cattle consumption. Cultivation of the ponded area was found to produce higher pasture yields than areas without cultivation, with ripping being more successful than pitting.

The Influence of Waterponding on Trees and Shrubs

A photographic comparison of ponding banks on Mt Swan station prompted an assessment of the differences in tree and shrub density and cover between ponded and unponded areas. Density was measured using 4 m wide belt transects 50 or 100 m long, depending on the ponding bank. Cover was measured along these transects using the line intercept method. Pasture biomass was also estimated. Figures 3 and 4 below clearly illustrate increases in tree and shrub density and cover at all sites. Despite the higher tree and shrub density and cover, the pasture biomass was higher in the ponded areas for all sites except site D (Figure 5). At site D, the exceptionally high tree and shrub density and cover appears to have had an impact on the total pasture biomass. However, perennial grass biomass was higher behind the ponding bank at site D, despite the tree and shrub density and cover. The results suggest that although ponding has resulted in tree and shrub density and cover increases at this site, the ponding banks were still functioning to provide increased perennial pasture.

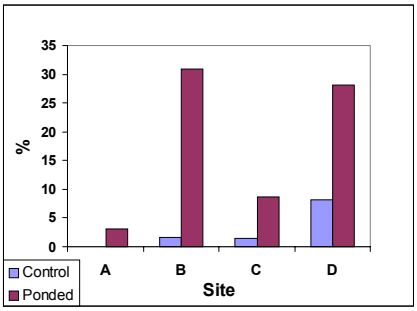


Figure 3. Tree and shrub cover

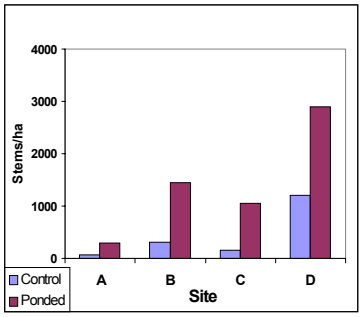


Figure 4. Tree and shrub density

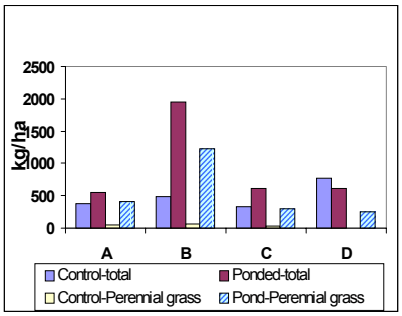


Figure 5. Total pasture biomass and perennial grass biomass

The Economics of Waterponding Banks

An alternative perspective on the economics of ponding banks has been pursued. This approach assesses the economic value of the additional pasture produced by comparing it with the costs of hay. This is particularly relevant in situations where ponding banks have been built in holding paddocks. Results so far suggest that this approach provides a more positive outcome than the previous economic analysis, which examined ponding banks in a general grazing situation. Table 1 illustrates the outcomes of this approach, compared with a carrying capacity model (whereby the additional pasture produced was converted into additional carrying capacity of the land).

Table 1. Comparison of the 'carrying capacity' approach and the 'holding paddock' approach for assessment of the economics involved with ponding banks for the Murray Downs data

Own machinery or hire	Rainfall	Cost of a pond ($)	Time required for construction costs to be recovered*	
			Carrying capacity approach	Holding paddock approach
Own machinery	Good	60	11 years	< 1 year
	Average	60	30 years	1-2 years
Hire machinery	Good	180	33 years	2 years
	Average	180	88 years	5 years

* The time required for the extra pasture behind ponds to equal hay costs does not take into account the two to three years required for establishment of pasture after construction.

The Use of Selected Native Species Seeded Behind Waterponding banks

The objective of this section was to determine the success of selected native species for use in seeding programs for ponding banks in the long term at a site established eight years ago (by CLMA) on Palmer Valley Station. The ponding banks were seeded with a variety of native species, including grasses and chenopods.

The most successful native species to seed at this site (a scalded and sealed clay loam soil) was *Astrebla pectinata*. The results also suggest that *Bothriochloa ewartiana* and *Dichanthium sericeum* are also suitable species to use. The least successful species sown were the chenopods species. The following species were seeded but were absent after eight years and therefore are not considered to be useful in the longer term for sowing in this land type: grasses - *Diplachne fusca, Chloris pectinata, Enteropogon acicularis;* chenopods - *Atriplex amnicola, Atriplex canescens, Atriplex codonocarpa, Atriplex lentiformis, Atriplex paludosa, Atriplex vesicaria, Chenopodium auricomum,* Kimseed Kochia, *Maireana aphylla, Maireana convexa, Maireana polypterygia, Maireana pyramidata* and *Maireana triptera.*

PROJECT: Grazing Management and Soil Physical Properties

Project Officer: C. Ballenger

Location: Alice Springs region

Objective:

To identify differences in soil physical properties as a result of 32 years of grazing exclusion in a sandy open woodland, north east of Alice Springs.

Background:

Hard-hoofed domestic stock are known to cause soil compaction in pastures around Australia. In fact, the pressures caused by stock are comparable with those of agricultural machinery. Yet, the majority of studies on soil compaction as a result of grazing have been undertaken in sheep grazing country and often in higher rainfall areas where stocking rates are considerably higher than in central Australia. In addition, no studies of soil physical properties have been undertaken that involve long-term cattle grazing exclosures in the Alice Springs region.

The study site for this project was at the Spinifex bore exclosure, Mt Riddock Station, approximately 140 km north-east of Alice Springs. The exclosure was set up in 1968 and has a history of vegetation studies.

Results:

Fieldwork was completed in 2000 and the results were outlined in the 1999/2000 Technical Annual Report

A seminar on the project results was presented at the "Rangeland Biology and Ecology Seminars". A summary of the results was presented as an Alice Springs Rural Review article.

The project was completed with the publication of Technical Bulletin No. 289 *The Impact of Grazing on Soil Physical Properties in a Sandy Open Woodland, Central Australia.* Discussions of results were conducted with pastoralists.

PROJECT: Barkly Rangeland Management Course

Project Officers: C. Materne, J. Akeroyd, A. Doust and J. Peart

Location: Barkly Region

Objective:

- ***To enable all Barkly pastoralists and their employees to attend a Barkly Rangeland Management Course.***
- ***To update and implement courses to improve land management skills of participants.***
- ***To stimulate interest of participants in rangeland management and monitoring.***

Background:

By investigating opportunities for beef production, a large body of rangeland information on the Barkly Tablelands has been gathered through research. Strong interest in this information by district pastoralists facilitated the development of a series of training days.

This project comprises a series of Barkly rangeland management courses 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 understanding by participants of native pasture dynamics, train them in plant identification and basic monitoring techniques and to 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 DPIF and DLPE presenters to cover the range of topics.

This project is a joint effort between DPIF, DLPE and the Natural Heritage Trust (NHT).

Developments:

NHT funding has ensured that the Barkly rangeland management course will continue until the end of 2002. Five courses involving six stations and 57 participants have been completed during the 2000/2001 period. Unfortunately, due to the early start to the 2000/2001 Wet season, three courses were cancelled. The North Australian Pastoral Company (NAPCO), Australian Agricultural Company (AA Company), Stanbroke Pastoral Company and Ucharonidge Station were also involved in the training.

Presentation material and handouts are constantly being developed and modified. A three poster series was produced to complement the course, and a set given to each participating station.

Dates have been set for a further three courses in 2001, and it is planned to hold an additional seven courses during 2002.

PROJECT: Calibration of Faecal NIRS (Near Infra-red Reflectance Spectroscopy) for Predicting Diet Quality in Grazing Cattle

Project Officers: J. Akeroyd and C. Materne

Location: Brunchilly Station

Objective:

- ***To contribute data collected from Barkly stations towards establishing faecal NIRS calibration equations for northern Australia.***
- ***To gain a better understanding of cattle diets in the Barkly Tablelands region.***

Background:

This project is part of a national project coordinated by CSIRO Townsville for the calibration of faecal NIRS across northern Australia. Calibration of faecal NIRS for northern Australia will allow pastoralists to utilise faecal NIRS technology as a support tool to assist with timely decision-making regarding supplementation and to gain a proper understanding of herd performance and pasture quality. Until now faecal NIRS technology had only been calibrated from data from eastern Queensland. To be commercially useful, its calibration is required across the whole of northern Australia.

Developments:

Five pen experiments were conducted on Brunchilly station at approximately two-monthly intervals. Steers in three pens were each fed one of three forage types (Mitchell grass dominated, Flinders grass dominated and mixed pasture species of 'red country' short arid grasses). Samples of the feed offered, feed refused and faeces produced were taken daily. CSIRO subjected the faecal samples to NIRS and wet chemistry analysis and compared the results.

The first trial was a test of the project methodology. Trials two and three were disrupted by unusually heavy rainfall; however, experiments four and five yielded good data.

It is clear from the results that a large proportion of the diet of free-grazing cattle consisted of non-grass species, especially in good seasons.

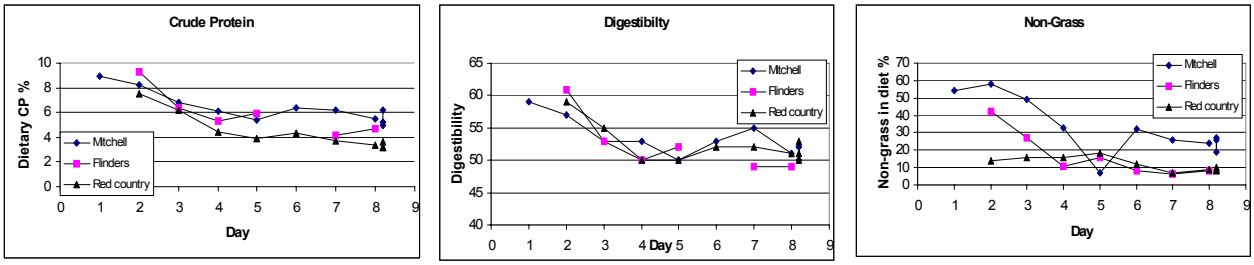


Figure 1. Faecal NIRS analysis results from experiment four, April 2001

The background (free grazing) diet is reflected in the results on day one as they enter the pens. At the end of the week the faecal measurements represent the diet fed in the pens. In early April the diet of cattle free grazing Mitchell grass country contained 9% crude protein while in the pen it was less than 6%. Similarly, the digestibility declined from almost 60% to just over 50%. This matches the decline in the non-grass (forbs and herbs) from 55% of the free grazing diet to 25% of the pen fed diet when the animals are not able to graze selectively.

The trial will continue over the 2001/02 Wet season and will be reassessed at the beginning of the dry season (April 2002).

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

Project Officers: R. Dyer, L. Cafe, R. Cowley and M. Cobiac

Project Location: Katherine/VRD

Objective:

- ***To ensure that by 2001, throughout the VRD and Sturt Plateau regions of the Northern Territory 90% of players in the pastoral industry are aware of the importance of sustainable grazing management practices; and***
- ***50% of pastoral leases have partially or completely adopted relevant sustainable grazing management practices.***

Background:

The first phase of this Meat and Livestock Australia (MLA) funded project has been developing effective burning strategies to control native woody shrubs, understanding the competitive relationship between trees, shrubs and pastures and to develop pasture growth models that can be used to investigate effects of stocking rates and carrying capacity. This has involved extensive collection of data. Continuing work between 1997 and 2001 has aimed to include many review recommendations and focuses on incorporating available data and information into simple management guidelines that fit into whole property management. The project is currently nearing completion, and the final report will be completed by December 2001. To ensure effective technology transfer and promotion of management systems several approaches will be taken in six sub-projects.

Results:

1. Better Understanding and Management of Native Pastures in the VRD
Critical growth parameters for important pasture communities throughout the Katherine region are now available. These have been incorporated into pasture growth models and can be run in WinGRASP, a Windows based software application that allows seasonal fluctuations of growth to be simulated based on these growth parameters and daily climate records. Differences between communities, soil types, pasture condition and rainfall zone on seasonal pasture production and factors that limit growth can now be investigated. These models are required to investigate seasonal reliability of pasture production, fuel load accumulation and estimation of both short-term and long-term stocking rates. Much of this information has been utilised in the MLA Grazing Land Management learning project.

2. Economic assessment of Grazing Management Options
A framework for investigating the ecological and economic impacts of a range of fire regimes has been developed in conjunction with CSIRO. During this year two workshops were conducted involving DPIF, CSIRO, AGWEST, and BFC NT where model outputs from FLAMES, GRASP and ARENA models have been integrated. A final workshop is planned before the end of the year to complete the project and produce a report.

3. Assessment of Stocking Rates and Carrying Capacity for Pastoral Properties
An integrated, database-GIS software package has been developed for the calculation of current property and paddock stocking rates and estimation of safe carrying capacities based on land type. This allows the production of reports (SR_Calc) and maps (SR_Map) of property map units, paddocks types, stocking rates and carrying capacity. Additional software extensions allow the impact of new paddocks, paddock subdivision on carrying capacity to be investigated. Tools have also been developed to determine the area within certain distance bands to water and examine the impact of water point number and placement. Data from Kidman Springs, VRD, Wave Hill, Auvergne and Bunda stations are currently incorporated into this system.

The use of pasture growth models combined with results from the Mount Sanford stocking rate trial and Kidman Springs has enabled the analysis of seasonal fluctuations and utilisation rate on stocking strategies. These tools are being used in conjunction with pastoral properties to investigate a range of grazing and stocking scenarios, particularly relating to flexible stocking rates and intensification.

4. Practical Burning Guidelines to Manage Pasture Communities and Woody Plant Populations
Final analysis of data investigating the impact on fire on pasture condition and woody plants has been completed. Preliminary fire management guidelines have been formulated and promoted.

A fire publication titled *A Savanna Burning: Understanding and Using Fire in Northern Australia* is drawing together research results and information from agencies across northern Australia. This is due for publication in September 2001.

5. The Impact of Woody Vegetation
The effects of trees on native pasture production have been successfully incorporated into the GRASP pasture production model. Output from this model is currently being used to determine the likely economic impact of unchecked woody weeds on pastoral production.

6. Sustainable Grazing Practices Producer Demonstration Sites
Aerial videography data has been collected from all sites and image analysis methods have been refined to estimate cover classes across extensive areas. It is anticipated that this will provide an insight into factors that determine grazing distribution and that predictive models of grazing pressure based on land type, distance to water, land condition, burning and previous grazing can be developed. If successful, these models will enable the most appropriate placement of water points and the determination of prescribed burning.

The impact of fire on modifying grazing distribution in variable landscapes and distance to water has been investigated and quantified.

PROJECT: Aussie GRASS: Spatial Validation of GRASP Pasture Production Models and NOAA Fire Scar Images in the Top End, NT and Kimberley, WA

Project Officers: R. Dyer and L. Cafe

Project Location: Katherine/VRD/Sturt Plateau

Objective:

- ***Complete calibration and validation of NT GRASP models from SWIFTSYND sites throughout the Victoria River and Katherine regions.***
- ***Collect an independent spatial validation data set for associated pasture communities throughout the Top End of the NT and the Kimberley, WA.***
- ***Coordinate with QDNR to carry out validation of spatial models of NT GRASP sites throughout the northern NT and the Kimberley.***

Background:

This is a sub-project of the Aussie Grass (Australian Grassland and Rangeland Assessment by Spatial Simulation) project. Aussie Grass is a National Climate Variability Program funded project administered by the Land and Water Resource Research and Development Corporation (LWRRDC). The project involves both research and extension organisations in New South Wales, South Australia, Western Australia, Queensland and the Northern Territory. The Aussie GRASS project aims to:

- Compare the ability of various regional models to simulate biomass and, where appropriate incorporation these into the model.
- Improve inputs to the model both spatially and temporally.

- Collect field data to calibrate and validate the spatial model.
- Develop extension products that meet the requirements of the project stakeholders.

Results:

An extensive spatial pasture biomass data set, totalling over 110,000 observations has been collected for the NT and Kimberley. This data has been used to calibrate and validate a working spatial model of pasture growth and total standing dry matter for these areas and has been incorporated into seasonal condition products that can be viewed and downloaded from the Aussie GRASS internet site. A range of fire products including fuel load, curing state and fire risk is also available.

A final report has been completed and submitted.

PROJECT: Mt Sanford Stocking Rate Demonstration

Project Officer: D. La Fontaine, N. MacDonald and G. Roeser

Project Location: Mount Sanford station

Objective:

To investigate the medium and long term effects of different stocking rates in terms of ecology and economics.

Background:

This project has been running on a 65 sq km area of land leased from Mt Sanford Station since 1993, sponsored by the NHT. For the last seven years the site has been blessed with a remarkable run of good wet seasons, the best spell since rainfall recording began in that area 71 years ago.

Cattle performance on the trial has been excellent, averaging 81% weaning and 151 kg/year steer growth. With an average grass growth of about 2.2 t/ha, the heaviest stocking rate (15 cows/km^2) has worked out to a utilisation rate of 23% which is about right. The main conclusions from the trial to date are that great cattle performance, sustainable pastures and high stocking rates are all achievable if cattle are able to graze the whole paddock evenly. This means fewer cattle per water point. For stable perennial grasses, a utilisation rate of 25% of the year's pasture growth is a good target, but pastures in poorer condition dominated by annuals will need a lighter utilisation rate if the perennial grasses are to regenerate. This is advisable despite the fact that the annual pastures will deliver better animal performance in good years.

Developments in 2001

Pasture conditions this year are excellent, favouring the preferred grass species and especially Queensland blue grass, without any major "weed" problems. Our Wet season rainfall total was 1094 mm, which is the wettest year we have recorded. The flooding in the area in February and March did not impact on the site apart from restricting access during those periods. Plenty of soil moisture has been retained, and pastures still show greenness in August, which is unusual. Mitchell grass has shown significant flowering during the mid-dry season.

The stocking rate treatments were changed in October 2000 as a result of continuing exceptional seasonal conditions. The lightest stocking rate treatment (5 head per $km^{2)}$ has been removed, and two higher rates (22.5 and 30 head per km^2) imposed (approximately 34% and 45% utilisation) to test the effect of higher levels of grazing on pasture condition and animal productivity. The introduction of the higher stocking rates has necessitated dropping the supplementation comparison and from October all paddocks have been receiving a supplement.

Data from the project has provided a basis for Heytesbury Beef to design their own trial of the commercial implications of implementing the results from the Mt Sanford work. The Project has received $35,000 in operational funding from the MLA to assist maintaining the project until further external funding is secured.

PROJECT: Technology Transfer to Pastoral Land Managers

Project Officer: T. Oxley

Project Location: Katherine, VRD, Roper River, Sturt Plateau

Objective:

- ***To enable at least 15 properties to use the full range of decision support tools available.***
- ***To provide user-friendly documentation from results of current research to promote the use of new technology.***
- ***To evaluate the products available and provide feedback to the researchers who manufacture them.***

Background:

Pastoralists control 75% of the land area of the Katherine Region, with property sizes often exceeding 3000 sq km. For even the most experienced land managers, this huge scale is a problem. Gradual changes in land condition are due to both climatic and management factors and a full appreciation requires a broad spatial perspective that is hard to acquire on the ground, and awareness of a time scale is beyond the experience of most managers. New technology presents exciting opportunities to make more informed management decisions. However, the adoption of emerging new technologies by pastoral land managers is impaired because of poor awareness, access and support.

The Natural Heritage Trust has provided funding to DPIF to employ a full time technology transfer officer for two years. The major objective is to increase the number of managers in the region who use decision support tools and internet based information for seasonal climate and weather forecasting, fire management, estimation of stocking rates and carrying capacity, herd modelling, land condition monitoring and property management planning. By identifying the needs of land managers and providing hands-on support, this project will contribute to an increased awareness and adoption of technology options.

This position will also be involved in the preparation of user-friendly documentation to promote results of current research activities focusing on new technology related to regional management issues, and will also evaluate information products and provide feedback from land managers to researchers and developers.

Results:

Initial contact visits have been made to 17 properties. Almost all properties expressed interest in using at least one type of decision support system. Return visits were made to six of the properties, with regular contact being established for assistance in the use of decision support systems, particularly PAM 2000, Rainman, the Stocking Rate Calculator and Breedcow Dynama. Regular articles relating to new technology available are being placed in the *Katherine Rural Review* and this continues to create interest in the project.

A considerable amount of time has been dedicated to developing and presenting group training programs such as “Better Decisions in the Business of Beef”(Breedcow/Dynama software), rangeland management courses for station staff and the grazing land management course for land managers.

Work with the current focus group has been wound up to the extent that most feel that the support they require to continue using the technology is only a phone call away to solve specific problems. It is expected that the next six months will be spent working with a new focus group that has been selected to represent a broad range of property ownership, including private, company and Aboriginal owned stations.

PROJECT: Sustainable Fire Management in the Victoria River District and Sturt Plateau

Project Officer: A. Johnson

Project Location: Sturt Plateau and VRD

Objective:

To develop and promote sustainable fire management practices across the Victoria River District and Sturt Plateau. This will largely involve the production of calibrated maps from satellite imagery detailing fuel conditions and areas at high fire risk.

Background:

The use of fire in the grasslands of Northern Australia has changed dramatically with changing land use.

The suppression of fire on black soil grasslands has led to the increase in woody vegetation, and a build-up of old rank fuels unsuitable for productive grazing. On the other hand, areas with less grazing importance such as sandstone communities are being burnt more often and many fire sensitive species such as obligate seeders are declining due to the presence of regular hot fires. This project aims to address these issues and promote regional strategic burning practices to promote and protect biodiversity whilst also maintaining productive rangeland condition.

Strategic burning practices are often unsuccessful due to missing the window of opportunity for optimal burning conditions. The use of satellite imagery to remotely assess fuel conditions (fuel curing and fuel loads) will enable better timing of controlled burns.

Results:

The project is now completed, and a final report, multi-media CD and Fuel Curing Guide have been produced.

PROJECT: Development of a Grazing Land Management Education Program for Northern Australia

Project Officers: N. MacDonald, R. Dyer, T. Oxley and M. Cobiac

Project Location: Katherine, VRD, Roper River, Sturt Plateau

Objective:

To develop a Grazing Land Management (GLM) learning product that provides participants with the understanding and tools required to:

- ***Competently manage the natural resources.***
- ***Enhance enterprise profitability.***
- ***Demonstrate their stewardship and "duty of care".***

Background:

Sustainable and productive management of grazing lands is a high priority for the beef industry of northern Australia. However, there has been growing frustration with the accessibility and uptake of information from R&D that should assist with sound, ecologically based management of those grazing lands. This poor uptake is largely due to a failure to integrate, validate and effectively deliver our knowledge.

The objective of the GLM project is to coordinate the development of a learning package that grazing land management that will be used throughout northern Australia by August 2001. The package will contain a core of generic information relating to basic ecology relevant to a wide area, locally specific information and case studies and workshop activities. Several modes of delivery are proposed, including workshops, INTERNET/ CD ROM based external learning. The delivery of the completed workshop series to end-users will be strictly quality controlled and based on successfully securing tenders submitted to MLA. Officers within DPIF are contributing with other agencies across northern Australia. The GLM project will be an important extension outlet for grazing management work carried out throughout the Katherine region.

Results:

Activities throughout the year have included participation in project planning meetings, consultation with research and extension officers to identify the source and availability of information relating to identified learning outcomes, involvement in the development of a workshop scheme for the estimation of on-property carrying capacity and stocking rates. Production of the information required for the project has necessitated the bringing together of most of the recent Katherine rangelands and animal research. A pre-pilot workshop was conducted in Katherine in July to gather input on the content and structure of the workshop from agency and industry perspectives.

FISHERIES

PROGRAM: Aquatic Resource Management

SUBPROGRAM: Coastal and Estuarine Fisheries

Coastal Line Fishery	**Project Officer T. Hay**
Main Features	
Fishery Status/Development Stage:	Developing 1996 assessment using preliminary data estimated at 100 –1,000 tonnes/year. High recreational pressure
Stock Assessment Reliability:	Low
Stock Assessment Method:	Analysis of time series of commercial catch and effort data. Preliminary age structure data and stock reduction analysis.
Commercial Harvest 2000: Species Composition % total catch 2000	152 tonnes (multi species) 67% black jewfish, 12% golden snapper, 2% tricky snapper, 13% various lutjanids, lethrinids and cods
Value of commercial harvest:	$0.75m (est.)
Five-year trend and average (commercial):	Catch: Increasing - average 102 tonnes Effort: stable
Recreational Harvest 2000:	Unknown 1995 - estimated 600 tonnes (FISHCOUNT)
Indigenous Harvest 2000:	Unknown

Licence Information (year):	1996	1997	1998	1999	2000
Total number of commercial licences issued:	80	71	67	66	64
Number which took 90% of catch in 2000:	22	12	12	11	14
Number of active licences in 2000:	44	33	31	30	31
Number of licensed fishing tour operators:	192	245	246	183	150

Management Arrangements:	*Commercial*: Input controls. Limited entry, licence reduction scheme and gear restrictions. *Recreational*: Output controls, possession limits. Licensing of FTO's.

Introduction:

The Northern Territory Coastal Line Fishery is a multi-species inshore fishery; targeting reef associated species such as black jewfish, golden snapper, cod, shark, other small snappers and emperors and some pelagic species such as trevally and queenfish.
Four major sectors utilise this fishery including the commercial, recreational and traditional fishers as well as fishing tour operators (charter).

The Fishery operates in waters from Queensland to the WA border and is managed by the Northern Territory. Fishing activity is restricted to within 15 nm of the coastline. Within this zone, all NT waters are generally open, with some restrictions imposed in areas such as Aboriginal lands or waters, Aquatic Reserves and National Parks.

A major workshop was held in Darwin during 1996 to provide advice on the status of NT fish stocks, including the Coastal Line Fishery. Professor Carl Walters, an internationally recognised expert on fisheries stock assessment, led the review and found that although the fishery was not heavily exploited, there were signs of sequential depletion, particularly around major population centres. He warned that at some time in the future, with the development of new fishing techniques or an increase in effort, stocks could be threatened. Using the limited data available, an annual estimate of between 100 – 1,000 tonnes was derived.

The commercial catch for the Coastal Line Fishery increased by approximately 50% in 2000. Corresponding recreational estimates are only available for 1995, gathered during the first survey to estimate the impacts of recreational fishing within NT waters. FISHCOUNT indicated that the estimated NT recreational catch for inshore fish species was approximately six times greater than the commercial coastal line catch. A second survey is being conducted now. The results are expected to be released in early 2002.

Profile of the Fishery:

Catch and Effort
The commercial catch for the coastal line fishery has increased from 97.9 tonnes in 1999 to 152 tonnes in 2000 (Figure 1.). Fishing effort is recorded as hook days (HD), which equates to the total number of hooks in the water per day over the entire fishery. Fishing effort was high in the early developmental years of the fishery, however effort has remained low over the past few years and does not reflect the recent increase in catch.

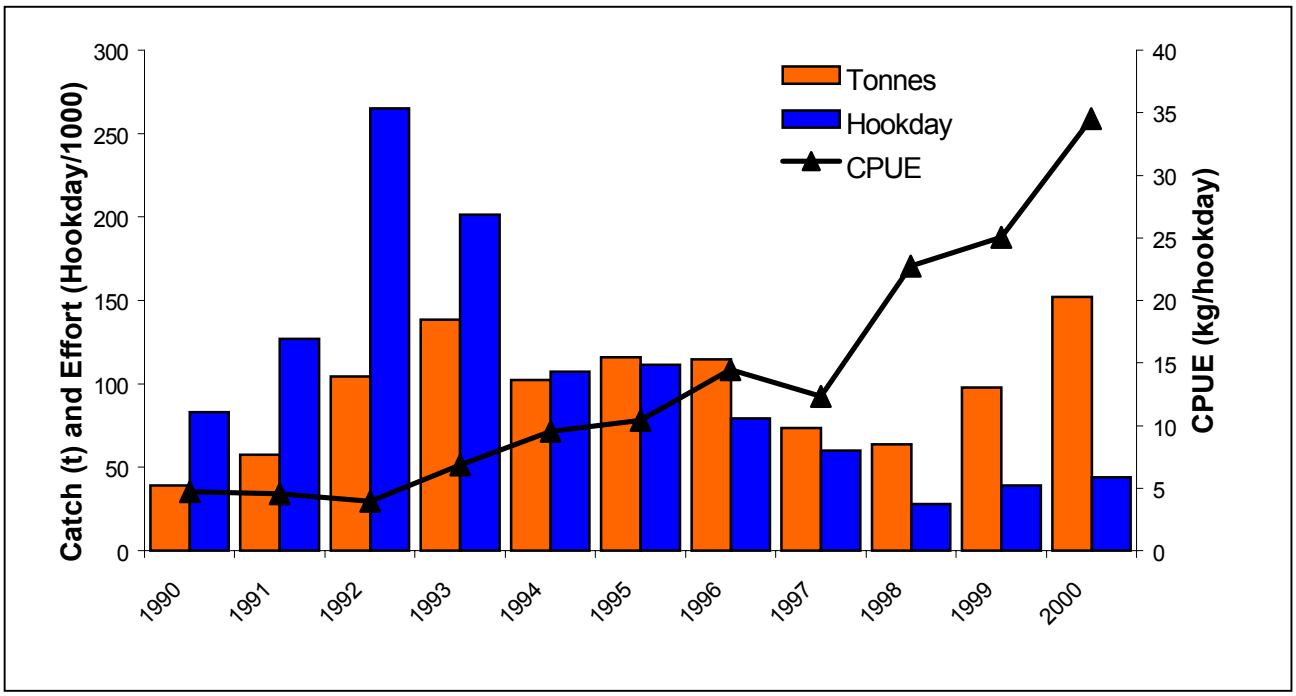


Figure 1. Catch, effort and CPUE for the commercial fishery 1983 – 2000

Catch per unit effort (CPUE) remained stable during the period 1990-1993 averaging 5 kg per hook day. This increased to an average of 12 kg per hook day during the period 1994-1997 and has further increased in 1998, 1999 and 2000 to 22.7, 25 and 34.2 kg per hook day, respectively.

Patterns such as these may indicate an increase in fishery production brought about by favourable environmental conditions. If this were the case the commercial catch composition should demonstrate increases in catch for all species, as they become more abundant (Figure 2).

Analysis of the Coastal Line Fishery catch composition indicates that the 56% increase in total catch from 1999 to 2000 can be directly attributed to one species, the black jewfish. The total catch for this species almost doubled over the 20-month period, increasing from 58 tonnes to 101 tonnes. In 1990 black jewfish contributed only 11% to the total catch and this has increased to 67% in 2000. Golden snapper catches have however remained relatively stable at approximately 12% of the total catch over this same period.

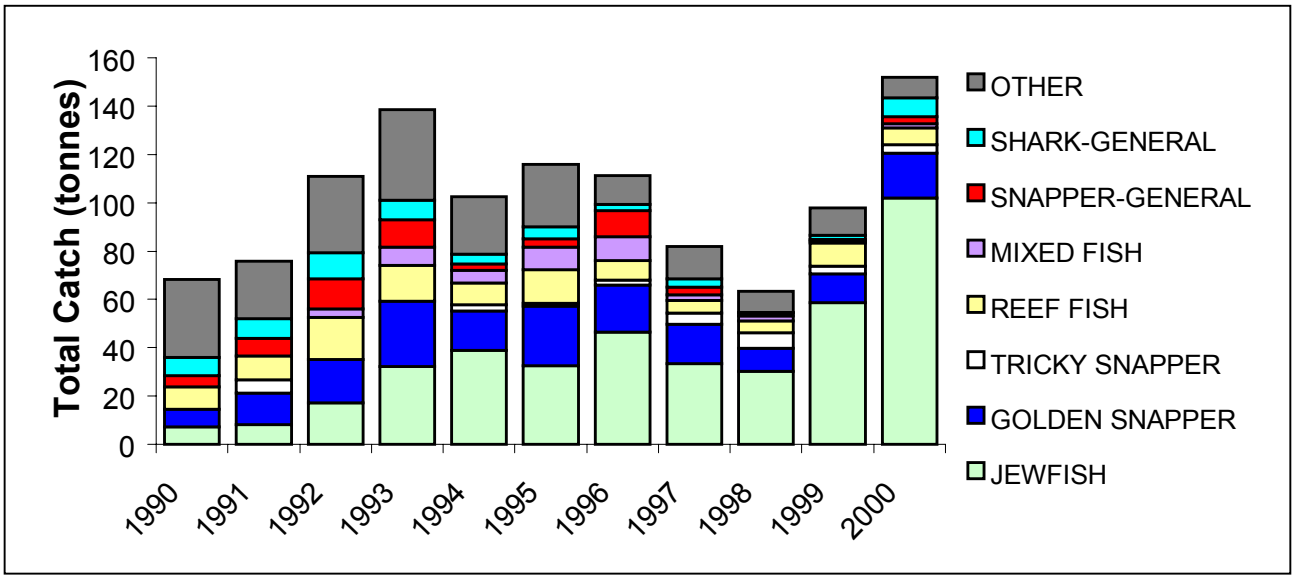


Figure 2. Catch by major species in the NT coastal line fishery 1983 – 2000

Black jewfish form large aggregations; however the function of this behaviour is currently unknown. Other fish species often aggregate in inshore areas to spawn. High levels of fishing mortality imposed on such aggregations are not sustainable; however such an outcome highly depends on the spatial and temporal scales at which fishing mortality is applied.

Similar concerns raised in north Queensland prompted a recently completed study where target fishing of black jewfish aggregations was examined. This work has documented the absence of sexually mature black jewfish from the study area as well as a significant and rapid reduction in size of fish harvested (Phelan et al. 2001 in press).

Commercial fishing continues to be based around major population centres. Over 90 percent of the total catch is taken from the greater Darwin region, five percent from the Nhulunbuy/Groote Eylandt regions and less than one percent from the Borroloola region.

All catch taken to date by the coastal line fishery is by line, resulting in negligible interaction with threatened species such as dugong or turtle. All fish species permitted to be taken by this fishery are of good eating quality and are therefore highly marketable.

Recreational

Fishing within the coastal strip adjoining the NT out to 15 nm, including the estuarine systems, provides an extremely popular fishing area for a large number of anglers targeting species such as jewfish, snappers, emperors, cod, bream and pelagic species such as trevally and queenfish. Species caught by recreational anglers vary significantly depending on area fished, time of year and state of the tide.

Detailed historical information on the recreational catch of coastal species in the NT is limited. However, a survey of the recreational fishing sector (FISHCOUNT) undertaken throughout 1995, estimated that recreational fishers caught in the vicinity of 600 t of coastal species. The Darwin area accounted for around 65% of the catch with 25% from the McArthur River region. Black jewfish account for approximately one third of the total recreational catch with an estimated harvest of 240 tonnes in 1995.

Recreational fishers do not require a licence in the NT, although possession limits exist, including a five jewfish limit which came into force in 1996 and a general possession limit of 30 fish per person which came into force in 1997. During 2000, further refinements to the possession limit are expected with a five golden snapper limit proposed as well as including the managed species within the 30 fish possession limit.

A comprehensive National Survey of Recreational and Indigenous Fishers (NSRIF) is being undertaken during 2000/01 and will provide further estimates for harvest of coastal fish species.

Fishing Tour Operators (FTO's)
FTO's are licensed to conduct guided and charter fishing tours. Only recreational fishing gear can be used and the catch may not be sold, traded or bartered. The same gear and possession limits apply as for the recreational sector. FTO licences are issued free of charge, are not transferable and there is no limit on the number of licences issued.

There are currently 180 licensed FTO's. Targeting reef fish is the second major fishing activity reported by FTO's, accounting for around 25 % of the total hours fished. Initial summaries of 1999 data indicates around 70 000 coastal fish were taken, with around 70 percent reported released. The major species taken were golden snapper, mangrove jack, cod, tricky snapper, Spanish flag, jewfish, parrot fish, shark, queenfish, and trevally.

The level of activity of FTO's targeting reef fish appears relatively consistent based on logbook data. Tours are undertaken around Darwin, Fenton Patches, Bynoe Harbour, Fog Bay to Point Blaze and the Peron Islands. A small number of charters operate out of Gove, Borroloola and across Arnhem Land.

Indigenous
Indigenous people utilise fish and aquatic life of the coastal region as a subsistence food source as well as a source of recreation. Section 53 of the *Fisheries Act* guarantees indigenous people their right to use the resource in a traditional manner. Indigenous people are also entitled to use recreational fishing gear to catch fish.

No information has been gathered on this sector, but the NSRIF 2000 survey will provide some details on catches taken by indigenous fishers.

Aquaculture
Development of technology to culture golden snapper has continued at the Darwin Aquaculture Centre and fish have been raised through all larval stages and can be grown to commercial size. This has been facilitated by the development of appropriate live feed, which has improved larval survival.

Research
Preliminary stock assessment of coastal Finfish was attempted in 1996 using historical catch and effort data and preliminary biological data collected over the initial 12-month period. Estimates of sustainable yield for this multi-species fishery ranged from 100 to 1000 tonnes per year.

Catch and effort statistics from the commercial fishery are compiled and analysed on an annual basis. Logbook information is data poor and it is unlikely that reliable assessments will be possible, without substantial modification to the temporal and spatial scale at which the data is reported.

Unfortunately funding for fishery monitoring and research for the Coastal Line Fishery was withdrawn in October 2000 due to budgetary restraints imposed within the Fisheries Division.

Barramundi *(Lates calcarifer*) 2001	**Project Officer: R. Griffin**
Main Features	
Fishery Status or Development Stage:	Fully exploited in some areas, under-exploited in others.
Stock Assessment Reliability:	The assessment is considered very reliable.
Stock Assessment Method:	Analysis of time series of commercial catch and effort data. Age structure, surplus production and delay difference models.
Commercial Harvest 2000:	825 tonnes barramundi, 312 tonnes threadfin salmon.
Value of commercial harvest (including by-products):	$5.4m
Annual average based on most recent five-year trend (commercial):	Catch: Rising, average 672 tonnes Effort: Stable, average 30,400 100 metre net days.
Recreational Harvest 2000:	Not known – about 300 tonnes in 1995.
Total number of commercial licences issued: Number of licensed fishing guides:	26 155 (116 active) 60% of effort targeting barramundi).
Management Arrangements:	*Commercial:* Input controls. Limited entry - 26 licences, each with a net length limit (usually 1,000 m, some less). Mesh size limits. Spawning season closure (1 October to 31 January). Area limitations. *Recreational*: Output controls, size and possession limits. Licensing of guides.

Commercial Fishery

Background:

The commercial fishery is managed by input controls. Only 26 licences are issued. Legislation prohibits commercial fishing inside the mouths of most rivers and creeks, limiting activities to the coastal zone. Commercial operators target barramundi in the three to eight-year old age group using gillnets. The kind and size of nets used is regulated. A maximum of 1000 m of net is allowed to be used (some licences are restricted to less). Nets with a minimum mesh size of 150 mm (6 in) are allowed for most tidal mud flats while 175-mm (7 in) mesh is allowed for use in the rivers, which remain open to the commercial fishery. A minimum legal fish length of 55 cm applies.

Catch and Value

The commercial barramundi fishery developed rapidly in the 1970's to the point of overexploitation. Radical reduction of effort in the 1980's has led to a recovery of stocks and stability in the industry (Figure 1). In the late 1980's and 1990's reallocation of parts of the resource to the recreational sector has occurred. The 2000 barramundi catch of 825 t is slightly higher than the previous year (809 t). It is much higher than the five-year average of 672 t. The value of the commercial catch of all species retained in the barramundi fishery in 2000 was $5.4 million. Of this, $4.6 million was for barramundi and $0.6 million for threadfin.

Fishing Effort
Fishing effort is recorded as 100 m net days, with one 100 m of net fished for one day being one 100 m net day (hmd). Effort has remained very stable over the past 10 years with effort in 2000 being 30.64 hmd compared with the five-year average of 30.4 hmd.

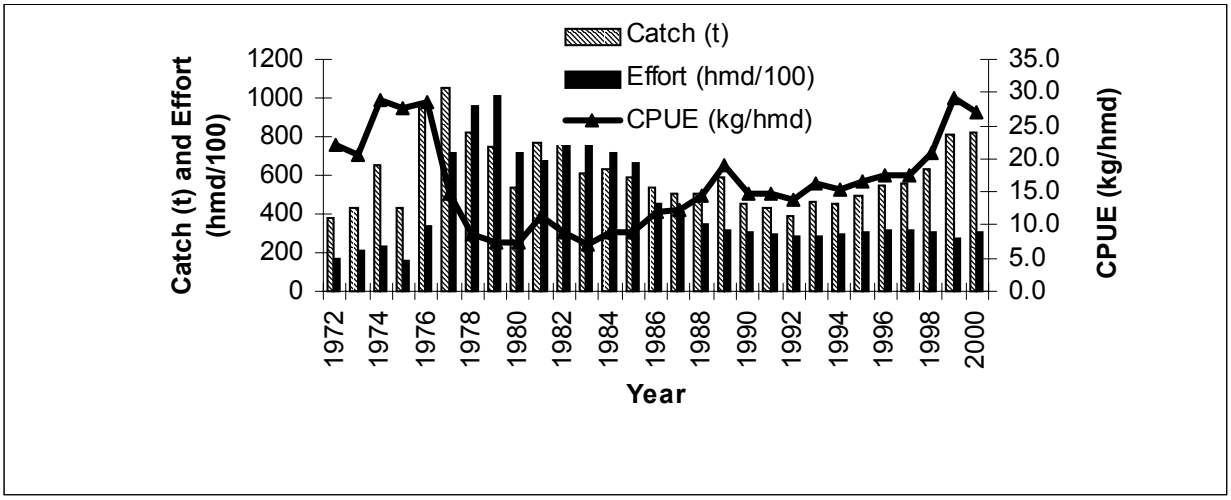


Figure 1. NT Barramundi fishery, catch, effort and CPUE 1972 to 2000

By-catch
Gillnets in the barramundi fishery catch a variety of fish species other than barramundi and threadfin *(Polynemus sheridani*), including jewfish (*Protonibea diacanthus*), sharks (*Carcharhinus* sp mainly), blue salmon (*Eleutheronema tetradactylum*), triple tail (*Lobotes surinamensis*) and catfish (*Arius* sp). All but the catfish are generally retained and marketed either by species category or as mixed fillets. Occasional catches of non-fish species, such as crocodiles (*Crocodylus porosus*), dugong (*Dugong dugon*), and turtles occur. Most of those animals are released alive but some deaths do occur. Where dugong encounters were more frequent in the southwest Gulf of Carpentaria, special gillnet exclusion zones were declared.

Habitat Issues
Coastal tidal brackish/freshwater swamps are important nursery habitat for barramundi in their first year. Most of those habitats in the NT are pristine and not threatened. In the Mary River works to control salt-water intrusion impacted on some of this habitat. Research programs are in place to assess those impacts and to develop appropriate actions to ameliorate them.

Environmental Influences
The amount of Wet season rainfall in the area and productivity of the coastal swamps and floodplains affected Barramundi recruitment. In El-nino years when monsoonal rainfall is delayed, recruitment is generally reduced.

Recreational Fishery:

Background
Barramundi is a popular recreational fishing target and is an icon species for anglers Australia-wide. Fishing tourism and guiding is a rapidly developing sector of the fishery. Commercial fishing guides are required to be licensed and to submit detailed logs of fishing activity. Barramundi caught by recreational anglers are generally one to four years of age and are most commonly encountered in upstream waters. The Mary River and Daly Rivers, as well as the rivers in Kakadu, are important fishing locations due to their proximity to major urban centres. The Victoria, McArthur and Roper Rivers are also popular.

The recreational fishery is regulated by means of possession limits, a minimum length (55 cm) and some seasonal area closures. The Mary River is subject to a special management regime and a possession limit of two barramundi applies, while in the rest of the NT the possession limit is five.

A major survey of recreational fishing in the NT was undertaken in 1995. Annual estimates of recreational catch and effort for the Mary River are available for 1989 to 1995. No new estimates are available.

Research Activity 2000:

Stock Assessment
Stock assessment of barramundi is achieved primarily by monitoring and analysis of trends in the commercial catch and effort. With a 29-year time series of information available, assessment and simulation using a range of models has been productive and informative. Earlier assessments, using surplus production models, have been replaced by more sophisticated and appropriate models, including age structured and delay difference models. Modelling indicates that current harvests are within the limits of sustainability and that populations have recovered well from overexploitation, which occurred in the late 1970s and early 1980s. That modelling also indicates strongly that high levels of recruitment were maintained at quite high levels, even at the lowest stock levels observed.

"Estimates of optimum annual exploitation rates vary from 20-30%. Current exploitation rates by commercial fishing range among rivers from less than 3% (Mary, Kakadu) to 10-20% (Daly, McArthur, Roper). Exploitation rate by recreational fishing can be estimated only for the Mary River, and there it is about 5-10% annually of the juvenile stock. Thus three major stocks now appear to be harvested at near maximum sustained yield levels by commercial fishing (Daly, Roper and McArthur), and two are now exploited at rates far below their commercial potential (Mary and Kakadu rivers)." (Walters et al. 1997, Fishery Report No. 39).

A further stock assessment review of barramundi fishery under the leadership of Professor Carl Walters of the University of British Columbia was conducted in August 2000. That review used slightly improved versions of previous models to assess populations. The same conclusion was reached, that is, the NT commercial barramundi fishing is at relatively low levels in most areas and sustainability is not under threat (Fishery Report No. 56).

Fishery Monitoring
Apart from compilation and analysis of catch and effort statistics, no commercial fishery monitoring was undertaken in 2000/2001. Catches at major recreational fishing tournaments on the Daly River and elsewhere in the NT were monitored and data recorded. The annual Barramundi Classic is a tag and release contest, which has been conducted on the Daly River for over 10 years. Tag recoveries are recorded and analysis of accumulated tag recovery data has commenced.

Fishery Independent Monitoring
Monitoring of the barramundi population at Corroboree Billabong on the Mary River by depletion methods has been conducted each year since 1989. A 450-m section of the billabong is isolated by fine mesh block-nets and the population intensively fished over several days using gillnets ranging in mesh size from 75 mm (3 in) to 200 mm (8 in). That monitoring has revealed a very strong alternation of year class strengths, which continued in 2000, although the effect was not as marked as in previous years. Annual estimates of the population of the experimental area, by age class, for fish age 0 to age 2 are shown in Table 1. The abundance of three year-olds, survivors of a very strong recruitment in 1997, was very high, contributing to an abundance of legal sized barramundi almost equal to the highest observed in Corroboree Billabong.

Table 1. Annual estimates of barramundi population by age class for the Corroboree Billabong experimental area, 1989 to 2000

Year	Age 0	Age 1	Age 2	Total 0-2	Biomass (kg)
1989	371	72	21	464	1,050
1990	14	476	39	529	1,032
1991	293	1	68	362	350
1992	0	134	27	161	506
1993	931	17	80	1,028	880
1994	43	170	16	229	1,134
1995	394	44	55	493	649
1996	24	269	109	402	1,215
1997	2,000	125	236	2361	1,390
1998	38	243	10	291	828
1999	603	40	33	676	390
2000	163	312	46	521	1,116

A model based on predation and competition has been developed which explains this alternation. A paper describing the model is in the final stages of preparation for publication. The amount of Wet season rainfall is also an important determinant of recruitment.

Biological Research

Since most of the basic biology of barramundi is well known, no direct research on factors such as growth or reproduction has been undertaken. In recent years, barramundi research efforts have largely focussed on the Mary River wetlands. The second two-year phase of a major project, funded by the Natural Heritage Trust, commenced in September 1999. The aim of the project is to assess the impacts of saline intrusion (and measures to control it) on use of wetlands habitat by barramundi. An experimental trial to assess the effects of spillways in saline intrusion control bunds is nearing completion. The first phase of the study has shown substantial differences in the fish fauna associated with bunded and unbunded wetlands.

Mud Crab Fishery	**Project Officer: T. Hay**
Main Features	
Fishery Status/Development Stage:	Fully or heavily exploited in all areas fished
Stock Assessment Reliability:	Medium
Stock Assessment Method:	Analysis of time series of commercial catch and effort data, size structure, recruitment models and density/area assessments.
Commercial Harvest 2000:	1,037 tonnes
Commercial Effort 2000:	983,524 potlifts
Value of commercial harvest 2000:	approximately $13m
Five-year trend and average (commercial):	Catch: Rising, average 698 tonnes Effort: Stable, average 967,336 potlifts
Total number of commercial licences issued: Number which took 90% of catch:	49 40
Number of licensed fishing guides (target mud crab):	Nil
Indigenous Harvest 2000:	Unknown
Recreational Harvest 2000:	1995 data indicates 40 – 50 tonnes.
Management Arrangements:	*Commercial:* Input controls. Limited entry -49 Licences, 60 pots, Minimum size limits (males 130 mm, females 140 mm) some area closures. *Recreational*: Input controls. Gear limitations. Output controls, size and possession limits.

Introduction:

Four species of mud crab have been identified from the Indo-West Pacific region, with two species found in Northern Territory waters. *Scylla* serrata dominates the NT commercial catch (approximately 99%) and *Scylla olivacea* accounts for the remainder.

The fishery operates in tidal waters from the Queensland border to Western Australia and is managed by the NT commercial, recreational and indigenous fishing activity for mud crabs, confined to coastal and estuarine areas. All NT waters are generally open, although fishing activity may be restricted in certain areas, such as Aboriginal lands or waters, Aquatic Reserves and National Parks.

Since 1984 the fishery has been actively managed, with a Management Plan first introduced in 1991. Amendments were made to the Plan in 1993 and 1995 and in 2000, a formal review of the Plan was commenced. The Mud Crab Fishery is the Northern Territory's most valuable wild caught fishery, valued at $13 million in 2000.

The first survey of recreational fishing activity in the NT was conducted in 1995. FISHCOUNT estimated the NT recreational harvest of mud crab to be approximately 52,000 animals or 48 tonnes. A second survey is currently underway and results are expected in early 2002.

Stock assessment workshops were held in 1996, 1999 and 2000 to provide advice on the status of NT mud crab stocks. Professor Carl Walters, an internationally recognised expert on fisheries matters, led the reviews in 1996 and 2000 and found that based on available data and documented current fishing practices, the fishery although heavily exploited, was unlikely to suffer from recruitment overfishing.

Profile of the Fishery:

Commercial
The fishery is limited to 49 fully transferable licences. Each licence holder is entitled to use a maximum of 60 pots that must comply with specified dimensions and construction materials.

Crabbers generally operate from 5 m aluminium dinghies powered by 40 to 130 horsepower, two or four stroke outboard motors, depending on loads and distances travelled. Crabbers may travel in excess of 100 km to set their pots and then often stay in the vicinity for a number of days before returning to their base to unload the catch.

Crab pots are baited with fresh meat or fish and set in estuarine and coastal waters. Pots are generally checked on each daylight high tide and on some occasions, if tides and other conditions are favourable, they may be checked again at night using a spotlight. Pots are hand hauled and all crabs are checked for size and degree of 'fullness'. Crabs deemed to be commercially unsuitable are returned to the water at the point of capture.

Live mud crabs are stored in moist hessian lined crates and transported to Darwin at least weekly prior to onshipping to interstate and export markets. Most crabbing operations work from small, temporary, basic land-based camps. As yet electronic aids such as radar, sounder or GPS are virtually nonexistent, although HF radio communications are at times used.

The by-catch of non-target species is minimal for the mud crab fishery. Crab pots are highly selective towards large mud crabs due to the large mesh size used in their construction. Also the aggressive nature of mud crabs is likely to deter other animals from entering the pot. Commercial crabbers are also in some areas entitled to use a restricted bait net to catch bait specifically for their operation. Target bait species include catfish, blue salmon, shark and mullet. Other species may also be taken in small quantities as an incidental bycatch.

The NT Mud Crab Association has recently introduced a code of conduct for the commercial fishery. A number of changes to fishing operations and handling practices were introduced. Of greatest importance was the banning of harvest of "empty" crabs, now deemed as commercially unsuitable crabs. These are crabs that have recently moulted and have not fully grown into their new shell.

Catch and Effort
The 2000 NT commercial mud crab catch reached 1,037 tonnes and was valued at approximately $13 million. The Mud Crab Fishery is the most valuable NT wild harvest fishery representing approximately 40% of the total value of NT landings (excluding aquaculture). Catch and effort and CPUE data for the NT mud crab fishery are shown in Figure 1. Catches have continued to increase over the fifteen-year history of the managed fishery and preliminary figures for the year 2001 indicate that this trend is continuing.

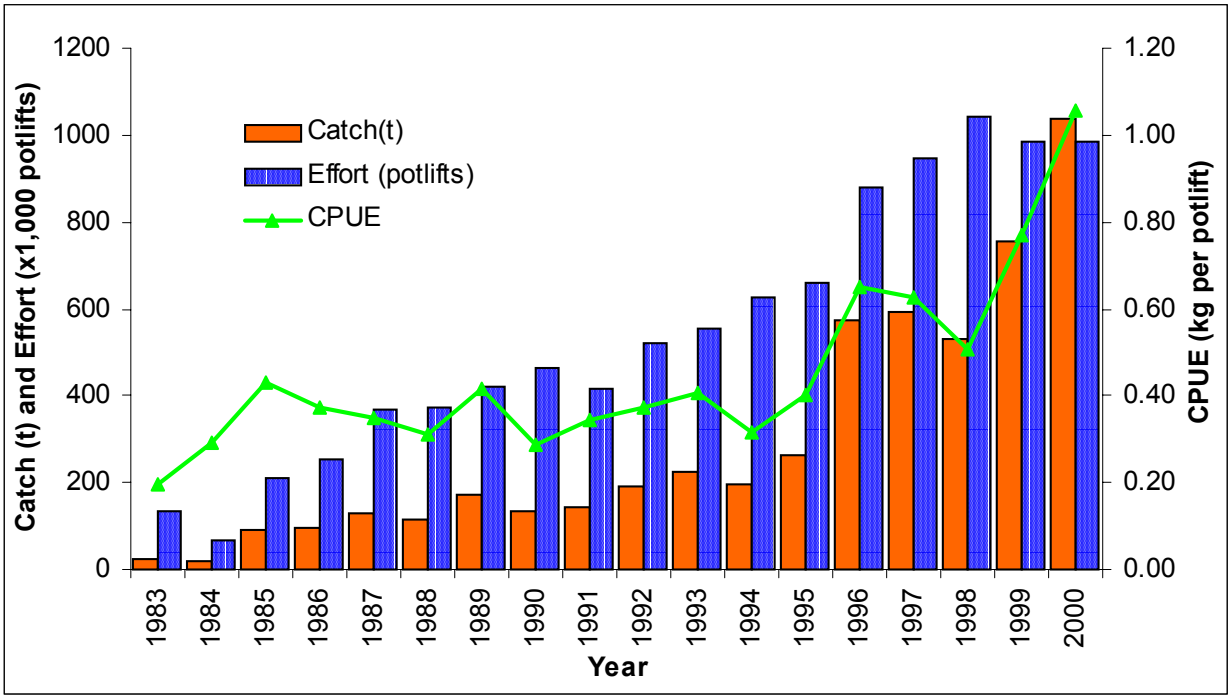


Figure 1. Catch and Effort NT mud crab fishery 1983 – 2000

There are no restrictions on the number of times per day a fisher can check or move each pot. With this in mind, fishing effort is recorded as pot-lifts. Effort has increased gradually over the past 10 years and has remained stable over the last five. Total effort in 2000 was reported at 983,524 pot-lifts compared with the previous five-year average of 967,336 pot-lifts, a difference of approximately 5 days fishing per licence across the entire fishery.

The major fishing areas for mud crab in the NT are the Borroloola region (McArthur River to Qld border), Roper River (Limmen River to Roper River), Darwin Area (Daly River to the Mary River) and Arnhem Land (East Alligator River to the Roper River). The Blue Mud Bay region, north of the Roper River, has historically produced only a small proportion of the catch; however recent logbook data report an increase in activity and associated catches. Negligible activity was reported on the western coast of the Territory. The majority of commercial fishing activity has concentrated in the remote south and western regions of the Gulf of Carpentaria with around 83% of the total commercial catch reported from this region.

Recreational

Mud crabbing is a popular recreational activity and provides entertainment and enjoyment to a large number of Territorians and visitors. Crabbing is often undertaken in conjunction with other fishing activities in coastal and estuarine regions. As such, a wide variety of vessels is used, although the specialised crabber prefers small dinghies. A licence is not required to enjoy recreational fishing, however the sale or barter of recreational catch is not permitted.

The majority of the recreational catch is taken using pots or dillies and the use of hooks and spears is also permitted. Fishing methods and techniques are similar to the commercial sector with most recreational crabbing occurring in the vicinity of the major coastal population centres of Darwin and Borroloola. Gear restrictions of five pots per person, or if two or more persons on a vessel, a maximum of 10 pots applies. An “in possession” limit of a maximum of 10 mud crabs per person applies with a vessel limit of 30 mud crabs if there are three or more people on the vessel.

Detailed historical information on the recreational catch of mud crabs in the NT is limited. The first survey of recreational fishing in the NT was conducted in 1995 (FISHCOUNT). It was estimated that recreational fishers landed 75,000 mud crabs throughout the survey period of which over 52,000 were retained - this is equivalent to around 40 to 50 tonnes. Darwin Harbour accounted for around 65% of the catch with 25% from the McArthur River region.

A comprehensive National Survey of Recreational and Indigenous Fishers (NSRIF) is being undertaken during 2000/01

Indigenous Fishing
Mud crabs are believed to be a significant food source for coastal indigenous Australians. Section 53 of the *Fisheries Act* guarantees indigenous people the right to utilise the fish and aquatic resources in a traditional manner. Indigenous people are entitled to use recreational fishing gear to crab, but spearing or hand harvesting is often utilised.

No information has been gathered on this sector, but the NSRIF 2000 survey will provide some details on catches taken by indigenous fishers.

Fishing Tour Operators (FTO's)
FTO's are licensed to conduct guided and charter fishing tours. Only recreational fishing gear can be used and the catch may not be sold, traded or bartered. The same pot and possession limits apply as for the recreational sector. FTO licences are issued free of charge, are not transferable and currently there is no limit on the number of licences issued.

Of the 150 licensed FTO's, none reported targeting of mud crab as their primary fishing activity in 1999, although operators will fish for mud crab for their clients on request in conjunction with other fishing activities. In 1999 reported catch was in the vicinity of one tonne with around 20 % of this figure released.

Aquaculture
Successful production of juvenile crabs from larvae is the focus of current research at the Darwin Aquaculture Centre and survival rates are approaching what may be considered economically viable.

Considerable work is still required on the commercial nursery production of mud crabs, the growout of large crabs and adult nutrition. However, it is anticipated that commercialisation of research results is possible and this project has now received additional support from the Fisheries Research and Development Corporation.

Research
The NT Mud Crab Research Program commenced in 1990. Over the past ten years a great deal of information has been collected on the growth, recruitment, migration and mortality of the mud crab. A sound understanding, of the biology of the target species and its interactions within the ecosystem, as well as the dynamics of all sectors of the fishery, are fundamental requirements in managing a fishery in a sustainable manner.

In 1996 Professor Carl Walters, a world-renowned stock assessment scientist, was consulted to lead an initial assessment of the mud crab fishery. Analysis methods used included general analysis of trends in the commercial catch and effort data combined with estimation of fishing mortality using swept area analysis and a relatively new habitat/density method. Seasonal patterns of recruitment and a fishery dynamics model were also used to confer estimates of fishing mortality. The workshop results estimated exploitation rate for this fishery was around 70 percent of the adult population. High exploitation rates are indicative of crab fisheries worldwide where species exhibit short life spans, early maturity and high fecundity.

Dr Walters' analyses were based on the response of the fishery to the estimated heavy exploitation in conjunction with species biological characteristics and current fishing practices. Another important finding was the confirmation that analysis of catch and effort data did not provide sufficient detail for realistic stock size estimation for this fishery. He strongly advocated the development of a fishery independent method of assessing this fishery.

In following recommendations of the 1996 assessment, a National workshop was held in Darwin in 1999 to re-assess current research. A major outcome of this workshop was the development of a five-year national strategy for mud crab research, recommending a number of strategies including the development of new methods to estimate stock size

Research in 2000
DPIF has been developing and testing techniques for the past three years using depletion and mark recapture methods. This work is about to be extended across the Territory and northern Queensland with the granting by the Fisheries Research and Development Corporation of $659,000 funding for a three-year

project. The project, titled “Methods to Estimate Abundance and Habitat for Northern Australian Mud Crab (*Scylla serrata*)”, aims to firstly map critical mud crab habitat using remote sensing technology and then estimate the abundance of animals per unit of habitat, resulting in an estimate of stock size. The work was due to start in January 2001.

As part of the ongoing Fishery Monitoring Program, biological data is recorded from the commercial catch on a monthly basis. This included carapace width, sex, stage of maturity, moult stage and weight from 100 animals from each of the four most heavily commercially fished regions (Adelaide River, Roper River Blue Mud Bay and McArthur River). Based on this limited data, there does not appear to be any significant trend in the median carapace size of the catch sampled.

A follow-up workshop to the one undertaken in 1996 was held in Darwin in August 2000 to review the research directions, update and analyse work that had been undertaken since 1996. Dr Walters was again invited to lead the review. Results of the analyses undertaken indicate that the high catch rates reported over the past four years were not solely caused by increased fishing effort. Dr Walters suggested that such increases were due to consecutive episodes of unusually high recruitment caused by favourable environmental conditions. He also stated that it is unlikely that such high catch rates would be maintained and catches may well return to previous levels in the future. For this reason it was strongly recommended that fishing effort should not be permitted to increase, as this may result in overfishing.

A Fishery Assessment Report outlining research in more detail has been completed in 2000 and is available from DPIF publications.

SUBPROGRAM: Offshore Marine Fisheries

Spanish Mackerel *(Scomberomorus commerson*) 2000	**Project Officers: R. Buckworth and C. Bryce**
Main Features	
Fishery Status or Development Stage:	Near full exploitation.
Stock Assessment Reliability:	Low as available data provides insufficient information about stock status.
Stock Assessment Method:	Analysis of time series of commercial catch and effort data and age and size structure data, using age structured dynamic models of the mackerel fishery, with some data from the historical Taiwanese fishery. Surplus production and delay difference models have also been used.
Commercial Harvest 2000:	301 tonnes (Spanish mackerel in the troll fishery only)
Value of commercial harvest (including byproducts):	~ $1.4m, based on the ex-vessel price
Annual average based on most recent five-year trend (commercial):	Catch: Rising, average 256 tonnes Effort: Stable 753 fishing days
Recreational Harvest 2000:	Not known; 1995 estimated recreational catch of 25000 fish of all *Scomberomorus* species
Total number of commercial licences issued:	18
Number which took 90% of catch:	9
Number of licensed fishing guides (catching Spanish mackerel):	57 (catching 2,919 Spanish mackerel)
Management Arrangements:	The number of commercial fishery licences is limited with new entrants acquiring and surrendering two existing licences or a licence that has been issued on the surrender of two licences. Possession limits apply to recreational fishers.

Commercial Fishery:

Background
The commercial fishery is managed by input controls. The fishery was restricted to only 28 licences when it was declared in 1991. Additionally, in order to reduce the capacity of the fishery, these licences have been subject to a “2 for 1” trading restriction. Under this scheme, new entrants must acquire and surrender to DPIF two existing Spanish mackerel fishery licences, or alternatively, secure a licence that has previously been issued on the surrender of two licenses.

The Spanish mackerel fishery is a hook and line fishery. The main fishing method is trolling, in which a number of baited hooks or lures are towed behind a moving boat, at speeds of 3-6 knots. Operators are permitted to use a mother vessel, containing catching and processing facilities, together with two dories (these are smaller craft, typically 5-6 m long). Two to four lines are towed behind a dory and up to eight lines from a mother vessel. To provide bait for mackerel fishing, each licensee is also permitted to use a restricted bait net (a seine net with length of 200 m, a drop of 2 m with a mesh size of 55 mm) in coastal waters.

Most fish taken in the commercial fishery are between 4-6 years of age, and around 1 m in length. Substantially larger fish (>30 kg) are occasionally landed and there have been reports of fish as large as 100 kg and exceeding 2 m in length landed interstate. Males are usually smaller than females of the same age, and females achieve the largest sizes. Fish are ready to spawn as young as two years of age, so that most fish have the opportunity to spawn several times before being fully subject to the commercial fishery.

Fish are usually processed to frozen fillets or trunks, on-board the mother ship. In recent years there has been a growing market for fresh (chilled on ice) product, including whole fish. The product is typically shipped interstate, after being landed in Darwin.

The management regime also sets by-catch limits for the shark fishery, the demersal fish trawl fishery and the northern prawn fishery, in which incidental catches of Spanish mackerel are made.

Catch and Value

Although Spanish mackerel has probably been fished in the north of Australia since it was first settled, the earliest commercial catch figures (from 1960s and 70s) suggest only minor volumes were landed until the early 1980s. Poor prices in the mid 1980s ($2.20/kg for frozen fillet, landed price) caused the fishery to contract, but increasing demand through the late 1980s saw the troll fishery increase steadily. Prices for frozen fillet have frequently exceeded $9/kg during 1999 and 2000. Substantially higher prices may be achieved for chilled product and in spot markets.

Fishing Effort

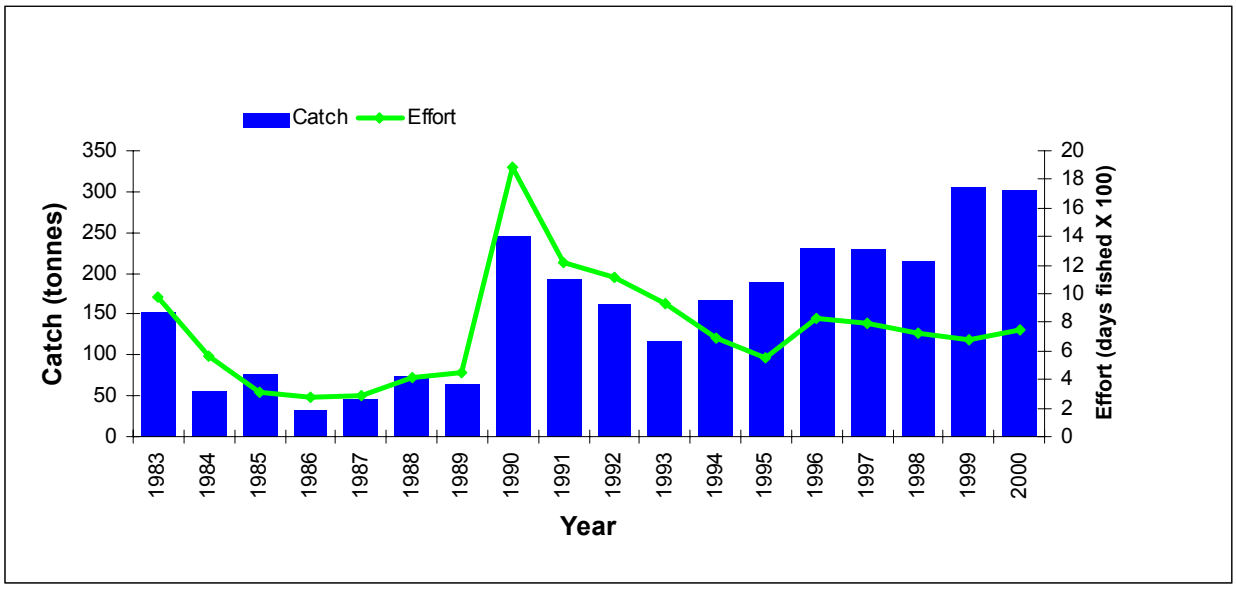


Figure 1. Catch and effort for NT Spanish mackerel fishery (1983-2000)

Fishing effort in the commercial troll fishery is recorded as days fished, although some operators provide daily logbooks that precisely indicate fishing time, and monthly logs indicate the typical number of hours fished per day. Total effort in the fishery peaked at 1887 days fished during 1990. At more than double the annual average effort of the late 1990s (1996-2000 average of 753 days fished), the 1990 effort reflected rising prices, and response by fishers to the proposed changes to management arrangements. The 2000 effort of 752 days was at the five-year average, increasing by about 10% over 1999 but yielding a slightly lower catch. There are indications in the logbook data that fishing operations have changed fishing strategies and technology, so that the impact on the fished stock of a day's fishing may have changed over the course of the fishery. This will be the subject of future analysis.

By-catch

The observed by-catch of non-target species is very low. This is due to the very selective nature of the fishing operation, and targeting practices. This by-catch is typically grey (also known as broad barred) mackerel (*Scomberomorus semifasciatus*), long tail tuna (*Thunnus tonggol*), coral trout (*Plectropomus* spp.) cobia (*Rachycentron canadus*) and various trevallies (*Carangidae*).

Habitat issues
Spanish mackerel is typically caught around reef fringing headlands and shoals. Spanish mackerel adults are thus found offshore. However, juveniles are found in estuarine and near shore conditions (such as mangrove creeks) and thus are dependent on the quality of these habitats.

Environmental Influences
Recruitment and production (the combination of growth and survival) of Spanish mackerel is likely to vary with productivity of inshore and oceanic waters. There has yet to be an investigation of such relationships.

Recreational Fishery:

Background
Spanish mackerel is a valued light game fish, pursued for its fighting response to bait and lure, and for its excellent table qualities. Fishing tourism and guiding is a rapidly developing sector of the fishery. Commercial fishing guides are required to be licensed and to submit detailed logs of fishing activity. Catches recorded by fishing tour operators (FTOs) have increased substantially in recent years to about 3000 fish. Around 64% of these fish are released.

The recreational fishery is regulated by means of a possession limit, currently set at five fish per person per day. There are no size restrictions for Spanish mackerel in the NT.

Research Activity 2000:

Stock Assessment
Stock assessment of Spanish mackerel relies on analysis of trends in the commercial catch and effort data. Auxiliary information is provided from sampling of catches for length and sex composition. Daily logbooks (a subset of the commercial fishery information) provide mean size information by fishing session. Additionally, samples of otoliths (ear bones) are taken to provide information on age structure. Assessments during the early 1990s, 1997 and 2000 were limited by the poor information content of catch and effort data. Age structure data supports a hypothesis that the fishery has been recovering from heavy fishing by Taiwanese gillnetters during the 1970s and 1980s, explaining increases in CPUE during the late 1990s and the absence of older fish in the age structure data collected in the early 1990s. There is also some genetic evidence for this hypothesis. Modelling suggests that current harvests are near the limits of sustainability: the increasing CPUE of recent years and age structure information are consistent with the fish population recovering but the extent to which the population might continue to grow cannot be determined from existing information. It is important to note that, without alternative information on harvest rates to constrain our models, it is possible that the increasing trend in catch rates of recent years really reflects increasing efficiency of operators, and/or trends in environmental factors.

Monitoring:

Fishery Monitoring
As well as compilation and analysis of catch and effort statistics, length composition and reproductive status data were collected on samples of nearly 2000 fish during 2000 (these represented about 7% of the landed catch). In a cooperative program, such information is collected by researchers onboard commercial vessels, or by their crews. Species, sex and size composition information is also gathered opportunistically at recreational fishing competitions. This information is summarized in Buckworth and Clarke (2001). It is planned that a tagging program will also be developed as a method of tracking harvest rates.

Fishery Independent Monitoring
There has been no fishery independent monitoring of the Spanish mackerel fishery - the species is not amenable to most methods of survey.

Biological Research:

For Spanish mackerel, most of the basic biology - growth, diet, reproduction - is well known. However, stock structure – the degree to which fish mix together over spatial scales, has been largely unknown. Thus the extent to which fishing in any one area of northern Australia might affect fishing in another, by either taking part of a highly migratory stock, or by impacting on the production of larvae, is unknown. Thus the scale at which management should be set has really been unknown. In response to growing fisheries in the NT,

Queensland and Western Australia, FRDC has funded a project to examine the stock structure of *Scomberomorus commerson* in northern Australia, over the period 1998 to 2001. A collaborative project between DPIF, Fisheries WA, QDPI and the University of Queensland, the study is using information from samples taken from across the north of the continent.

Material from samples provides for the analysis of parasite loads, genetics and the chemical composition of otoliths. Initial results indicate that Australian *S. commerson* from northern Australia are indeed composed of a mosaic of sub-stocks, in which animals separated by as little as a few hundred kilometres are very unlikely to mix. On a seasonal scale, some males may mix with adjacent sub-stocks. There is some gene flow between stocks, which might be maintained by the movements of only a few animals between stocks. This hypothesis accommodates the observed long-range movements of some animals in tagging studies, but could also include movements of larvae.

Genetic analyses have shown a substantial reduction in genetic variation over the last two decades. This is also consistent with a large reduction in population size by the foreign fishing of the 1970s and 1980s. Further collaboration between the northern administrations, for the development of tagging protocols appropriate for Spanish mackerel, was initiated.

TIMOR REEF FISHERY 2000	**Project Officers: J. Lloyd, C. Tarca and C. Errity**
Main Features	
Fishery Status or Development Stage:	Fully exploited
Stock Assessment Reliability:	Medium/low
Stock Assessment Method:	Analysis of time series of commercial catch and effort data. Age structure, surplus production and delay difference models.
Commercial Harvest 2000:	397.9 tonnes
Value of commercial harvest (including byproducts):	$2.1m
Annual average based on most recent 5-year trend (commercial):	Catch: fluctuating average 359 tonnes
Recreational Harvest 1999:	nil
Total number of commercial licences issued: Number which took 90% of catch:	15 5

Commercial Fishery:

Background
The Timor Reef fishery is located approximately 150 nautical miles to the north and northwest of Darwin and extends to the outer limit of the Australian Fishing Zone (AFZ), (Figrue 1). The target species of the Timor Reef fishery is Goldband snapper which accounts for 57% of the total catch. Other significant commercial species are sharptooth snapper, saddletail snapper, red emperor, red snapper and a variety of cods.

Traps have now replaced droplines as the preferred fishing method, with the majority of operators having converted their operations to traps this year.

Catch and Value
The total catch of the fishery this year is almost double that of 1999. It is thought that this is mainly due to the change of fishing gear to traps. The value of the Timor Reef fishery for 2000 was approximately $2.1 million, with the majority of fish consigned to the whole fresh fish markets in Brisbane and Sydney. A complete overview of landings by Timor Reef fishers is provided in Figure 2.

By-catch
There is very little by-catch, less than 1 % of total catch in this fishery, as operators target snapper by recognising their ‘marks’ on the sounder.

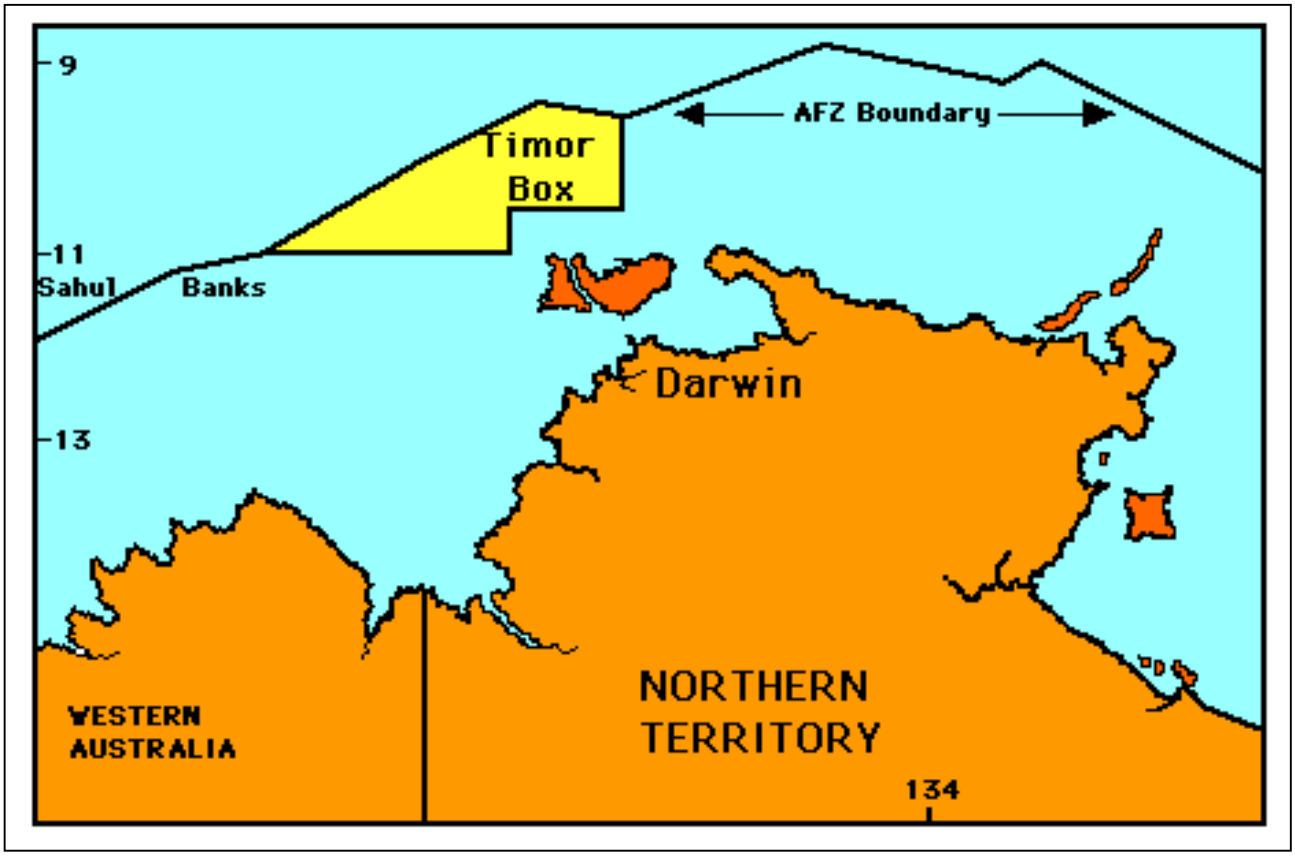


Figure 1. Timor Reef Fishery

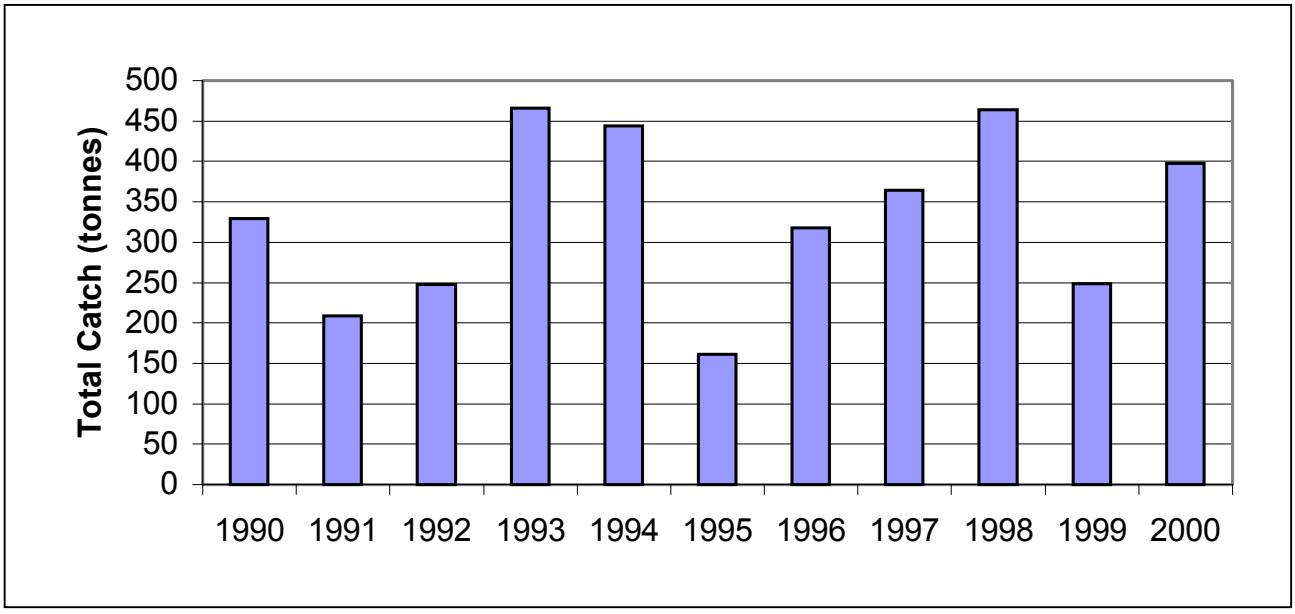


Figure 2. Catch for the Timor Reef fishery for the period 1990 to 2000

Research Activity 2000:

Stock assessment

Professor Carl Walters of the University of British Columbia conducted a stock assessment workshop in August. He was engaged as a consultant to the Northern Territory Fisheries Division to conduct a review of the major fisheries. This review involved industry participants (both Northern Territory and Western Australia) together with scientists and managers from Northern Territory, Western Australia and Bureau of Resource Sciences. All available information was drawn together, including details about Indonesian effort from foreign

fishing observers in the region immediately adjacent to the Timor Reef fishery. Previous assessments were reviewed and further assessments were undertaken using models assembled by Prof. Walters. Full details of this assessment are presently being written up and will be available as a Fisheries Report in the near future.

Monitoring
Monitoring of the Timor Reef fishery has been conducted on commercial boats since 1990. While onboard, officers document fisheries practices, catch composition and, where possible, measure all commercial species.

Biological Research
Indonesia and Australia share gold band and red snapper resources in the Timor and Arafura Seas. Therefore in order to obtain a better understanding of the biology of these species, together with the stock structure and dynamics, a collaborative ACIAR funded project with NT, CSIRO and Indonesia was initiated in 1999. This project is focused on Goldband snapper (*Pristipomoides multidens*) and red snappers (*Lutjanus malabaricus, L. erythropterus*) stocks of northern Australia and eastern Indonesia, and now East Timor. Monthly samples have been obtained since April 1999 for biological research. Otoliths are removed, sectioned and read to provide growth information, and gonads are initially staged macroscopically, then histology is undertaken to provide reproductive information.

SUBPROGRAM: Aquatic Pest Management

PROJECT: Monitoring

Project Officers: A. Marshall, S. Sly and T. Williams

Location: Northern Territory

Objective:

- ***To develop and implement management strategies designed to minimise the potential risk of the introduction of aquatic pest species in view of protecting biological diversity, aquaculture, commercial and recreational fisheries, marina, defence, port and tourism industry interests.***
- ***To monitor the marinas and Northern Territory international ports for incursion of aquatic pests.***

Background:

The invasion and eventual eradication of the black striped mussel, *Mytilopsis sallei* from Darwin marinas highlighted the potential threat that an aquatic pest invasion poses to our environment, aquaculture, fisheries, tourism and port industries.

In light of the cost associated with the eradication of the bivalve (in excess of $2.2 million) and the adverse flow-on effects to the economy, marina owners and the fishing industry requested the Northern Territory Government introduce measures to minimise the chance of similar events recurring.

Along with the vessel inspection program, a monitoring program was established, funded in part by Coast & Clean Seas Program, to detect early stages of aquatic pest invasion and to develop a greater understanding of the water quality and biodiversity dynamics of Northern Territory marina systems. At present, published literature on the subject is limited.

Monitoring will assist the effort to detect pests and record the recovery of the three marinas after their chemical treatment for black striped mussel eradication. The concurrent monitoring of a newly filled marina provides an opportunity to assess the resilience of marina ecosystems and the processes of colonisation of newly created marine niches in the tropics.

Results/Discussion:

No recognised aquatic pests were detected in the marinas over the period of sampling.

Eighteen months of intensive water quality and biological diversity monitoring after chemical treatment in the marinas has provided comprehensive baseline data for the three established marinas and documented the colonisation of Bayview Marina Estate which was not chemically treated. Intensive monitoring of Bayview Marina Estate will continue for a further 12 months since the current species diversity in the marina differs significantly from that recorded from the three established marinas.

Concurrent monitoring of copper levels from chemical treatment in the marina has indicated a continued slow exponential decline in levels approximating natural background levels in Darwin Harbour.

The monitoring conducted in the Darwin Harbour has not been quantitatively assessed to the same degree as the marinas. Initial data collected from the marina and open water plates as part of the Coast and Clean Seas Program supports the intuitive notion that greater species diversity persists outside the marina environs. The Port of Darwin (POD) Survey provides the basis on which the appearance of exotic species can be judged. However, the POD survey does not fully elucidate seasonal variation in species diversity.

A sample of results from the Coast and Clean Seas funded monitoring project are presented below. Water quality in marinas varied according to season and was greatly influenced by Wet season runoff. The two

figures below indicate the variation of temperature and salinity over 12 months of sampling. Although not indicated on these figures, results recorded for the Coast and Cleans monitoring project highlight the variation of salinity between the surface and bottom levels of the marina reflecting the impact of fresh water runoff received over the Wet season. Fresh water being lighter and less dense than sea water sits over the heavier more dense sea water. Such environmental conditions provide a hostile environment for native species but can provide invasive opportunities for more tolerant exotic species.

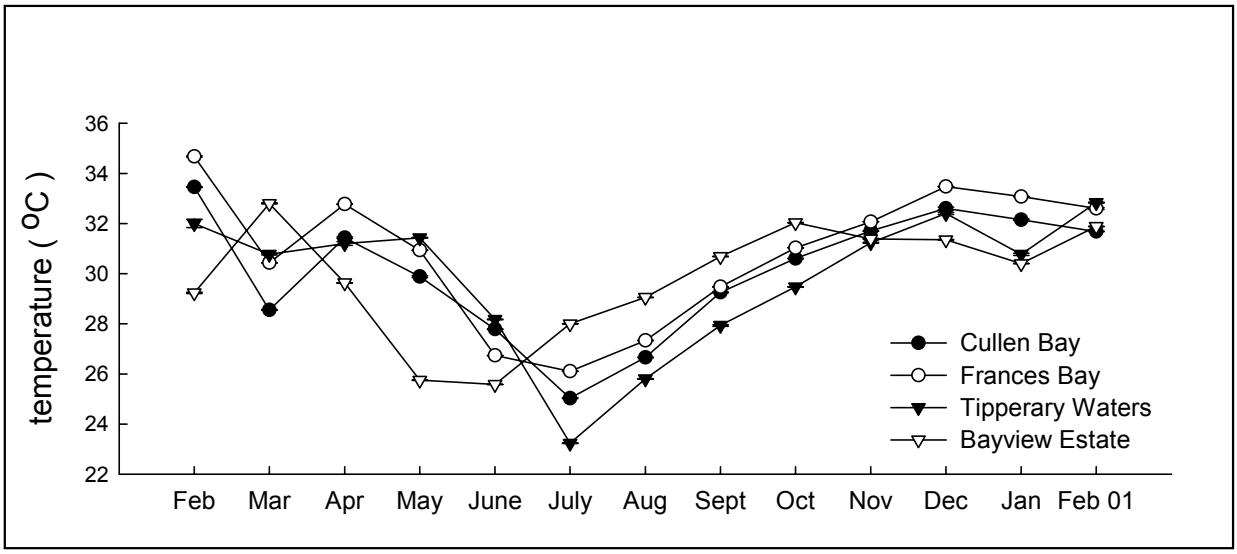


Figure 1. Mean monthly surface temperature (^{o}C) levels for the four marinas from February 2000 to February 2001

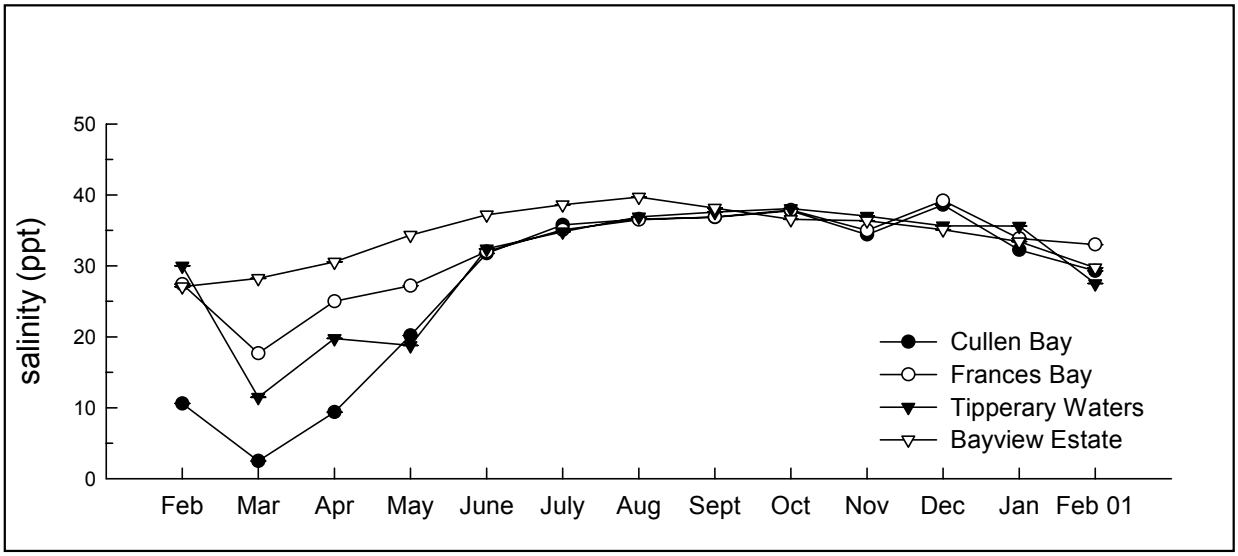


Figure 2. Mean monthly surface salinity (ppt) levels for the four marinas from February 2000 to February 2001

Table 1. Biodiversity of species discovered on settlement plates in the four marinas and Darwin Harbour open water sites.

HIGHER TAXA	Total Species	Cullen Bay Total	Frances Bay Total	Tipperary Waters Total	Bayview Total	Open Waters Total
Kingdom Protista	3 species	3	2	2	2	1
Kingdom Plantae Phylum Chlorophyta Phylum Rhodophyta	24 species	12	13	11	14	18
Phylum Porifera	7 species	4	2	2	4	5
Phylum Cnidaria Class Hydrozoa	6 species	3	2	2	4	4
Phylum Annelida Class Polychaeta	8 species	5	5	4	6	3
Phylum Mollusca Class Bivalvia	9 species	4	3	3	4	5
Phylum Bryozoa	21 species	9	5	7	8	11
Phylum Crustacea Class Maxillopoda	6 species	5	4	4	4	5
Phylum Chordata Class Ascidiacea	19 species	9	5	5	7	12

Over 100 species of organisms were detected from settlement plates distributed in the marinas. Biodiversity varied according to season, depth and plate positioning (vertical or horizontal). The Coast and Clean Seas report and follow up technical reports will discuss these relationships in greater detail.

Conclusion:

Early recommendations for marina management include:

- A continuation, at a reduced scale, of water quality monitoring and aquatic pest monitoring;
- A continuation of inspection of international yachts prior to entry to the marina as being recognised as potential vectors for aquatic pests; and
- Increasing in flushing (water exchange) over the Wet season, and if possible, implementation of water flow systems to reduce stratification (water layering) which will enable water quality to return to more preferable background levels that are less favourable for the introduction of aquatic pests.

High traffic areas in Darwin Harbour are due to increase with increasing use of the International Port at East Arm in conjunction with the completion of the national railway link. Vigilance in the greater Harbour area is of particular importance to obtain information on what constitutes natural assemblages to facilitate the better recognition of exotic species.

PROJECT: Vessel Inspection

Project Officers: A.Marshall, S.Sly and T.Williams

Location: Northern Territory

Background:

Following the success of the black striped mussel eradication campaign of April 1999 the Aquatic Pest Management Program (APMP) was established in recognition of the threat exotic species pose to the marine environment of the Northern Territory, and the vulnerability of Darwin marinas to invasion by exotic pest species. Consultation with fishing industry members, marina owner/operators, and ship repair and

maintenance facilities resulted in the development of interim protocols to minimise the risk of an incursion of exotic aquatic pests similar to that of the black striped mussel recurring in Darwin's four marinas.

Cabinet approved a $20,000 per year contribution toward the cost of the inspection of vessels wishing to enter Darwin marinas during the financial years 1999/2000 and 2000/2001.

In August 2000, the threat posed by apprehended vessels brought into Darwin Harbour became apparent during a routine Darwin Harbour diver survey when black striped mussels were discovered on the hull of an apprehended foreign fishing vessel. Subsequent negotiations with the Department of Immigration and Multicultural Affairs, the Australian Fisheries Management Authority, the Australian Customs Service, Coastwatch and the Royal Australian Navy resulted in the development of inspection protocols designed to minimise the risk of apprehended vessels introducing aquatic pest species into Northern Territory waters. The APMP provides the only border control protection against the introduction of aquatic pests from international boating traffic.

The project is resource expensive to the Aquatic Pest Management Program hence the desire to train third party inspectors to facilitate the adoption of an auditable, privately run cost recovered inspection service. The development of a specific training package is incorporated within the public education project.

In addition to the current inspection protocols that are in place for vessels wishing to enter Darwin marinas and those apprehended by Commonwealth agencies, there is a need for further research in conjunction with the Port Corporation and ship repair and maintenance facilities. This will help to determine the level of risk associated with other vessel classes entering the waters of the Port of Darwin. Once such risk is identified, procedures will be developed and implemented.

Increased commercial traffic resulting from the development of the East Arm Port facility, railway, and gas pipeline increases the risk of exotic species entering Northern Territory waters.

The introduction of the AQIS Decision Support System sometime during 2001/2002 will not address the issues of non-ballasted vessels and as such any vessel inspection protocols developed and implemented by the APMP represents Australia's sole defence against the introduction of aquatic pests via boating traffic. As such other States are looking to the Northern Territory for guidance on policy that works to exclude aquatic species, which can be introduced by international boating traffic.

Results:

The vessel inspection program has processed a total of 364 vessels since its inception in May 1999. The number of vessels processed during 2000/2001 increased by 160% from 134 to 252.

A strong seasonal influence is obvious as approximately 80% of total vessels are inspected during the Dry season between April and September, reflecting the prevailing favourable sea conditions (Figure 1).

A total of 197 yachts, 26 trawlers and five other vessels were inspected. The five other vessels included three defence craft serving Timor, one floating hotel from Timor and one oil rig. Of the 263 vessels inspected only 13 yachts were quarantined as a result of unidentified bryozoans on their hulls.

The average cost recovered from the relevant Commonwealth agency for the inspection of an apprehended vessel at Buoy No 5 outside of Darwin Port limits was $771.60. Three of the 35 apprehended vessels inspected were found to be infested with black striped mussels. All three vessels were Iceboats from the Province of Probolinggo, Indonesia (Figure 2).

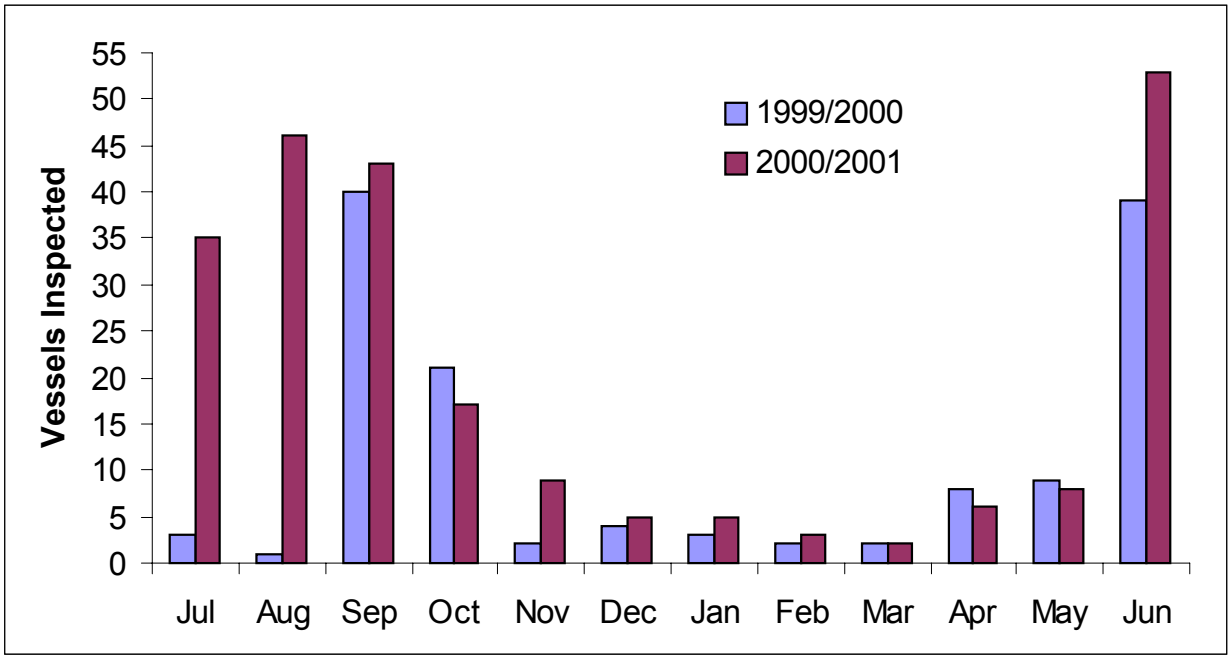


Figure 1. The number of vessels inspected in each calendar month for the financial years 1999/2000 and 2000/2001

Figure 2. Indonesian type 3 Iceboat from the Province of Probolinggo

PROJECT: Freshwater Pest Species

Project Officers: A. Marshall, S. Sly and T. Williams

Location: Northern Territory

Objective:

To protect Northern Territory inland waters by preventing the establishment of exotic aquatic pest species through legislation, public awareness and eradication operations.

Justification:

During 1999/2000 three exotic species were recognised as a threat to biological diversity in Northern Territory freshwaters. As a consequence the issue of freshwater pests is emerging as an additional responsibility of the Aquatic Pest Management Program (APMP).

APMP accepts the role of coordination in the event of a requirement for small-scale control of invasive fresh water and marine species; however the program relies on the cooperation of the Fisheries Division as a whole in addressing aquatic pest incursions.

The control and eradication component of the APMP represents the first level of response to a pest infestation.

Background:

Prior to the establishment of APMP, staff from Fisheries Research undertook the eradication of exotic fish. Since its inception, the role of APMP has incorporated the management of exotic freshwater species both faunal and floral. In this capacity, APMP has been instrumental in the eradication of at least three established populations of exotic freshwater species: the jewel cichlid, guppies and mosquito fish.

Eradication of the Jewel Cichlid

The jewel cichlid (*Hemechromis bimaculatas*) is a native of Africa and a prohibited import to Australia. The exotic fish is a prolific breeder and highly competitive and effective at displacing native species. Destruction of the population was essential to ensure maintenance of native biological diversity and discourage translocation by inquisitive individuals. The cichlid population was resident in the drainage channel of the Royal Darwin Turf Club, known locally as “Racecourse Creek”. It is thought that the original fish may have been introduced to the water body by some well meaning member of the public who did not realise they were in possession of an illegal fish. The individual would no doubt have been ignorant of the potential harm the exotic species could cause to the pristine natural waterways of the Northern Territory.

In October 2000 DPIF staff, in collaboration with the Turf Club and staff from the Museum and Art Gallery of the Northern Territory, used the biodegradable natural pesticide rotenone to kill all fish in Racecourse Creek. An estimated total of 1 500 dead fish were removed from the 4-km length of waterway. Approximately 30% of the fish were native species: oxeye herring (*Megalops cyprinoides*), empire gudgeon (*Hypseleotris compressa*) and red-tailed rainbow fish (*Melanotaenia splendida australis*) accounting for about 10% of the biomass of fish removed. The remaining 70% of fish, which accounted for approximately 90% of biomass, were estimated 1000 jewel cichlids (*H. bimaculatus*) and 200 guppies (*Poecilia reticulata*). Although jewel cichlids were the target species, it was an extra bonus to eradicate the guppies from the waterway.

In February 2001 APMP restocked Racecourse Creek with native red-tailed rainbow fish and emprire gudgeons, sourced from a genetically similar population, to assist the establishment of a natural food web and thus keep mosquito numbers under control.

No further populations of exotic freshwater fishes have been recognised in Racecourse Creek.

Eradication of Mosquito Fish

In April 2001 an extensive program was undertaken in Alice Springs to eradicate a number of isolated populations of the mosquito fish *Gambusia* species from back yard ponds after an initial population resident in Ilparpa Swamp was eradicated with the assistance of Alice Springs Regional Waterwatch Coordinator, Robbie Henderson.

It was following publicity on the Ilparpa *Gambusia* sp. eradication exercise that local residents came forward declaring populations of the noxious species in their own backyard ponds. APM staff visited Alice Springs to coordinate the eradication exercise. *Gambusia* sp. was eradicated from two backyard ponds and the Todd Street Mall Church pond by using a combination of biodegradable poison (rotenone) and pumping the water dry.

Gambusia sp. is a prohibited introduced pest that has similar invasive characteristics as the Jewel Cichlid *H. bimaculatus*. It is believed that *Gambusia* sp. was originally introduced into Australia as a mosquito control fish. However, it has proven ineffective in mosquito control and only serves to displace and out compete our native species for food and space. The primary concern was the possibility of translocation of *Gambusia* sp. into the local catchments such as the Todd or Finke where it could threaten our native fish stocks.

After the successful eradication exercise APMP increased public awareness through advertisements and news articles in addition to the distribution of flyers. At this stage no more reports have been received of sightings of *Gambusia* sp.

Conclusion:

Aquatic Pest Management will continue to respond to aquatic pest sightings and attempt to eradicate any aquatic pest species. In addition, the APMP will promote public awareness of the problems associated with the introduction of exotic fish and the importance of not releasing aquarium fish into our local waterways. Brochures and posters will also be developed highlighting those feral fish that should be reported.

PROGRAM: Aquaculture

SUBPROGRAM: Crustacea

PROJECT: Mud Crab Aquaculture - FRDC Project 'Development of Commercial Production Systems for Mud Crab (*Scylla serrata*) Aquaculture in Australia: Part 1 Hatchery and Nursery

Project Officers: **C. Shelley, G. Williams, I. Ruscoe, R. Naylor and C. Moir**

Location: Darwin Aquaculture Centre, Channel Island

Objective:

To examine the feasibility of the commercial production of mud crab, Scylla serrata.

Justification:

If economical methods of rearing mud crabs can be developed, mud crab aquaculture will be an additional opportunity for existing or potential aquaculturists to diversify their production, or to set up facilities specifically for mud crab culture. Once the methods have been developed, producers will be able to target niche markets such as those for soft shell crabs, ovigerous females, "out of season" crabs, crab meat and supply of juveniles to overseas crab farmers, in addition to markets already established for the Australian mud crab fishery.

2000/2001 Results:

After the centre was relocated to Channel Island significant problems arising from the high silt and organic loading in the sea water were experienced. The poor water quality resulted in bacterial and fungal disease in the broodstock and led to a sharp decline in larval survivals. New protocols for water, broodstock and larval management were developed and have largely overcome these problems. Tanks for the maturation of females and the incubation of "berried" females are now on semi-closed recirculating systems equipped with foam fractionators, fluidised bed bio-filters and UV sterilisers.

The use of chlorinate to disinfect culture water for larval rearing has been discontinued and replaced with 5um filtered, settled and foam fractionated water in the new larval rearing protocol. Survivals from zoea 1 to megalop in small -scale experimental trials are now regularly over 65%. The main focus of research is to obtain similar high survival rates on a commercial scale.

The commencement of the FRDC mud crab aquaculture project was delayed six months to 1/1/2001 because of delays in staff recruitment and as a result of de-stocking crustaceans at the Darwin Aquaculture Centre. The project is now well under way and the milestones for the first six months have been met. A technician, Cameron Moir and a Ph.D. student, Maurice Pizzuto have been appointed to the project. Articles were published in *Aquaculture Asia* and *Territory Business* to publicise the project.

The company Proaqua has joined McRobert Aquaculture Systems and Seafarm in supporting the project by supplying the Aquamats™ required for the experiments.

In November 2000 it was discovered that imported green prawns that later tested positive for White Spot Syndrome Virus (WSSV) were inadvertently fed to the crab broodstock. As soon as this was discovered the entire area was de-stocked, disinfected and dried out. All crabs at the centre were destroyed as a precautionary measure. This included several family lines that had been reared from eggs. Feeding of any

prawns to the crab broodstock was immediately discontinued. Testing by CSIRO using enhanced PCR techniques did show that the imported prawns and some of the previously destroyed broodstock were positive for WSSV. Tests done on similar prawns purchased from a local bait outlet also tested positive to WSSV. Subsequent testing for WSSV on local farmed and wild prawns and crabs has shown no further positive results.

SUBPROGRAM: Finfish

PROJECT: Barramundi Aquaculture

Project Officers: **G. Schipp, J. Bosmans, D. Gore, F. Murakami, C. Kuo and B. Dalliston**

Location: Darwin Aquaculture Centre, Channel Island

Objective:

Support the development of barramundi farming and stocking of barramundi for recreational fishing by providing barramundi larvae and fingerlings to local and interstate clients.

Justification:

The NTG is committed to support the development of barramundi farming in the Northern Territory and has a contract to supply Pivot Aquaculture Ltd advanced barramundi fingerlings for grow-out at the company's cage farm site in Port Hurd, Bathurst Island.

2000/2001 Results:

Larval Production
Brood-stock barramundi at the Darwin Aquaculture Centre were successfully induced to spawn regularly between September 2000 and June 2001. Larvae were sold to Adelaide, Kununurra and Cairns.

Fingerling Production
Minister Palmer officially opened the new, dedicated barramundi nursery in November 2000. The production of the first batch of fingerlings through the nursery was completed by December 2000. Due to establishment delays at the Pivot sea cage farm the first production from the nursery was sold to local and Western Australian farmers.

The first delivery of fingerlings to the Port Hurd sea-cage farm took place on March 3 when 123,000 fish between 125 and 150 mm were loaded into Pivot's modified milk tanker and transported by barge to the cages. Further deliveries took place in April and May. Over 300,000 fish have been sent to the cages so far.

Brood-stock
The production problems experienced with the broodstock in 2000, when they failed to spawn, were overcome by improvements to the broodstock holding tanks. The improvements included better temperature control, addition of a foam fractionator on the re-circulation tank to reduce the organic load of the water and installation of a 'spare' broodstock tank kept 'off cycle'. That is, the tank was kept cool during summer and warm during the dry season. A physical barrier was installed to screen the broodstock tank from the rest of the hatchery. Since the introduction of these improvements the fish have been continuously in breeding condition for ten months.

PROJECT: Reef Fish Aquaculture

Project Officers: **G. Schipp, J. Bosmans, D. Gore, F. Murakami, C. Kuo and B. Dalliston**

Location: Darwin Aquaculture Centre, Channel Island

Objective:

Development of high value finfish, including copepod technology.

Justification:

To ensure the long-term viability of the Northern Territory finfish aquaculture industry, it is necessary to investigate other candidate species to give farmers the opportunity to diversify production and to meet market demands. The NTG has made a commitment to investigate new, high value, finfish species for aquaculture.

1999/2000 Results:

Experiments on the rearing of barramundi cod, *Cromileptes altivelis*, continued during 2000/ 2001. Investigations focussed on improving water quality and hormone therapy of male fish to assist their reproductive development.

Water Quality
Improvements were made to the broodstock holding tanks and filtration equipment to overcome problems with poor water quality. Following the relocation of the Aquaculture Centre to Channel Island, the existing filtration system could not cope with the high silt load of the seawater during monsoonal rains and spring tides resulting in turbid water in the fish holding tanks. During periods of poor water quality the barramundi cod had a reduced appetite and appeared lethargic.

An upgrade of the sand filter system resulted in a significant improvement in water quality and better health management for the fish.

Hormone Therapy
Most of our male fish were mature at capture and for the first month in captivity. After two years in captivity they had not re-matured. Also fish that had attained a size of 5.0 kg or more, and were supposed to have undergone sex inversion from female to male, had not shown any signs of maturing. In January 2001, we began a series of hormone treatments for the male fish. Several of the males were implanted with either silastic or cholesterol pellets containing 17 ⍺ methyltestosterone at 100 $\mu g.kg^{-1}$. By the end of June 2001, three of the males that had received a cholesterol pellet had matured, as had one of the silastic pellet treated males and two of the control (untreated) males. Maturation was evident by presence of active sperm in a biopsy sample. It is unclear at this stage whether it is the hormone or the improvement in water quality (or a combination of the two) that is having a positive effect.

SUBPROGRAM: Aquatic Animal Health Services

PROJECT: Development and Implementation of Aquatic Health Services

Project Officers: **J. Humphrey, K. Fomiatti, S. Walsh, L. Small, N. Elliott, N. Cox, S. Benedict, M. Barton, G. Schipp, G. Williams, S. Wilmore, R. Wilson and C. Day.**

Location: Berrimah Veterinary Laboratories and Darwin Aquaculture Centre

Objective:

To develop and implement disease diagnostic services and disease control programs to support aquaculture and fisheries in the Northern Territory

Justification:

Successful aquaculture depends on optimising production in a disease free environment. The maintenance of healthy farmed populations of fish and shellfish depends on the early detection of disease as a basis for control and treatment, as well as protection from introduced diseases through quarantine and health certification. This project supports current and future aquaculture in the Northern Territory through a program of disease diagnosis, health certification, quarantine and disease prevention and control.

2000/2001 Results:

Disease diagnostic tests have continued to be developed and expanded in pathology and histopathology. Bacteriological tests for the common marine Vibrionic bacteria have been implemented in collaboration with the Fish Health Unit, Mt Pleasant Laboratories, Department of Primary Industries, Water and Environment. Molecular based polymerase chain reaction (PCR) assays for the diagnosis of white spot syndrome virus (WSSV) have been developed and are in routine use. Electron microscopic capabilities are now available for ultrastructural diagnostic procedures. Further characterisation of a range of fish and shellfish parasites has been undertaken. A major development during the year was the attainment of certification in the area of fish diseases from the National Association of Testing Authorities (NATA).

Pre and post import conditions and testing for movements of fish, crustaceans and molluscs have been developed and implemented to decrease the risk of introducing or transferring disease in translocated species. Overall monitoring and surveillance activities for fish, crustaceans and molluscs have further defined the nature and geographic distribution of pathogens and parasites in the Northern Territory, as a basis for disease diagnosis and control and as a basis for quarantine.

PUBLICATIONS, CONFERENCE PAPERS AND PRESENTATIONS

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