

A HISTORICAL OVERVIEW OF AGRICULTURAL RESEARCH AT DOUGLAS DALY RESEARCH FARM

(1960s - 2010)

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Note on agency names: The name of the Northern Territory Government's agricultural, pastoral and land conservation departments have changed several times since the 1970s. When referring to past projects and documents, the name of the agency at that time is referred to.

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INTRODUCTION

The aim of this report is to document the Northern Territory (NT) Government's investment and progress in agricultural research at the Douglas Daly Research Farm (DDRF) over the past 48 years. The report provides a comprehensive record and overview of the large range of research projects that were carried out in response to the demand and development of the agricultural industry in the Douglas Daly region of the NT.

Although DDRF had served the agricultural sector of the Douglas Daly region for a long period, there was no prior long term record of the research activities carried out by DDRF. This report provides a useful overview of many research activities carried out and demonstrates the fundamental importance of the facility to the agricultural sector.

Results obtained from research projects have been presented and demonstrated to the public through various methods, including public field days, district "farm walks", organised visits from farmers, graziers and other interested visitors. Outcomes of the research were also published and made available to interested people and researchers through government publications, libraries, handout information, agricultural and other research journals, manuals and newsletters.

This report does not seek to compare and evaluate the outcomes of the research as this aspect is well covered in numerous publications. However, a comprehensive reference table of all trials and publications arising from research conducted on DDRF and within the Douglas Daly region by DDRF staff is included.

The report is presented in parts which outline the history of DDRF and the research carried out by various government departments and partner institutions.



Figure 1. Entrance to Douglas Daly Research Farm

1 DOUGLAS DALY RESEARCH FARM (DDRF)

DDRF is an NT Government research facility that was set up in the 1960s to investigate and research the development and extension of agriculture in the Top End of the NT.

DDRF is located 230 km south of Darwin (13°50'S, 131°11'E) and 220 km north-west of Katherine in the Douglas Daly region. The south and north-west boundaries of the property are represented by the Daly and Douglas rivers.

The Douglas Daly region has been recognised for many years as being a potentially valuable agricultural area within the NT. Its rainfall and soils have made it suitable for many aspects of agriculture, such as pastoral production, horticulture and agroforestry.

The NT Government established the research farm to explore the potential of the area and carried out trials to help the emerging agricultural industries within the district and beyond. The focus of agriculture within the Douglas Daly has changed over the years from cropping in the 1980s, intensive livestock production in the 1990s to a mixed diversity of agricultural industries in later years.

Research carried out on the farm has changed accordingly as the demand for new knowledge grew.

1.1 HISTORY OF DDRF

DDRF was first occupied as a temporary field research site in 1962-63 with the consent of the pastoral lessees. During September and October 1962, 3 ha were partially cleared and 1.6 ha were totally cleared for trials on cotton.

Limitations of the research area were the lack of permanent staff and access during the wet season. Trial crops were sown before the wet season and were only visited again once the rivers returned to normal resulting in no control over trials. As a solution, two staff members were located at the site during the 1963-64 wet season to monitor and maintain trials.

The site was formally proposed as a research facility in 1965 because of the large areas of Tippera, Blain and Florina soils and guaranteed water from the two perennial (Douglas and Daly) rivers (Saunders 1983).

In 1967, negotiations commenced with lessees of Douglas and Tipperary stations to sub-lease land for use as a research site and in 1968, 4020 ha formally made up the new DDRS on a 10-year sub-lease. This was renewed in 1978 for a further 10 years.

The Agricultural Development and Marketing Authority (ADMA) was formed in the late 1970s and agricultural land within the Douglas Daly region was made available for cropping. Grain production trials at DDRF were the main focus for the department during the early 1980s.

As part of the ADMA acquisition of land, 1250 ha of the research site was included in the development resulting in DDRF becoming smaller in size; however, it was no longer under any lease agreement. In later years, DDRF acquired more land and is currently under three land parcels: NT Portions 2640, 3425 and 2047.

The present size of the property is 3100 ha with approximately 2500 ha of cleared land, mainly for improved pastures with some wet season fodder and grain crops. The crop and fodder irrigation projects take up 80 ha. Paddock size ranges from 2 ha to 300 ha depending on trial types and land usage (Map 1).

The first permanent power source was installed in 1972. Accommodation, farm buildings and facilities gradually improved through the 1970s with permanent housing for staff constructed in 1982. The office and laboratory facilities were constructed in 1983.

Early research in the area was focussed around peanuts (*Arachis hypogaea*) and cotton (*Gossypium* spp.) as potential crops to grow in the Katherine – Daly basin. Various crops followed, such as sorghum (*Sorghum bicolor*); soybean (*Glycine max*); guar (*Cyamopsis tetragonolobus*); safflower (*Carthamus tinctorius*); maize (*Zea mays*); and sesame (*Sesamum indicum*) as well as introduced pasture species sown into cleared and non-cleared areas.

Since 1984, sentinel cattle herds have been used to identify any new arboviruses through the National Arbovirus Monitoring Program (NAMP). The sentinel herds are bled monthly with insects on the animals being collected. Light traps are used to collect insects from the surrounding environment for identification.

Animal performance and pasture sustainability were assessed under grazing using new grass and legume species. Cattle management, breeding, nutrition, reproduction, market requirements, grazing and carrying capacity trials have been assessed over the years to identify best management practices for the cattle industry.

The increasing live export trade also required fodder for cattle feed on boats and pre-loading yards resulting in the evaluation of hay and fodder crops to identify potential species for fodder production. The tropical twining legume Cavalcade (*Centrosema pascuorum*) was one successful species identified for wet season production, which led to several years of research on best management practices of this legume.

The change to the agricultural practices within the Douglas Daly in the 1990s, from cropping to cattle production, instigated the introduction of farming systems trials. These trials included both cropping and grazing practices which were assessed to find the optimum combination to improve productivity, soil properties and to help eliminate weed infestation.

The soil conservation trials - Crop Erosion Research Project (CERP 1985 to 1989) and Land Management Strategies for the Semi Arid Tropics (LAMSAT 1991 to 1995) were undertaken to monitor farming and grazing techniques. These trials assessed water and sediment movement associated with land management strategies to determine best practices to reduce soil loss and erosion. Both were collaborative projects between the Conservation Commission of the NT (CCNT) and later the Department of Lands, Planning and Environment (DLPE), Department of Primary Industry and Fisheries (DPIF), Queensland Department of Primary Industries (QDPI) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Soils Division.

An Irrigation Development Program began in 1996 in response to an increasing interest in using irrigation to produce field crops. This was partly due to the introduction of new centre-pivot irrigation systems in the Katherine-Daly Basin bringing the total of pivots being utilised to 24.

The NT Irrigators, Grain and Fodder Producers Association (NTIGFPA) and the department were actively promoting irrigation (especially in peanuts) as a viable alternative to wet-season farming. Prior to this period there were some small plot experiments conducted using irrigation in the mid to late 1980s. The focus of these experiments was mainly crop physiology rather than irrigation investigations.

More recent research has been centred on cattle, such as Brahman vs. Composites, Senepol crossbreeding, improved heifer performance and fertility, rotational grazing and continuation of the NAMP.

Crop and pasture research continues through the pasture evaluation trial, peanut varieties, bio-fuel evaluations and agroforestry.

As well as conducting scientific research trials, DDRF produces peanut seed under contract, quality hay, irrigated fodder and grain sorghum. Maize and grain legume crops are also grown as required. Cattle, including Brahman and Composite bulls, surplus heifers as well as export steers from the grazing trials are sold.

While agricultural research is the main priority for DDRF, other organisations and government agencies have used the facility as a base for staff and temporary accommodation for work and research carried out on the research farm and in the surrounding region. These organisations include the Bushfire Council of the NT, CSIRO, the Australian Geographic Society, Charles Darwin University (CDU), the NT Department of Natural Resources, Environment, the Arts and Sport (NRETAS), the Tropical Rivers and Coastal Knowledge (TRaCK) research group and interstate universities.

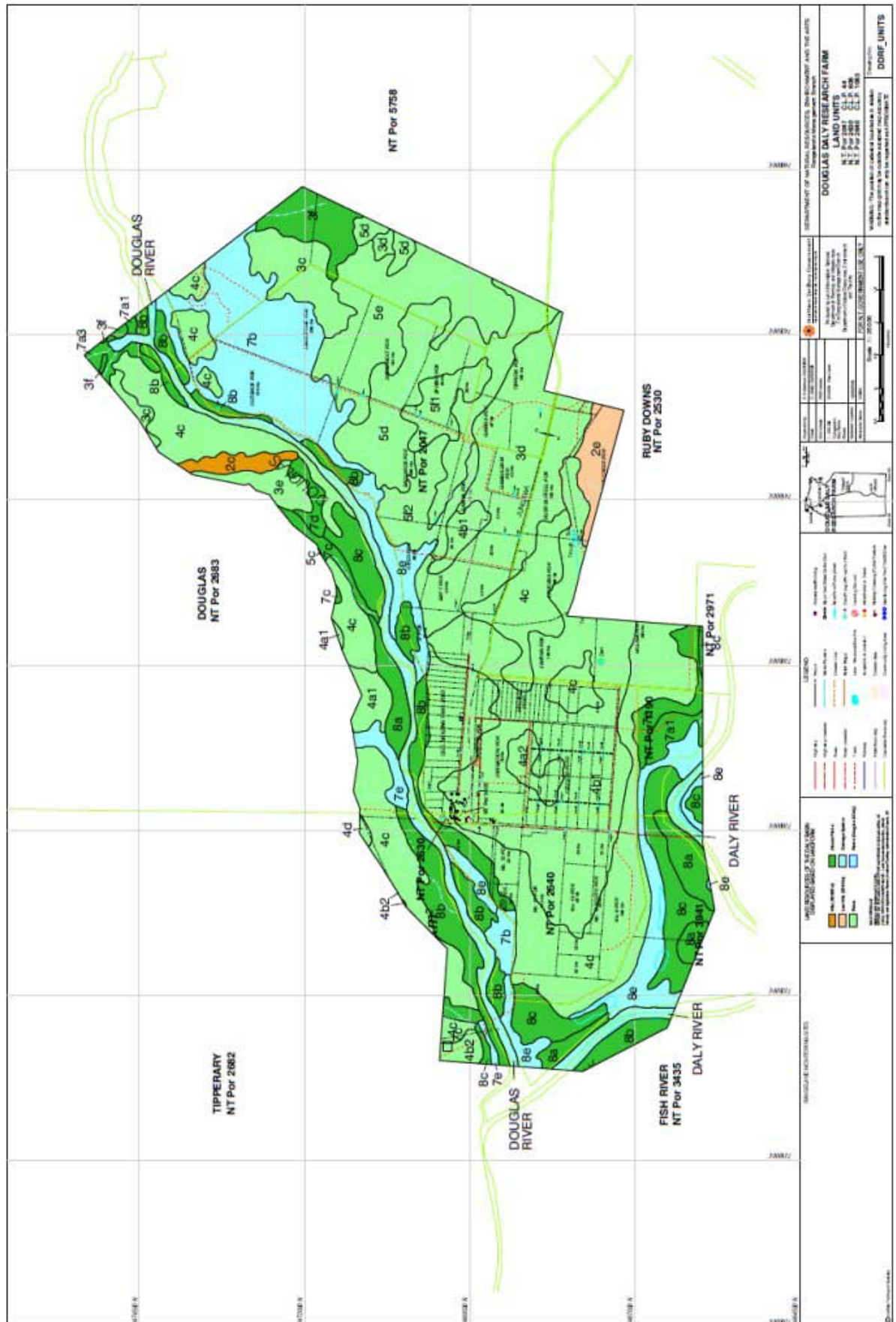
The office complex has a clean and a dirty laboratory, which have been used for different kinds of sample processing. The clean laboratory was also used for soil analysis in the 1990s.

Other buildings include machinery sheds, workshop, a power generator shed, hay storage and general storage sheds. There are four grain silos with grain drying and handling equipment.

The facilities at the farm have made it ideal for training, such as Chemcert/SmartTrain, bushfire training, First Aid courses, low stress cattle handling workshops, pasture schools and grader, backhoe and bulldozer operator courses. The Australian Defence Force has also utilised the facilities during its training exercises and DDRF has taken on many roles from prison to command centre for the exercises.



Figure 2. Old staff accommodation



Map 1 – Douglas Daly Research Farm Land Units (Aldrick and Robinson 1972)

Work experience students from NT high schools have utilised the facilities at DDRF and more recently Indigenous trainees and agricultural apprentices have been part of the workforce.

DDRF is also a DrumMuster depot and supplies local produce quarantine inspection services.

A primary school was established on the property in 1982 to cater for the growing demand of families moving into the region with the expansion of agriculture. In 2010, this educational facility is still important for the surrounding community. A community library is also situated at the research farm.

Research results have been distributed to industry through field and open days as well as organised agricultural tours. Information such as Technotes and Agnotes, is also provided to visiting and other interested persons on request.

1.2 SOIL AND WATER

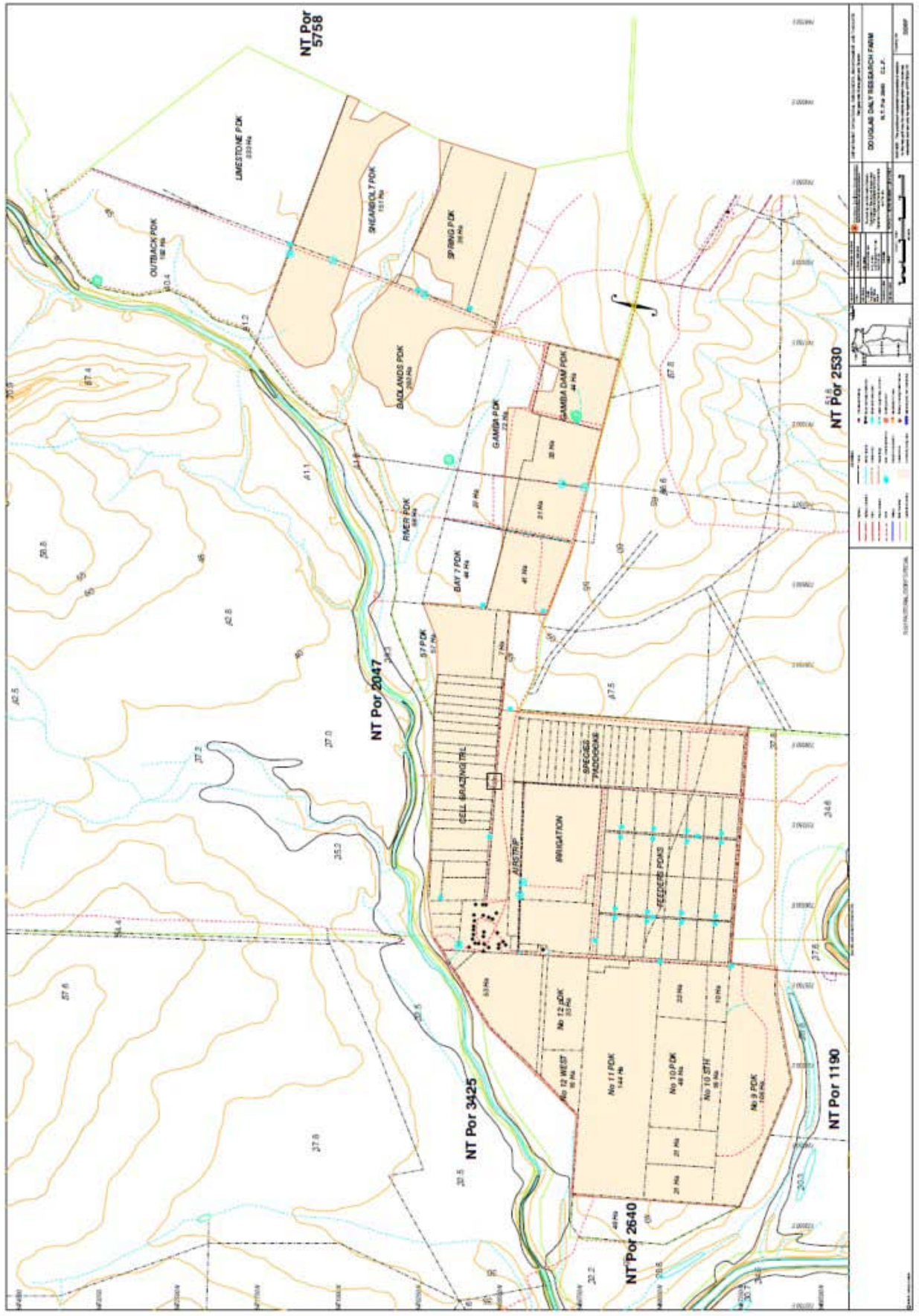
The topography of the land is relatively flat with the majority of the soil type being sandy red earths (Blain soil type 4C, 4B1, 4A2) and loamy to heavier red earths (Oolloo and Tippera soil types). Areas of loamy yellow earths are found in the north-eastern end of the property (5D, 5F, 5E) with some river levee soils from the Douglas River boundary (refer to Map 1).

The main water supply for stock and domestic purposes is from two bores located near the homestead area. Water is pumped into an overhead tank and piped to water troughs and housing. A third bore is also located in the north eastern end of the property with additional stock water being supplied through natural springs and man-made dams to the paddocks in this area. Irrigation water is supplied through two turbine pumping bores with the water used through centre pivot irrigation systems (Map 2).

1.3 SEASONAL CONDITIONS

The local climate is characterised by tropical rainfall for seven months of the year with the remaining five months receiving little or no rain. Annual mean rainfall is 1207 mm with mean monthly minimum temperatures ranging between 13 to 24 °C and mean monthly maximum temperatures ranging from 31 to 37 °C.

DDRF has been recording climate data since the establishment of an official meteorological recording station in January 1968. Daily measurements of rainfall, temperatures, humidity, pan evaporation, wind run and barometric pressure have been recorded and for a few years, cloud cover and type have also been recorded.



Map 2 – Douglas Daly Research Farm – contours, paddock layout, cleared area and water points

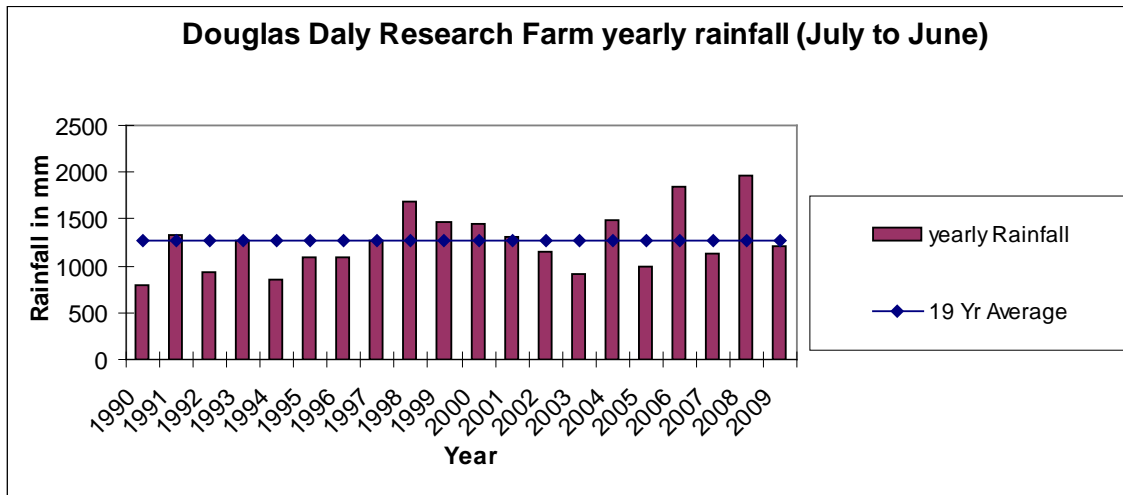


Figure 3. Annual rainfall since 1990 with the average annual rainfall (1207 mm) over the 19 years

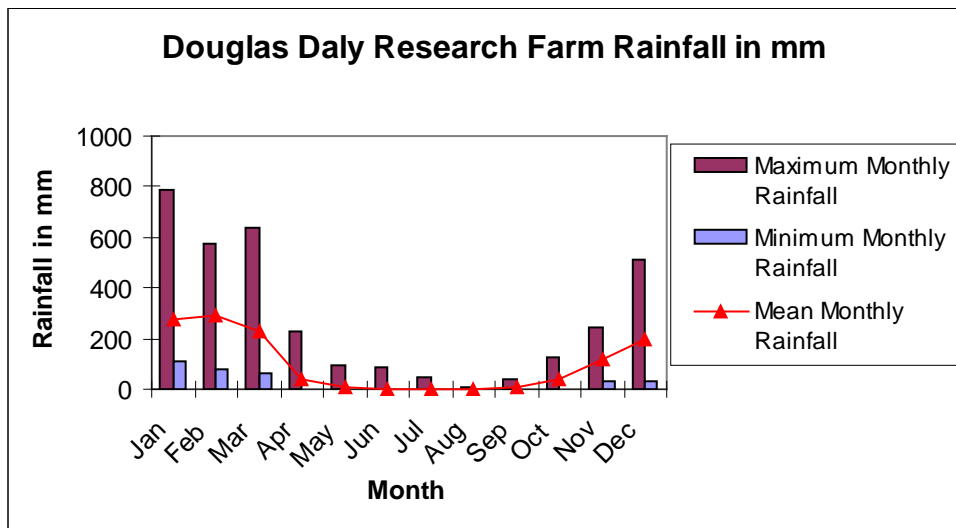


Figure 4. Maximum and minimum monthly rainfall and mean monthly rainfall

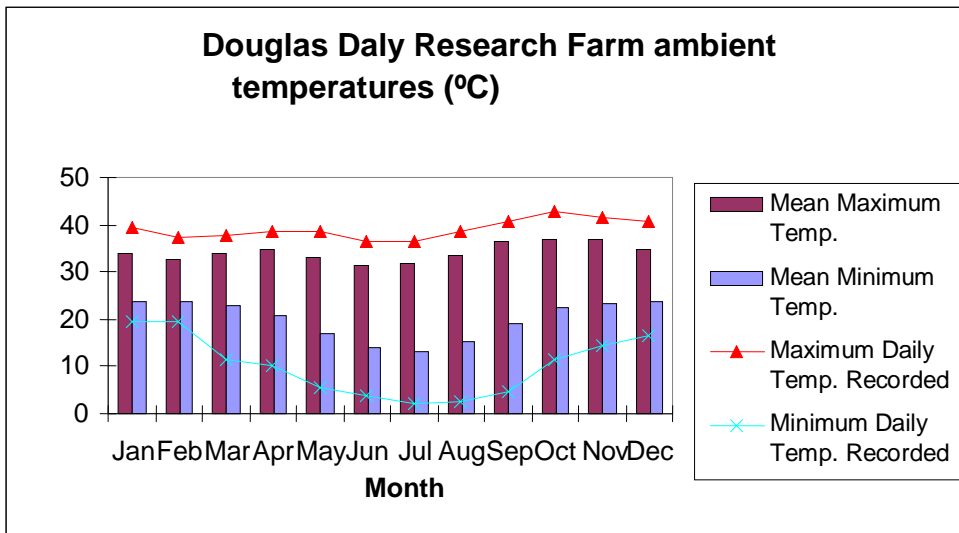


Figure 5. Monthly mean minimum and maximum temperatures and the minimum and maximum daily temperatures recorded for each month

2 AGRICULTURAL RESEARCH (1969-2005)

Agriculture trends in the Douglas Daly region have changed since the area was opened up in the 1980s by the ADMA Scheme, which initially promoted cropping. The limited marketing opportunities for produced grains coupled with the use of southern farming practices and the remote living situation saw many of the original farmers leave the district after a few years.

The development of improved pastures and the availability of live cattle export markets in South-East Asia resulted in a new focus on beef production in the 1990s. The Douglas Daly region was used not only for growing out cattle for export, but also as a depot despite road conditions being challenging, with the live export port in Darwin being less than 250 km away.

Improved cattle production resulted in increased supplementary feed requirements between station yards, in holding depots and during transport by ship. Fodder crop production became an important industry for the Top End and the region in order to supply high quality fodder and fodder cubes for transporting cattle by ship to Asian markets.

The agricultural focus changed again in the past decade as the Douglas Daly has become a more diversified agricultural region. Cattle production is still a prominent industry; however, other enterprises, such as hay production, turf, peanuts, horticultural crops (melons, pumpkins and onions) and forestry production of African mahogany have emerged.

Agricultural research at DDRF during this time has changed to keep up with the needs of industry. Part 2 briefly outlines the research that has been carried out. A detailed reference summary table of all trials is presented in Part 5.



Figure 6. Auto harvesting of French bean seed crop

2.1 NON-IRRIGATED CROPS

There have been many different research projects conducted on crops at DDRF since the first assessments of cotton, peanuts and millet in the early 1960s. Sorghum, maize and mung beans (*Vigna radiata*) were extensively trialled for many years from the late 1970s to the 1990s. Trials included planting, planting equipment, harvesting methods, timing and techniques, plant nutrition, herbicide usage and weed control methods, insect and fungal issues, variety performance, soil types and tillage trials (conventional, minimal and no-till) (Anon. 1981).

2.1.1 Cereal and grain legumes

Sorghum and maize variety trials were assessed regularly in the 1980s and 1990s as seed companies developed new varieties. Information obtained from the trials included grain yield, plant height, resistance to disease and head mould, lodging resistance, head type, insect problems, timing of maturity and head exertion. (Shotton and Price 2000; Price 1992a). The results were utilised by producers in the following season to determine farm management practices, such as time of planting, stock grazing potential of the post harvest crop stubble and choice of varieties.

Grain legume crops have been trialled since 1964 and include soybeans, guar, safflower, mung beans, chickpeas (*Cicer arietinum*), cowpea (*Vigna unguiculata*), navy beans (*Phaseolus vulgaris*) and lablab (*Lablab purpureus*). Research has included developing no-till planting methods incorporating the time of sowing to best suit climatic conditions, fertiliser requirements, weed control, insect and disease monitoring, varieties and harvesting techniques.

Maize

Maize germplasm and elite maize hybrid evaluations were assessed during the 1980s and early 1990s in a collaborative trial with QDPI to compare potential new hybrid varieties for the Queensland and NT semi arid tropics.

Results from the hybrid evaluations varied yearly depending on seasonal conditions. For instance, in January and February, plants grew vigorously with many setting double and triple cobs, but these were not filled if the rain ceased early and temperatures rose.

In the 1990–91 season, variety Barker was the highest yielding hybrid with T13 not far behind. Hycorn 80, a commercial variety used by NT farmers, had the third lowest yield of those evaluated. Hausler (1993) also found that Barker was a strong performer in harsher conditions whereas T5, a usually strong performer, did not cope with harsh conditions. Results also indicated that T13 yielded consistently higher and could be recommended as a commercial variety.

The aim of the germplasm evaluation study, which was assessed between 1981 and 1992, was to compare and evaluate experimental lines on the basis of yield, seed vigour, stalk strength, ear height, tolerance to moisture stress and resistance to Java downy mildew.

Many experimental lines had great promise in this environment and lines that were drought-resistant were disappointing in a situation that was expected to favour them. The abrupt end of the season in 1990-91 caused the maize to suffer in the hot, dry conditions during grain fill. Hausler (1991) found plants grew to half their normal height and cobs did not fill, resulting in low grain yields.

The effects of tillage practices on maize were assessed in “The rotation of tropical grains under different tillage methods trial”. No-till maize out-yielded conventional till maize by 33% over an 11-year period indicating continuing benefits from the no-till treatment. The average yield for no-till and conventional till was 3.66 t/ha and 2.75 t/ha, respectively (Thiagalingam et al. 1996b).

Leaf nutrient concentration at flowering showed differences between elements in the two tillage systems. The no-till nitrogen (N), calcium (Ca), zinc (Zn) and manganese (Mn) concentrations in the leaves were lower than in the conventional till system. However, the no-till phosphorus (P) concentration was 14% higher than the conventional till, showing better utilisation of P.

Maize was an important commercial crop in the Douglas Daly during the ADMA program, but declined following the cessation of the program and the closure of several small animal feedlots where maize was an important feed. More recently, maize production has been renewed by the Peanut Company of Australia (PCA) in the Katherine region as part of their rotational cropping practices with peanuts.

Mung beans

One of the main outcomes of research was the breeding and release of the mung bean cultivar "Putland", which was planted on Garabaldi Station in 1991 and used as a farmer demonstration site. Yeates (1991) found the 10-ha site gave an excellent result of 1.1 t/ha even though only 11 mm of rain fell in March that year.

Suitable herbicides for use in no-tilled mung beans were trialled from 1990 to 1995 as Trifluralin was the only herbicide registered at that time for use on mung beans in the NT. This was unsuitable for no-till techniques as it is required to be incorporated into the soil. Yeates (1992) found both Stomp® (pendimethalin) and Pursuit® (imazethapyr) controlled most of the broad-leaf weeds although Pursuit® failed to control tar vine (*Boerhavia nyctaginaceae*) and was inconsistent in its control of grasses.

There was a small market for mung beans in the animal feed industry and for sprouts in the local and interstate markets, but production was limited in the NT due to the high costs of road freight and distances to markets. Currently, mung beans are used locally as a green manure crop by horticultural producers.

Soybeans

Soybean varieties have been studied at DDRF from the early 1980s. Soybeans were trialled for several years to assess agronomic requirements, such as herbicides for weed control, fertilisers and time of application, insect control, time of planting and plant populations. Early results (DPP 1982, p. 28) indicated that soybeans were well adapted to the area with yields up to 4 t/ha achievable.

Crop disease surveys (DPIF 1988, p. 73) found soybean crops under stress were also attacked by the fungus *Macrophorina phaseolina*, which affects germination and seedling survival and was regarded as potentially serious.

During the tillage trials (1984-2000) Thiagalingam et al. (1996) found soybeans averaged a 31% higher yield over an 11-year period under no-tillage (2.24 t/ha) compared with conventional tillage (1.71 t/ha).

The variety Buchanan was recognised as one of the better variety in the earlier years of soybean research.

The varieties Buchanan and Leichardt were compared utilising no-till and conventional tillage practices with both performing similarly with little change in yield. O'Gara (2000) also trialled several soybean varieties and found that Leichardt was the better adapted variety.

The major agronomic issues for growing soybeans were achieving good establishment, correct nutrition, controlling pod sucking insects and weed competition. O'Gara (2010) reported that commercial yields of 1 to 3 t/ha on dry land and 3-5 t/ha under irrigation could be achieved.

Many herbicides were examined in the mid 1980s to study their effectiveness on weeds and effect on the soybeans. Sertin® was found to be the best post-emergent herbicide for grass weed control and Goal® performed reasonably well as a pre-emergent herbicide (DPP 1986).

Soybeans have potential for human consumption and animal feeds due to their high protein and oil content; however, the costs of production do not favour NT production. There was strong interest in NT-based bio-fuel production from soybeans in 2007-08 but this was impacted by changes in crude oil prices and economies of scale in terms of the area of land available for soybean production.

Lablab

Lablab bean production was assessed at DDRF during the 1980–81 wet season. The purpose of the trial was to multiply seed stocks and to gain knowledge on the agronomy of lablab, including harvesting methods.

The crop yielded 6 t/ha of dry matter and 0.5 t/ha of seed. At planting, 200 kg/ha of single superphosphate fertiliser was applied; the crop received no weed, pest or disease control applications.

Schultz (1981a) recommended that early stage (December and January) weed control for grasses and broad-leaf weeds would be required. Fertiliser inputs were high for the returns obtained, but seed harvesting was found to be fairly quick and easy. Also the stubble was suitable for no-till planting for future crops.

Lablab has been grown locally as a green manure on a limited basis with no increasing demand for the seed at this stage.

Peanuts

Peanut production had been investigated since the 1960s and was extensively investigated through the 1980s and 1990s. Flint (1995) covered many areas from fertiliser requirements, plant population, pest and disease management, row spacing effects, weed control and herbicide application, plant growth regulator applications, harvesting techniques, varieties, tillage treatments and farming rotations.

Ham (2004a) focused on irrigated production (1997-2008) in the dry season due to better control of water requirements, fertiliser applications, pest, disease and weed control, and harvesting (refer to Section 2.2.3).

This research on peanut production and agronomy has assisted local producers and the PCA, who invested in peanut production properties in the Katherine district and reported wet and dry season yields of 3 to 4 t/ha.

Peanuts have been grown in the Douglas Daly region for over 20 years; however, commercial production of peanuts ceased in the mid 2000s due to growers moving interstate. The distance from the processing plant at Kingaroy, Queensland was one of the main factors which reduced profit margins for this crop together with high transport and production costs. Peanut seed production continues at DDRF under contract with PCA.

Sesame

Sesame production has been investigated since the late 1980s with research covering selections for the development of improved cultivars, herbicide requirements, nutritional requirements, wet and dry season production, rotations with legumes, planting techniques, tillage systems and plant populations.

The main success with sesame research was the breeding and release of the sweet cultivar lines “Giles” and “Edith”, and the eastern state lines of “Rosemarie” and “Rakabe” (Bennett 2003).

Population and row spacing trials of sesame (Bennett 1997) found that increasing populations from 200 000 to 400 000 plants/ha resulted in lodging and did not significantly increase seed yield although the higher populations had more moisture stress in low rainfall seasons. Narrow row spacing (16 cm and 32 cm) gave the highest yields because the canopy closed and suppressed weeds.

No-till planting trials aimed to determine whether mulch levels in no-till systems were limiting to the establishment of sesame, as previous seasons had shown that sesame often failed to establish satisfactorily under a no-till regime. The trial utilised a randomised block design comparing four mulch levels of 1.6, 2.7,

3.8 and 4.6 t/ha. Bennett (1997) did not find that the level of mulch significantly affected yields. This may have been due to the ideal establishment conditions at planting time. The efficiency of planter tines clearing high levels of trash was also investigated.

Thiagalingam (1991c) assessed the effect of N and P on sesame to find the appropriate level required for maximum seed production. Results indicated that application of N fertiliser significantly increased sesame yield but no response was found from increasing P applications.

Sesame seed yields were 0.9, 1.3, 1.5 and 1.5 t/ha at 0, 30, 60 and 120 kg N/ha application providing a yield increase of 45, 73 and 74% over the no N treatment. The experiment confirmed that 60 kg N/ha was adequate for sesame in this soil and environment. Sesame capsule number, plant height and harvest index also increased with the N application.

The P tissue levels suggested that the soil had high initial P which contributed to a nil response to P application. Similar experiments were conducted at Katherine and Larrimah.

As sesame is prone to high harvest losses, Oemcke (1991a and 1991b) conducted many trials on assessing mechanical harvesting techniques and plant desiccation to minimise seed losses. Extending the harvester front combined with quick cut knives was the most efficient method to reduce seed losses. Axial flow harvesters were also less damaging to the sesame seed thus improving harvested yields and quality.

The potential of using desiccants (Reglone®) to reduce harvest losses in sesame was also assessed by Oemcke (1991a) where pre-harvest losses five days after desiccation were observed to be minimal compared with natural drying down methods.

Oemcke (1992) later conducted an experiment where four areas of a sesame crop were either desiccated with Reglone® (diquat) at 2.5 L/ha and windrowed, harvested into windrows without desiccation, desiccated and not windrowed or left standing. The results were used to measure harvesting method effects on seed losses, plant dry down characteristics and plant and seed moisture.

Time between physiological maturity and harvest was also recorded. This study found pre-harvest losses were highest in the standing, untreated crop. Desiccation and/or windrowing were observed to reduce pre-harvest losses, as well as give a more even maturity at harvest than the standing, untreated crop.

As most of the sesame consumed in Australia is imported, the crop has potential for local, interstate and export market opportunities. The distance from the main markets, the specialised harvesting machinery required for the crop, the low crop stubble value and the low gross margin are the main reasons sesame is not commercially grown in the Katherine-Daly districts.



Figure 7. Sesame in flower

2.1.2 Fodder crops

Dry-land fodder crops have been an important industry in the Douglas Daly and are a major contributor to the overall NT mixed farming industry, mainly dominated by peanuts and hay/fodder grown in the Katherine, Douglas Daly and Darwin areas for the live cattle export industry. However, in 2009-10 there was a reduction in peanut production contrary to earlier indications.

Cavalcade

Cavalcade is a dual-purpose legume species, commonly grown as a hay crop for supplementary feeding or processing into pellets or cubes. In addition, it is also grown as a standing pasture or companion legume with grasses in mixed pastures.

Fodder yields have averaged 5 to 7 t/ha; however, commercial crops of 9 t/ha have been produced in favourable conditions (O’Gara 2010). Cavalcade hay makes up over 90% of the legume hay produced in the Top End and has crude protein levels of 8 to 12% depending on the growth and time of harvest.

O’Gara (2010) also describes how Cavalcade is suitable for rotation with cereal crops as it can contribute 50 to 200 kg N/ha/year to the soil. Many trials at DDRF looked at agronomic issues associated with growing Cavalcade and are discussed in other sections in this report.

Cavalcade fodder and seed production in the Douglas Daly region has been very successful with production increasing each year. DoR’s Pastoral Division has calculated that 17 000-18 000 t of hay with 49 t of Cavalcade seed were produced in 2009.

Pearl millet

Pearl millet (*Pennisetum glaucum*) has been used as fodder, hay, silage and has been harvested for seed production for stock or bird consumption. Due to its ability to recover nutrients and its use as a foundation crop to condition soil, it has also been used as a green manure crop grown in rotation with peanuts and

horticultural crops. DoR maintains pure seed stocks of two varieties of pearl millet, which are Katherine and Ingrid.

A trial to assess Katherine pearl millet production was carried out in 1980–81 to determine agronomic management, biomass, seed yield, disease and insect problems and harvesting issues. Schultz (1981d) found millet was a good crop for building up organic matter after first season post clearing operations. The crop had the ability to access soil nutrients when planted with minimal amounts of fertiliser where the comparison crop of maize suffered nutrient deficiencies. Grain harvest yields were reduced due to late harvesting and through using a maize harvester front. Planting into wider row spacing may have also helped. Total seed yield of the crop was 1.7 t/ha and the dry matter yield of above ground plant was 15.8 t/ha.

2.1.3 Fibre crops

The production and viability of fibre crops was investigated from 1987 to 1990 with the formation of a Kenaf Task Force. The main aim of the task force was to assess the feasibility of establishing a pulp industry in the Top End based on kenaf (*Hibiscus cannabinus*).

Kenaf

Most of the research on kenaf was carried out at DDRF and surrounding farms, which included studies of the relationship between soil moisture and germination, establishment and yield. Nutrition requirements and split application practices for N fertilisers were also assessed.

Small commercially grown areas were assessed to provide a better understanding of the yield potential, quality of pulp, processing aspects and to monitor the effect of different growing conditions and different land types on these factors.

Martin (1991a) conducted a soil moisture study on germination, establishment and yield and found that 35 mm of water applied to a soil with water available below 60 cm allowed kenaf plants to survive for 52 days without rainfall and produce a stem yield equivalent to those with applications of 51 and 84 mm of water.

Soil temperature played an important role in plant establishment. In a wet soil, the temperature at 50 mm depth was above the optimum for hypocotyl elongation 13 hours/day and above the optimum temperature for germination of 9 hours/day. An increased establishment density with increased amounts of applied water was due largely to temperature effects since maximum soil temperatures at a depth of 50 mm decreased with increasing amounts of applied water.

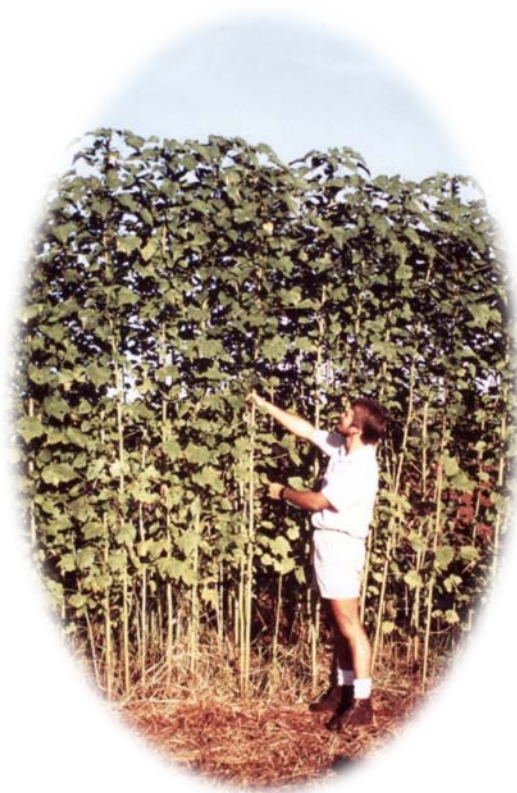


Figure 8. Kenaf trials nearing harvest

Martin (1991b) assessed N fertiliser requirements in 1989-90 with results showing the only significant effect of N fertiliser on stem yield was an increase from 7 to 9 t/ha, irrespective of the range and rate applied. In 1990-91, however, yield was progressively increased from 3 to 5.4 t/ha by N applications from 0 to 240 kg/ha.

Splitting the N applications increased yield from 3 to 5 t/ha. Thus, rain-grown kenaf required N applications in the order of 120 kg/ha for maximum yield and splitting the application improved its effectiveness. The lower yields in 1990-91 were due to late planting.

A significant point to emerge from the trial in 1989-90 was that although the total biomass/ha increased by 64% from 101 days after planting to final harvest at 145 days after planting, the total N in the biomass decreased by 47%. Presumably large amounts of N were lost by the crop through volatilisation and leaching from leaves.

The district farm trials were carried out for two seasons with contrasting rainfall patterns. The 1988-89 season was well above the average of 1055 mm from November to April (1490 mm), and the 1989-90 season was well below (780 mm). Martin (1991c) found at both Kumbyechants and Garibaldi stations there was a 33% reduction in yield for a 48% reduction in rainfall.

Although lower rainfall reduced yields, they were acceptable at 10 t/ha of stem. These studies provided evidence that kenaf could be grown successfully as a rain-fed crop in the NT and become a reliable source for a pulp mill. The quality of pulp produced from farm grown kenaf was as good as that produced from soft wood.

Although kenaf grew well in the district, no processing facility was established and the industry did not develop. The future of this crop will be affected by the costs and availability of alternative paper pulp sources such as wood chips.

2.1.4 Biofuels

Biofuel production from cassava (*Manihot esculenta*) was assessed at DDRF from 1978 to 1981 by evaluating yield potential and agronomic requirements. Eighteen varieties were assessed comparing survival rate of cuttings, plant population, tilling assessment; plant lodging, tuber number and harvest weight per plot.

Yields were obtained from two harvest dates (349 and 526 days after planting). The top yielding cultivars in the first harvest continued to yield well in the second harvest. Significant differences were obtained between varieties but not between harvest times. Schultz (1981b) made no recommendations from the trial regarding the growth period and agronomy of cassava.

The potential for biofuel production remains in the research phase. As noted in the soybean section, bio-fuel production is strongly influenced by fluctuations in crude oil prices and a need for a processing infrastructure and economies of scale.

2.1.5 Crop nutrition

Crop nutrition plays an important role in maximising yield and plant establishment. Monitoring trials were carried out to assess the nutrient status of crops and to monitor fertiliser requirements and management practices as the majority of plant and soil samples showed low levels of major and minor elements (Thiagalingam 1988). These results suggested future and further monitoring and research to define critical levels and appropriate fertiliser recommendations.

McNamara (1992) found that there was little difference in grain yields due to different boron rates, with a range from 4.7 to 5.2 t/ha. A sorghum crop requires 70 kg/ha N, 28 kg/ha P and sulphur (S), 40 kg/ha potassium (K) and 5 kg/ha Zn to produce 3 to 4 t/ha. Similar amounts are also required to grow maize.

Nitrogen trials

As N is one of the main contributing factors to crop yield, a rotation of tropical legume pastures followed by cropping was extensively researched to utilise available N via a legume, throughout the 1990s and 2000 (Thiagalingam 1991b). A number of pasture legumes in one and two year ley systems were assessed over several years (Thiagalingam 1993a). The most promising pasture legume was Cavalcade.

In the ley-farming trial of no-till sorghum under Cavalcade, in which direct drilled sorghum followed a grazed crop of Cavalcade, Thiagalingam (1991a) found that there was a significant response to 30 kg/ha of applied N.

At sowing, the soil surface had an average Cavalcade mulch level of 7 t/ha. Establishment to harvest populations dropped by 29% from 136 000 to 97 000 plants/ha with yields being 4.1, 4.5 and 4.7 t/ha for 0, 30 and 60 kg N/ha, respectively. The harvest index for sorghum in the sorghum/Cavalcade trial was 0.45, indicating reasonable grain production.

Nutrient concentration in plants was monitored at flowering and a significant increase in N, P, Ca, Mg and Zn was obtained with applied N. Nutrient levels in the leaves without N application also appeared to be adequate.

Cavalcade regenerated well under the sorghum crop, producing a fresh biomass of 3.5, 2.8 and 2.4 t/ha. Thiagalingam (1993a) found the dry matter yield of Cavalcade regrowth after one and two sorghum crops were between 12.7 and 14.9 t/ha, worth \$1200/ha to the farmer.

The N contribution and regenerative ability of various pasture legumes in a ley rotation with the no-till planted sorghum was also investigated. Thiagalingam (1993b) found that the total N content in a tonne of Cavalcade, Bunday and Maldonado (*Macroptilium gracile*) was 15, 19 and 16 kg/ha, respectively (1991/92 season results). However, after six months, the legume residue N content had declined by 16, 18 and 26% suggesting that Maldonado mineralised more N than Cavalcade during this period.

2.1.6 Plant uptake of radioactive material

Research on plant uptake of radioactive material from soil was conducted by the Australian Nuclear Science and Technology Organisation and the Department of Primary Industry, Fisheries and Mines (DPIFM) to obtain accurate predictive models of radiological doses should there be any atmospheric release of radioactive material.

The objective of the trial was to determine the amount of radioactivity that may be taken up by cultivated plants (sorghum and mung beans), which are used for animal and human consumption, on two soil types over four years. At each site the treated area was 30 m² in an enclosed area of 110 m². Materials used were ⁶⁵zinc, ¹³⁴caesium and ⁸⁵strontium.

For the plants growing in the areas labelled with radioactivity, mung beans generally accumulated more radioactivity than sorghum. Both crops took up slightly more radioactivity from Blain than Tippera soils.

A comparison between years suggested that the level of accumulation declined with time, particularly in the Tippera soil. The radioactivity was anticipated to bind more strongly with soil particles and hence be less available to plants as time progressed. There was some indication of down-profile migration; however, the greatest depth at which significant radioactivity was found at the end of the experiment (in 2003) was 15 cm and in all cases the maximum activity concentrations were within 4 cm.

Twining et al. (2003) concluded that radioactivity had not moved any substantial distance through the soil profile on either Tippera or Blain soils despite high rainfall each wet season. The retention in the soil surface may also be linked to organic complexation as most of the limited organic content of the soil is located in the first few mm.

2.1.7 Seed certification

The NT Seed Certification Scheme was introduced in 1969 to maintain a viable seed industry in the NT. Breeder, pre-basic, basic and certified seed production has been undertaken at DDRF since the 1970s. Seed was produced in accordance with seed certification rules. Production of early generations of seed stocks was carried out by a specialist agronomist where possible, in conjunction with the genetic specifications of each individual species and cultivar.

All certified seed crops were screened for any off-types throughout the growth of the crop. Weeds, diseases and pests in seed crops were controlled. Irrigation was used when required for establishing and maintaining the crop.

Harvesting, grading, drying, packaging and storage of the seed lots was carried out to promote high quality seed. All seed lots were tested for germination, purity and seed count at the Berrimah Farm seed testing laboratory prior to its closure in 2007.

Most of the seed stocks produced at DDRF were used within the Top End for further multiplication of commercial seed. The multiplication of Cavalcade seed was one of the successes for the cattle and fodder industries for its high yielding and high protein qualities. Commercial production of Cavalcade seed continues within the Douglas Daly with 49 t produced in 2009.

Other pasture and fodder seed production at DDRF included Bunday centro, Ooloo (*Centrosema brasilianum*), Maldonado, Wynn cassia (*Chamaecrista rotundifolia*), Ingrid and Katherine pearl millet, Highworth and Rongi lablab bean, mung beans, Arafura cowpeas, Glenn jointvetch (*Aeschynomene americana*), Cunningham leucaena (*Leucaena leucocephala*), and gamba grass (*Andropogon gayanus*).

Verano

In 1989, the seed production group conducted a seed harvesting trial of Verano stylo (*Stylosanthes hamata*) to determine the time to direct harvest for maximum seed yield. Norton et al. (1992a, b) found there was only a small window of opportunity to obtain maximum yield from direct header harvesting. Standing seed yield peaked on day 158 producing 0.5 t/ha.

2.2 IRRIGATED FODDER AND GRAIN CROPS

Irrigated crops have been grown at DDRF since the early 1980s with different forms of irrigation. The main purpose of the early irrigation work was to produce a crop rather than study irrigation.

Initially, peanuts, navy beans and certified seed were grown utilising moving and stationary irrigators, with centre pivots used since 1995.

An Irrigation Development Program was established in 1996-97 with research focussing on peanut production, evaluating soil preparation, fertiliser use, cultivars, soil moisture, yields, harvesting and herbicides.

O'Gara (2008 and 2010) stated that this work provided the basis for a more realistic approach to irrigation as a result of the research and development conducted and the knowledge and experience gained (O'Gara 2007b, c). The information enabled the department to advise and assist farmers who required information on irrigation and irrigated crop management. The industry was also in a better informed position to plan and manage irrigation developments through having access to better knowledge.



Figure 9. Centre pivot irrigation in action

2.2.1 Cotton

Cotton was planted under trickle tape in a 1-ha area in 1998 to develop a sustainable agronomic package for dry season production using Ingard varieties to deter insect pests and to reduce chemical applications. The project also attempted to develop suitable irrigation systems and scheduling for light and heavy soils and investigate the uptake of N fertilisers and N requirements. A more intensive research project was also undertaken between 1994 and 1998 at Katherine Research Station.

Martin (2000) found cotton (L23i seed line) suffered from very high insect pressure due to higher temperatures and needed spraying seven times with insecticide to control insects. The hand harvested trials yielded four to eight bales per ha.

Commercial cotton production did not develop as an industry in the NT although the crop showed potential for future assessment. Industry development would be influenced by water and land availability, specialised equipment and machinery and the economies of scale. Environmental concerns also limited the commercial production of cotton as it was viewed as an unsuitable industry at the time.

2.2.2 Fodder

A preliminary investigation into producing high quality fodder under irrigation and rain-fed conditions was assessed by O’Gara (1997) for two seasons (1994-1995) using eight grass and six legume species with the main focus of these experiments being aspects of crop physiology.

The Irrigation Development Program had been directed towards addressing priority areas, which had been identified with industry and resulted in research and development of irrigation for peanut, maize, forage sorghum, Rhodes grass (*Chloris gayana*), lucerne (*Medicago sativa*) and forage oats (*Avena sativa*) crops.

O’Gara (2004) also addressed the following through the program: assessing water requirements and irrigation strategies, assessing fertiliser requirements, disease management, weed management and evaluation of new varieties of alternative rotation crops. Nutrient requirements for maize, forage sorghum,

Rhodes grass and lucerne were assessed to determine nutrient removal from each cropping area to identify sustainable replacements.

One of the main outcomes of the irrigated research work (O’Gara 2006) was the development of cultural practices in this environment to grow lucerne for high yielding (average 22.5 t/ha) hay production and to identify a major disease of lucerne, called “little leaf”.

O’Gara (2007a) found irrigated maize in rotation with peanuts produced grain yields of over 12 t/ha. Rhodes grass (O’Gara 2006) was identified as a viable irrigated hay crop producing yields of 36 to 38 t/ha over seven harvests.

2.2.3 Peanuts

Quality peanut seed production, free of the peanut mottle virus, has been achieved at DDRF since 1995. This was particularly important to the industry as Queensland and NT producers had minimal seed stocks or suitable land to grow virus-free seed. Peanut variety trials indicated which varieties persisted well in the region, in terms of nut in shell yields, kernel grades and shell percents, resistances to pests and diseases, particularly the new “high oleic” varieties suited to the NT.

Population and yield/grade

Ham (2001a) found no differences in kernel yield or jumbo grade between the four populations of 70 000, 110 000, 160 000 and 210 000 plants/ha (pph). The trial indicated the most important aspect was the evenness of the plant population and for weed control and ground cover aspects a population of above 100 000 pph should be achieved.

Crop nutrition

An examination of varying rates of macronutrients (K, Ca and magnesium (Mg)) in peanuts on Blain soil found all of the treatments failed to show a response to any additional fertiliser applied. Ham (2001b) therefore recommended the use of more frequent, smaller applications of fertiliser, particularly K and N when required. He also recommended fertigation with careful management of irrigation. Optimum timing of planting to avoid heavy rainfall events was essential and using a green manure crop to increase organic matter was beneficial.

Base P placement and its effect on yield were assessed at DDRF in 1998. The three treatments involved broadcasting, single band and double band fertilisers prior to planting. Ham (2001a) found the results indicated little or no benefit in banding fertiliser if soil nutrition was reasonable (above 29 mg/kg available P); however, if soil P was deficient, there may be a cost benefit to band at least some of the fertiliser.

Irrigation

An irrigation trial in 1997 (Ham 2001a) examined three varying irrigation regimes for irrigated peanuts at DDRF. These were schedule irrigations based on class A evaporation, monitoring water using a neutron moisture meter calibrated to Blain soil type and to calculate crop coefficients for different crop stages.

The outcomes of the trial included calibration and familiarisation with the neutron moisture meter. Interpretation of the readings on the Blain soils at DDRF together with utilisation of weather data were used to determine irrigation schedules in lieu of another method or monitoring equipment.

Ham (2002) trialled the expert irrigation management system “Exnut” at DDRF to determine its effectiveness on Blain soils. The experiment found the system could be used in the Top End provided alterations were made to the program, especially when used in conjunction with a well calibrated Enviroscan (soil moisture measuring system).

Weed control

Herbicide trials used in irrigated peanut crops demonstrated the importance of weed control for both yield and quality purposes. Ham (2000b) trialled 13 different treatments with both pre and post emergent herbicides. Results showed there was a benefit from most of the herbicides used and from recommendations of which worked best with particular weed groups.

Diseases

Studies were also undertaken by plant pathologists to determine resistance to leaf spot and limb rot diseases. Bellgard (2001) concluded that if these diseases were not controlled, pod yield losses of 50 to 70% could be expected.

Seed storage

Peanut seeds stored in cool stores or sheds gave similar germination results, although the shed-stored seed had more variation between replicates (Ham 2001a). This demonstrated the importance of high quality seed for even, correctly populated crop establishment.

2.2.4 Maize

Research in irrigated maize production was extensively carried out over a four year period at DDRF, covering soil and land preparation, suitable varieties, plant population and row spacing, nutrition, pest and disease issues and control, weed management, irrigation management, harvesting and economics.

O’Gara (2007a) found that the grain yields of 9 to 12 t/ha were achievable on Blain soils with higher yields closer to 13 t/ha achievable with correct management and varieties. Maize is an expensive crop to produce due to high production costs in the NT. Optimum plant populations (70 000 to 85 000 pph), adequate water and nutrition, good weed, insect and disease management and the correct varieties are all important to maximise grain yields and returns.

2.3 PASTURES

Methods to increase beef production from introduced pastures has been and remains of fundamental importance to DDRF research objectives and activities. Some of the key areas have focused on improved mixed (grass and companion legume) pastures that provide better stock nutrition and produce higher quantities and quality of feed, grass species selection and performance, and the identification of the persistence and sustainability of different pasture types.

In the 1980s, the high costs from the Brucellosis and Tuberculosis Eradication Control (BTEC) program led graziers to intensive cattle husbandry by improving productivity through the use of protein/mineral supplements and enhancing native pasture and improved pasture use. This in some cases led to overstocking in newly fenced-off areas and overgrazing of native pasture. As a result, research focused on improved pasture development and the management of supplementation.

A large number of grazed and non-grazed pasture research projects have been undertaken at DDRF over the past 30 years, including long term studies such as the pasture species evaluation under grazing trial commonly referred to as the ‘species trial’ conducted over 25 years.

The objective of the ‘species trial’ was to evaluate promising pasture introductions under grazing to determine their long term potential for the Top End. The pasture species are under a continuous grazing regime on a Blain soil to determine their persistence, productivity and contribution to the performance of cattle.

The trial has shown the importance of a companion legume with the tropical perennial grass species. Results from across all years of the trial have shown the best live-weight gains (LWG) are achieved from the three grasses (sabi (*Urochloa mosambicensis*), buffel and pangola) with leucaena. The next best treatments for LWG were buffel–legume (Oolloo, Blue pea) mix pastures; the grass only pastures produced the least LWG. (Lemcke 2009).

Shotton 2010 (unpublished data) concluded that the 12 year annual average LWG per head over all pasture types was 175 kg with a range of 128 kg (pastures Tully and Wynn cassia) to 222 kg (buffel and leucaena). More recent results from this study will be discussed in Part 3.

The adoption of many pasture species and pasture management practices by industry (as described below) came directly from research trials and extension activities at DDRF. Common grass pastures types used in Douglas Daly and Katherine – Daly districts include buffel, Jarra, Strickland, Sabi, Signal and Tully. Cavalcade, Oolloo, Verano, Seca, Blue pea, Wynn cassia and leucaena are the most common legumes.



Figure 10. Cattle grazing on improved pastures in the late wet season

2.3.1 Pasture varieties

Pasture variety and growth trials were assessed using plant introduction trials from 1973 to 1986 (two sites) on Blain and Tippera soils, where 41 different grasses and 140 legume lines were evaluated. Shrub legumes have also been evaluated on Blain soil.

Cameron et al. (1984) found the best grass species included three *Andropogon gayanus* lines, four lines of *Hyparrhenia* sp, *Eragrostis superba* and one line of *Dactyloctenium*. The best legumes were *Clitoria ternatea*, *Stylosanthes hamata* and *Stylosanthes scabra*, *Centrosema pubescens*, *Celopogonium mucunoides*, *Cassia rotundifolia* (Wynn), *Aeschnomene* and *Vigna* spp.

Nutrient concentrations of pasture species of different pastures and fodder crops from a number of locations in the Top End (Daly Waters, Victoria River Downs, Douglas Daly, Tipperary, Coastal Plains and Darwin) were assessed (Cameron 2001a, b).

2.3.2 Pasture/legume

A non-grazed trial (1998-2000) studied the performance of pasture legumes sown into established buffel grass to measure the dry matter yield and pasture quality changes of the buffel and legume mix compared with grass only and applied N. Shotton (2000a) found applied N gave the highest biomass and Ooloo produced the most legume biomass.

These results were assessed again in a grazing trial (2000-08) to monitor the sustainability of the companion legume under constant grazing. Shotton (2009a) found some legume species were close to have died out completely from the trial area (blue pea and Maldonado) while others (Wynn and Ooloo) maintained levels or have spread outside the original plots.

2.3.3 *Centrosema*

Centrosema evaluations were carried out in the Douglas Daly district with 20 accessions representing four *Centrosema* species (*C. brasilianum*, *C. pascuorum*, *C. plumieri* and *C. pubescens*) being planted in December 1989.

In work at Ruby Downs Station, Cameron (1991a) found that all the *C. brasilianum* lines survived; however, most other lines did not survive the dry season. The highest yielding lines were *C. brasilianum*, CPI 92956, 92946, 55696, 55698, and *C. pascuorum* CPI 94292, all yielding greater than 1.0 t/ha.

At the Kumbyechants site the *C. brasilianum* lines averaged four plants/m² and *C. pubescens* five plants/m². The six *C. pascuorum* lines yielded between 2.3 and 3.2 t/ha of the sown legume, while five of the *C. brasilianum* lines yielded between 1.4 and 1.6 t/ha. The *C. pubescens* and *C. plumieri* lines yielded less than 0.7 t/ha.

Over the three years of the trial none of the new *C. pascuorum* lines yielded more than Cavalcade. The *C. brasilianum* lines showed promise as new pasture cultivars due to their perennial nature. *Centrosema* remains an important pasture legume in the region and the Top End for fodder production and grazing.

2.3.4 Blue pea

In 1988 a number of *Clitoria ternatea* (blue pea) introductions were also assessed. By October 1990 an average of two plants/m² had survived at both sites. The dry matter yields in May 1991 averaged 1.1 t/ha at Kumbyechants and 0.6 t/ha at Ruby Downs. Cameron (1991b) found no outstanding lines over the three years of the trial. Some of the lines which grew well in this trial were CPI 47187 (1500 kg DM/ha) and 48337 (1000-1100 kg dry matter (DM)/ha) and were components of the composite line released in Queensland as cultivar Milgarra.

Blue pea is not currently grown on a commercial basis but trials have shown that it is successful as a sustainable companion legume in buffel and other improved/introduced grass species.

2.3.5 Wynn cassia

An evaluation of Wynn cassia for hay or standing pasture was made at DDRF and the Douglas Daly region through a Douglas Daly producer initiated research and development project (PIRD). The project ran for two and a half years and included data collection and observations from DDRF, Midway, Bonalbo and Maneroo stations. Data collections included cattle LWG, herbicide resistance, protein, digestibility and energy levels of Wynn, the forage quality of Wynn, hay and pelleting properties, and fertiliser responses to Wynn and companion grasses.

The Wynn cassia Douglas Daly PIRD project concluded in November 2003, with Wynn cassia being an easy to establish, highly persistent, dominating legume of low palatability and low grazing value on fertile soils [in the Douglas Daly area]. It may have a role in soil conservation and may also have potential for hay and pellet production. The LWG of cattle grazing pure Wynn pastures at DDRF and Midway Station was 20 to 30% less than on other improved pastures evaluated under similar conditions.

Wynn cassia has been extensively planted in the Douglas Daly and the NT, although specialised management of this pasture species is required to prevent this species dominating mixed pastures.

2.3.6 Soil fertility

The DPIF Pastures Section conducted several trials in the Douglas Daly region in the 1980s–90s including soil fertility studies on the Tippera and Blain red earths at DDRF and yellow earths at Kumbychants and Middle Creek stations. Trial objectives were to look at the growth and yields of Verano, pangola (*Digitaria eriantha*) and *Centrosema* spp. using different applications of P and S plus Zn and molybdenum (Mo).

DM yields increased from 1200 kg without applied P to 3900 kg at 60 kg P/ha. Yield was increased from 1800 to 2700 DM/ha with S application, but yields were independent of rates of application.

Fertiliser trials (DPIF 1988) were set up on Tippera soils at Fenton and Ceres Downs in 1987 to examine the effect of added P and S together and Zn on its own on a Verano pasture.

S gave a response at all rates of application at Fenton but only where 20 to 30 kg S/ha had been applied at Ceres Downs. The reverse was the case for P with a linear response up to 45 kg P/ha at Ceres Downs and response only between 30 and 60 kg P/ha at Fenton. There was a small response to 5 to 20 kg of Zn.

2.4 WEED CONTROL

Crop and pasture weed control has been an ongoing issue within the Douglas Daly and the Top End with control methods being pre- and post-emergent herbicides, crop rotations and farming systems, varying amounts of mulch cover with no-till planting, herbicide wiping, mechanical slashing, spot spraying, hand weeding and biological control.

Most of the research carried out at DDRF has been focused on the method of controlling and managing weeds within a crop or pasture and not targeted at particular weeds species except in the case of the biological control of sida and Noogoora burr.

The screening of herbicides for weed control in various crops and pastures has also included the monitoring of some chemical movement through the soil profile (particularly Atrazine). This work provided important information to assist with weed management and improve the efficiency of the products but also identified the potential environmental impacts the chemical may have.



Figure 11. Herbicide wiping of broad leaf weeds

2.4.1 *Sesame*

A number of herbicides and application rates were trialled over several years to assess their effects on weeds in sesame crops. It was found that Dual® (S-metolachlor) performed well and Linuron® at 1 kg/ha produced an excellent result.

Martin (1996) found Trifluralin in 1992-93 was toxic to sesame at all rates, probably because it was not incorporated to a great enough depth and rain immediately after planting established harmful levels in the germination zone. In 1993-94 Trifluralin at 4 L/ha had no effect on sesame.

2.4.2 *Cavalcade*

The efficacy of Spinnaker® (Imazethapyr) and Flame® (Imazapic) on weeds in Cavalcade when applied at different times prior to the onset of the wet season has been studied. Eastick (2004a) found at the initial harvest that the most recent application of Flame® at rates of 400 mL/ha and 800 mL/ha, and Spinnaker® at the high rate of 280 g/ha caused a decline in Cavalcade yield compared with the Spinnaker® low rate (140 g/ha) and control plots. By the time of final harvest, this decline was only observed in the high Flame® application plots.

The control plots from the herbicide trial, which had high grass weed establishment, provided an ideal opportunity for an evaluation of grass selective herbicides. Weed control with all the pre-emergent herbicide treatments was unsatisfactory possibly due to high rainfall soon after the pre-emergent herbicide application.

The early post-emergence application of Spinnaker® produced excellent results, and appeared to cause no damage to Cavalcade, although grasshopper damage confounded observations of crop vigour.

Eastick (2004b) found the best grass weed control was with Verdict® (Haloxypol) at 200 mL/ha, especially on the more advanced grasses, although there was some variability of control of *Brachiaria pubigera*. Falcon® (S-metolachlor) and Fusion® (butoxydim/fluzifop-P) also produced excellent control, however Fusilade® (fluzifop-P) was less effective, especially at the lower rates applied.

Further trials conducted by Eastick (2004c) on Tippera soils demonstrated a "best bet" pasture rehabilitation/weed management strategy on a severely weed infested Cavalcade paddock. The demonstration strips indicated that Spinnaker® again was the best pre-emergent herbicide for Cavalcade, and that during post-emergence, the addition of the adjuvant Hasten® (methyl and ethyl oleate adjuvant) produced the best weed control.

2.4.3 *Sorghum*

Weed control in no-till grain sorghum crops investigated weed management practices that included plant population, row spacing, mulch cover and mulch type. The main findings by Yeates (1994) were that the correct mulch cover at planting was sufficient to deter weeds from establishing and with the correct sorghum populations and nutrition, the sorghum crop could out-grow and shade out most broad-leaf and grass weeds.

In 1995, the differences between Dual® (metolachlor) and Atrazine activity and movement in the soil in no-till and conventional till sorghum crops were assessed. There was no significant difference in sorghum biomass between the treatments, but initial sorghum establishment was variable.

Weed control was best in the Dual® treatment for both tillage treatments with conventional till reducing the most weeds. Eastick (1997) found that sorghum plant mortality was least in the control plots (no Atrazine applied), and the most number in the 6 L/ha Atrazine treatment.

There was a significant difference in sorghum mortality between the 4–6 L/ha Atrazine groups and the 0-2 L/ha. The difference between the number of plants between no-till and conventional till treatments was consistent with higher sorghum plant mortality in the no-till compared with conventional till treatments.

The effects of weed competition on sorghum yield were assessed for weed composition effects and control options. Martin (1996) found the effect of weed biomass on total crop, grain and yield was linear. That is, as weed biomass increased, crop yield decreased. For example, a 1% increase in weed biomass decreased crop yield by 1%. This is an important result since it suggests a general relationship, that is, the relation holds irrespective of site and/or weed differences. A similar result was found with the relationship between weeds and sesame yields.

2.4.4 Biological weed control

Biological weed control methods have also been investigated in the Douglas Daly region, such as the sida leaf beetle (*Calligrapha pantherina*), which defoliates the sida (*Sida acuta*) plant and can reduce its seeding ability. The sida leaf beetle was first released onto sida plants in September 1989 at Finniss River Station and subsequently at several hundred sites in the NT, either directly from laboratory cultures or from field collections.

Population increases in the field at times were dramatic, but dispersal from the point of release was slow. Populations have become more widespread with each succeeding wet season, but dry season survival is challenging. At DDRF the beetles spread throughout the farm and the surrounding region with varying numbers of beetles found each year.

In the 1990s the behaviour of beetles during the dry season was examined including their survival under different conditions, with the aim of developing a management plan for landholders to follow. During field studies, using insecticides to maintain some plants insect free, Flanagan (1992) showed that beetles can reduce seed production in spiny head sida by over 90%. This can lead to a more than one third reduction in plant density in one year.

2.4.5 Herbicide wipers

In most cases, selective chemical weed control is available by spraying in single crops and pastures; however, grass, broad leaf and legume weed control in mixed crops and pastures is more difficult. Various methods and chemicals have been trialled using herbicide wipers and mechanical methods such as slashing.

Herbicide wipers are a useful method for managing taller weeds in crops and pastures. Price and Shotton (2006) described how success depends 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, are commonly used to reduce plant biomass and damage to the plants to reduce competition, whilst also reducing weed seed production.

Different chemicals, surfactants, application rates and timing of application have been trialled using herbicide rollers and monitoring the effectiveness on a wide range of broad-leaf and grass weeds. The effectiveness was evaluated using botanical surveys to determine weed reduction over time.

The most widely used chemical has been glyphosate with 0.1% LI 700® (propionic acid/soyol phospholipids) and 0.25% Uptake® (paraffinic petroleum oil) wetter. The major contributing factor has been the height and density of the weed mass.

Eleven different chemical mixtures were trialled with a herbicide roller in 2001. Shotton (2001) found that glyphosate at 10 to 1 with both surfactants produced a 100% kill on sida and flannel weed (*Sida cordifolia*); however, all other treatments gave a 33% to 80% kill on both weeds. Gooseberry (*Physalis minima*) was controlled by all treatments. All chemicals used affected hyptis (*Hyptis suaveolens*) with six of the treatments giving 100% kill.

Senna (*Senna obtusifolia*) was the most difficult plant to kill with only Tordon 75-D® (2, 4-D/picloram) producing an 80% success rate. Pennisetum was only affected by treatments containing glyphosate.

Shotton (2002a) found in a later herbicide wiping trial at Ruby Downs Station that glyphosate at 1 : 5 (1 L product to 5 L water) with 1% LI 700 gave the best control of sida (84% kill) and the second highest for

Senna (72% kill). Grazon® (triclopyr/picloram) at 1:15 plus 2% wetter gave the best result on Senna (76% kill).

2.4.6 *Native regrowth*

Control of native regrowth is sometimes required after mechanical clearing of native growth for improved pasture production due to sucker re-growth from root stocks and seed banks. Other broad-leaf and grass weed invasion generally occurs after clearing and ground disturbance. The presence of these unwanted species reduces pasture production and creates problems in pasture maintenance and management.

Several trials to monitor and record the short and long term effectiveness of sucker regrowth control methods in improved pastures using herbicide soil pellets and herbicide wipers have been conducted within the Douglas Daly.

As discussed previously, the benefit of herbicide wipers is that the chemical is applied only to the targeted plants, thereby reducing waste, using non-selective herbicides and eliminating spray drift. Bonalbo Station trials found the most effective chemical for sucker re-growth when using a wiping method of application was Grazon DS® (15 parts water: 1 part product).

The application of Graslan® (Tebuthiuron) pellets has been assessed as an alternative method of controlling native regrowth and woody weeds in pastures. Graslan® is applied to the soil surface and sufficient rainfall is needed to incorporate the chemical into the root zone, which is then taken up by the target plants. Graslan® pellets have been extensively used in other states; however, there was limited information on its effectiveness in the NT.

Trials of the application of Graslan® pellets conducted at DDRF, Bonalbo, Stray Creek and Kumbyechants stations in 2004, gave mixed results. Shotton (2005b) found the effectiveness of the pellets at Kumbyechants was very poor with little control of native shrub regrowth. Application rates of 15 and 20 kg/ha on Bonalbo gave reasonable results controlling a number of native species although the higher rate also killed some grass species. The Stray Creek trial had a very successful kill-rate of 99% of the black wattle with rates of 10 and 15 kg/ha.

2.5 TILLAGE METHODS

One of the major successes of crop research between the 1980s and 1990s, was the development of conservation farming and no-till planting techniques which potentially improved crop yields, reduced the risk of soil loss, improved soil health and moisture retention and reduced soil surface temperature and crusting. (Thiagalingam et al. 1996).

Global climate change and the storage of carbon in plants and soil is becoming an important issue and producers may need to improve their skills in conservation farming to remain productive. The risk of erosion is increasing with more intensive rainfall events combined with the risk of drier or more unpredictable weather patterns and the high possibility of hotter temperatures.

An extensive series of trials were conducted at DDRF analysing no-till planting practices to determine the benefits, costs, management issues, machinery required, effects on yield, and longer term changes to soil and plant composition. No-till planting practices have also been trialled and monitored on fodder crops, fodder tree production and grass pastures.

No-till cropping has been widely adopted by industry in the Douglas Daly and Top End due to excellent results from this planting and cropping system and the reduction in soil erosion.



Figure 12. No-till planting of forage crops

2.5.1 Rotation of tropical grains under different tillage (ROTGUT) methods

The ROTGUT trial, (1984 to 2000) investigated the effects of conventional tillage and no-tillage cropping practices on a Tippera soil studying soil properties, weed populations, grain yields and insect populations. Tillage trials were also carried out on the Blain soils that examined yield and plant growth, row spacing, plant population, weed infestation, mulch cover and management, soil health, nutrition requirements and pest management.

After 15 years, the no-till areas had visibly less weeds than conventional tilled areas; however, soil surface compaction in no-till over time resulted in poor plant establishment and growth. Thiagalingam et al. (1996) found that the conventional till areas became increasingly weedy, particularly with nutgrass (*Cyperus rotundus*), summer grasses (*Digitaria* spp), Senna, Sida and buffalo clover (*Alysicarpus vaginalis*).

Crops in both treatment areas experienced different problems. The no-till areas required adequate moisture for the planter to work correctly, whereas too much moisture in conventional till reduced the areas to mud and made them un-trafficable.

Thiagalingam et al. (1994) found that grain yields of the five maize and soybean crops and the one sorghum crop under the no-till treatment were 33%, 31% and 12%, respectively higher than under conventional till. Similar results were obtained from further sorghum, grain legume and legume hay crops.

Results from the maize–soybean rotation showed that organic carbon, total N, available Ca, Mg, Zn, copper and P levels were 7% higher under no-till than under conventional till at the soil surface (0 to 5 cm).

During the 1995-96 and 1996-97 seasons, the DPIF Entomology Section evaluated pest levels. The first season showed the incidence of insect damage of sorghum was higher in the no-till plots (20.1% plants damaged) compared with the conventional till (3.8%). The second season showed similar results in a Cavalcade fodder crop where the no-till areas had 16.4% of plants damaged compared with 5.4% in

conventional till areas. From this study Young (1988) concluded that no-till plots suffered more insect damage than the conventionally tilled plots.

2.5.2 *No-till planting equipment*

No-till planting equipment for grain crops was investigated at DDRF after extensive trials of planters in Katherine. Two videos, “*Adding the Jam*” (O’Gara 1994) and “*To Till or Not to Till?*” (O’Gara 1995) were produced by the NT Government to demonstrate the practices and details of no-till and conservation farming methods. The book “*Striking the Balance*” by Fergal O’Gara (1998, 2010) highlighted aspects of conservation farming, farming systems, improved pastures and pest management for the semi-arid tropics of the NT.

2.5.3 *Soil erosion*

A great deal of time, money and effort has been devoted to tillage systems research to minimise soil erosion and promote sustainable methods of cropping and rotations in the Top End. The collaborative project “*Croplands Erosion Research Project*” reported by Dilshad et al. (1996) showed the no-till treatments had 1.5 to 2 times less water runoff than the conventional till treatments with less soil loss.

Jayawardhana (1998a) utilised the site again with the “*Land Management for the Semi Arid Tropics*” trial (LAMSAT 1991–95), which was to determine the effect of various stocking rates on soil movement. It also looked at cattle live-weight gain grazing improved and native pastures and observed the impact of the various stocking rates on the pasture system.

Following on from this research the LAMSAT modelling program was developed to predict animal production and soil erosion for tropical pasture systems in the NT. In 2004, the model was fully operational but was not being used or being developed further.

2.6 AGROFORESTRY

Agroforestry has been researched at DDRF since the early 1990s and with the emergence of African mahogany tree on investment properties within the Douglas Daly district, research has been conducted off-farm as well.

In 1998–2000 the Murambini Company conducted trials at DDRF to measure the growth rate of eucalypt hybrids and *acacia* spp on three different soils, Blain, Tippera and Yellow Earth. No data from this trial is currently available.

2.6.1 *Trees for shade and timber production*

In 1995, the evaluation of a number of potentially productive tree species for their suitability for shade and timber production in the NT commenced. This was a joint project involving Greening Australia and DPIF to evaluate the establishment of a number of potential timber-producing species at DDRF and to demonstrate the use of agroforestry principles in the dry tropics of the NT.

Reilly (2001) planted 960 trees for timber, shade and fodder in a trial with and without irrigation and with various spacing in 1995-96. The dry-land component of this trial was abandoned in October 1998 due to poor performance at this site. The surviving species ranged in height between 0.6 and 2.6 m with survival rate from 13 to 83%.

Trials were established to evaluate timber production levels on various soil types of selected species and further introductions under differing management regimes. The success of establishment, persistence and

growth rate is being monitored. The trials at DDRF and Berrimah Farm will be utilised for research and demonstration purposes.

2.6.2 Fodder trees

A range of specialist fodder trees and shrubs, 24 in total, were planted in December 1995. Six months after planting assessments of the performance and suitability to the environment were made. Assessments were based on height and a visual assessment of vigour, insect damage and survival in the first year. Approximately one third of the species planted had not survived the first dry season (Reilly 1995a).

After two wet seasons, the paddock was grazed as part of the Species Grazing Trial to monitor grazing preferences, persistence and animal performance. By 2002 only eight species of the 24 had survived with only 30-40% of the original trees persisting in some cases.

Only five of the original 24 species plots were remaining in 2008 with *Albizia lebbbeck*, *A. richardiana* (both with 30% survival), *Enterolobium cyclocarpum*, *Peltophorum pterocarpum*, *Samanea saman* (50, 60 and 100% survival, respectively). Shotton (2010 unpublished) reported that all remaining species have grown out of the browsing zone and largely act as shade trees now.

2.6.3 Teak

Propagation methods to determine the most suitable for teak (*Tectona grandis*) production were also investigated by Reilly (2003). The first plantings of teak occurred in December 1998 and the second in January 1999. Survival and initial growth measurements from the propagation methods using 1-L bags and Plantek trays were very successful (100% and 95% respectively).

2.6.4 African mahogany

In 2000 a small plantation of African mahogany (*Khaya senegalensis*) was established under irrigation on a Blain soil as one of four clone test sites using rooted cuttings taken from the Berrimah Farm hedge gardens, seed collected from locally grown trees and striplings from the same 10 sites in the hedges. Results will be available in the future.

Due to the expansion of the African mahogany investment properties in the Douglas Daly district, research into tree improvement program continues and is discussed in Part 3.

2.7 CATTLE

Since the 1970s DDRF has maintained a breeder herd to examine production parameters in order to improve overall production. This large on-going project is made up of a number of experiments and demonstrations. In 1987 the herd consisted of 200 breeders and was maintained totally on improved pasture of pangola, signal (*Urochloa decumbens*), buffel, Verano and Wynn cassia in a rotational system with supplement blocks available *ad lib* all year. Mating was restricted to a maximum of 13 weeks from January 1 and early weaning was in May when average calf age was 180 days.

A working group was established in 1994, consisting of three members of industry, the DDRF manager and the senior project officer, to coordinate sub-programs and demonstrations using the breeder herd. A number of experiments were carried out, including effects of yearly mating on herd productivity, effect of early weaning, effect of extended mating period, production of aged cows, bull performance and parentage determination, homebred bulls demonstration and a bovine ephemeral fever (BEF) vaccination trial (1995-1997). There have also been numerous additional cattle research trials, including a breeding herd program, the use of sentinel cattle, a crossbreeding program, feeder steer production, nutrition and fertility studies.

In 1996, the herd joined the Brahman Breedplan through the Australian Brahman Breeders Association and the National Beef Recording Scheme. By 1999 the herd had increased to 300 animals which included 50 yearling heifers that were joined each year. After joining, all empty animals were culled to reduce the herd back to 250 prior to the introduction of the yearly heifers. This project demonstrated the operation of a management system where only productive animals are kept each year.

The success of the DDRF Brahman improvement program was shown by the improvement in average days to calving and reproduction traits (scrotal circumference) with increases in the estimated breeding values (EBV). Jayawardhana (2007) reported that the DDRF Brahman herd in 2006-2007 was the highest rated herd of all the herds on the Brahman group Breedplan for these traits that year.

Cattle production is the main focus of the agricultural sector in the Douglas Daly region and the beef industry is the largest agricultural sector in area and financial terms in the NT (\$343.8 million in 2008-09). Many of the practices outlined in the following sections, have been adopted by industry.



Figure 13. Cows and offspring

2.7.1 Crossbreeding

In 1993, a crossbreeding evaluation trial at DDRF using Brahman, Boran and Tuli cattle breeds commenced to assess the progeny produced by artificially inseminating high grade Brahman cows with semen from Boran, Tuli and Brahman sires. Their growth rates and ability to meet South-East Asian live feeder steer export specifications and the local table beef trade was assessed. The reproductive ability of the female progeny was also monitored.

The Boran is an African *Bos indicus* and was reported to be well-adapted to tropical environmental stress as well as being highly productive. The Tuli is an African Sanga breed aligned to the *Bos taurus* type in terms of fertility and temperament while reputed to have the resistance to environmental stress of *Bos indicus*. These animals were imported by a CSIRO led consortium.

Jayawardhana et al. (1994) found the Tuli crosses had marginally higher weight gain than the Brahmans which were slightly higher than the Boran crosses. The carcass data between breeds was similar with the Tuli having a slightly larger eye muscle area. The Boran crosses finished at a lighter weight than the others.

Jayawardhana (1995a) mated the heifers from this trial as yearlings for three months. The pregnancy rates of the Tuli and Boran crosses at such light joining weights (221 to 307 kg) as yearlings supported their reputation as highly fertile animals. The Boran crosses had more problems with dystocia, and the Brahman with calf losses, while the Tuli crosses had no problem with either. If just the pregnancy rates are considered without taking account of losses, the Borans had the highest over the three years, next best the Tulis and then the Brahmans.

Another multi-breed composite breeding program at DDRF measured the relative growth, reproductive performance and carcass characteristics of interbred progeny of some tropically-adapted multi-breed crossbred bulls mated to Brahman cows, compared with progeny of Brahman bulls mated to Brahman cows. The program also assessed Brahman performance in reproduction and growth while minimising mature weight.

The program commenced in 2003 when a composite of 56.3% Brahman, 12.5% Africander, 12.5% Tuli, 6.3% Shorthorn, 6.3% Hereford and 6.3% Charolais was compared with the Brahman. This cross gave a mix that is 81% tropically-adapted and 19% un-adapted *Bos taurus* and was expected to retain about 64% of heterosis in the second generation onwards.

Multi-breed composites retain more heterosis (hybrid vigour) in future generations than do the old-style two-breed animals such as Droughtmasters, Braford's and Charbrays. Multi-breed composites also combine the good characteristics of different cattle types more and are expected to be more suitable for meat quality-based markets than Brahmans.

Jayawardhana's (2007) results from the breeding program showed that the composites achieved high pregnancy rates at very light weight ranges. The selected Brahmans also seem capable of becoming pregnant at lighter weights than the original Brahmans as a result of selection for fertility.

2.7.2 Bull fertility

Pre-mating predictors of a bull's fertility and their relationship to actual calf producing ability using DNA fingerprinting, serving capacity tests, and semen evaluation was assessed at DDRF from 1995. The results showed that the older bulls did not perform well in serving capacity tests.

Jayawardhana (2000) found the bull which fathered the fewest calves had a high serving capacity but had semen which was graded as doubtful using the Bull Breeding Soundness Evaluation (BBSE) system. BBSE takes into account the scrotal circumference, semen motility and percentage normal sperm. All other high scoring bulls fathered a reasonable proportion of the calves, but one of the low scoring bulls also sired a large proportion of the calves.

Homebred bulls

A homebred bull demonstration ran from 1995 and 1998 with 28 to 52 bull calves kept entire at branding. They were initially selected on Brahman content, conformation, presence of two palpable testicles, temperament and colour with the final selection done prior to mating on 400-day weight, testicular circumference, semen test results and negative Pompe's carrier status. The best 10% of these young bulls were used in the herd. This low retention rate gives a high selection intensity to maximise genetic gain.

Jayawardhana (2000) noted that one of these bulls, DDRF 4017, had exceptional figures. His 400-day weight EBV's were within the top 10 on the 1998 Brahman Group Breedplan Sire Summary. The retained

local bulls had an average 400 day weight EBVs 9kg heavier and scrotal circumference EBVs 1.7 cm larger than the average of the bought bulls used since 1994.

2.7.3 Early weaning

To study the effect of early weaning at DDRF in 1995-1998 cows were allocated to early or normal weaned groups with early weaning occurring in April. The difference in pregnancy rate and the difference in growth rate of the calves were assessed. The effect on first calf heifers was monitored with particular interest, as they have been the group with lowest pregnancy rates in the past.

The average pregnancy of early-weaned cows over the three-year period was 95% versus 91% in the normally weaned controls. Jayawardhana (2000) found the early weaners were constantly lighter than the normal weaners as indicated in May 1995 (19 kg lighter), February 1996 (16 kg lighter), May 1996 (26 kg lighter) and in April 1997 (12 kg lighter).

In 1995, 4.5% of the early weaners died of coccidiosis compared with no losses in the late weaned calves. Coccidia and worms were not controlled as one of the objectives was to monitor the parasite status of untreated weaners. By feeding an Olson's Weanermaster block containing monensin, a minimal coccidia control was achieved resulting in less mortality in the early weaners. This suggested that coccidia control is vital when early weaning.

2.7.4 Yearly mating

The effect of yearling mating on herd productivity (1994-2000) was studied by comparing management systems in which heifers were first joined either as yearlings or as two-year-olds. The yearling heifers were artificially inseminated before mating and were joined to yearling local bulls at a rate of 10% bulls. The yearlings and two-year old animals that did not become pregnant were culled.

Jayawardhana (2000) found that yearling mating should only be considered under very well managed conditions, as these animals were very sensitive to poor nutrition. Southern research indicated that heifers on adequate levels of feed over the first two trimesters of pregnancy have the lowest levels of dystocia. If it is possible to solve the dystocia problem, yearling mating has the potential to produce a major increase in herd efficiency as it means all the females in the herd are productive, thereby increasing feed efficiency.

During the six years of the study, 272 heifers were assessed; the average joining weight was 254 kg (range 222 to 271 kg), average yearling pregnancy rate was 57% (range 40 to 69%) , dystocia rate was 21% (range 11 to 31%) and the pregnancy rate of lactating cows was 70% (range 46 to 88%).

2.7.5 Extended mating

The effect of an extended mating period was also studied at DDRF by extending the mating period to four months from the first week in January to the first week in May. The effect on production was compared with the three-month mating period used in past years. Jayawardhana (2000) found that the pregnancy rate of the cows under an extended mating system in the absence of early weaning was 89% (1995, 1996) and 95% (1997) which was equal to the best pregnancy rate gained under the three month mating period.

2.7.6 Aged cows

Jayawardhana (2000) also assessed the productivity of aged cows by not culling them on age but by keeping them in the herd until they missed or lost a calf, had calving trouble, or died. The mortalities and fertility of these cows were assessed to see how long productive Brahman cows can be kept and produce calves.

The pregnancy rate in aged cows, over nine years old, was quite good except in 1994 when a feed shortage during the mating season caused a severe reduction in pregnancies (aged cows nine to 12 years). The oldest cows assessed were 17 years old.

In the six years from 1995 to 2000, the annual cull rate for functional problems such as losing a calf, being non-pregnant or having a semi-functional udder was in three to nine years of age (966 records) – 12%; 10 - 13 years of age (221 records) – 19%; and 14 - 17 years of age (30 records) – 43%. This data indicated that, in this environment, 13 years might be a good time to cull for age.

2.7.7 Bovine ephemeral fever

The bovine ephemeral fever (BEF) heifer vaccination study at DDRF (1995-1997) was to assess the effect of BEF on yearling heifer pregnancy rates and if vaccination could improve the problem. No significant differences in pregnancies were seen between the treated and non-treated groups during the study. La Fontaine (1997) observed a high level BEF activity in sentinel and commercial herds, right across the NT, including clinical cases south of Alice Springs. The 1996-7 results suggested that there may be a weight gain advantage from vaccination against BEF in years when the disease is highly active.

2.7.8 Feeder steer production

Feeder steer production systems have been evaluated since 1992 utilising a famlet system whereby stock from the Gulf and VRD were finished off on planted buffel pasture at DDRF. Ridley and Schatz (2005) ran various sub-programs during this time measuring the effects of different stocking rates (4) and genotypes (2 – Brahman and 25% Charolais); genotypes (3 – Brahman, 25% Charolais and Droughtmaster) and sex (3 – bulls/steers, steers and heifers) and responses to dry and wet season supplementation.

Ridley (2004) observed that various results from the different sub-programs showed that in comparison to Brahman steers, when slaughtered at the same fatness, ¼ Charolais steers had a 10% weight advantage, Brahman bulls a 15% advantage and ¼ Charolais bulls a 28% advantage. Steers grew more (12%) and were leaner (2.6 mm less P8 fat depth) than the heifers. Animals that grazed at lower stocking rates gained more weight but were not significantly fatter than those at a higher stocking.

Supplementation

Results from the feeder steer production trial also showed the benefits of supplementary feeding between wet seasons only, dry season only, all year round and no supplementation using Uramol® and Phosrite®. Not providing Uramol® supplementation reduced growth in the dry by 12.3 kg but the residual response in feeder heifers by the end of the wet was minor.

The results indicated Uramol® is unlikely to be cost-effective as a dry season supplement for cull heifer weaners; however, other data collected at DDRF suggested some potential benefit. A +12.3 kg/head response to Uramol® in yearling heifer weaners could be associated with a 7-8% improvement in conception rate (Ridley 2004) and in such circumstances the use of Uramol® would be cost-effective.

Ridley (1997d) found failure to provide Phosrite® in the wet resulted in a significant reduction in both total empty live weight gain (ELW) and post weaning efficiency (-25.4 kg/head and -33.2 kg/ha, respectively). With the 1/4 Charolais heifers, no supplementation resulted in a 49.5 kg/head less ELW gain over the year. The effect of not providing Phosrite® (45.5 kg/ha loss) was nearly five times as great as not providing Uramol® (10.2 kg/ha loss).

Weight loss during transport

Transport to wharf weight losses measured the effect of alternative pre loading regimes (3) on live weight losses between the origin and arrival at the live export loading facility. The feeder steer project at DDRF

provided a source of suitable cattle and a dummy trip of 500 km on bituminised roads was used to simulate the stress and duration of a hypothetical trip.

The first treatment was to muster on day 1 at 3 p.m., weigh, hold overnight with access to water only, weigh at 8am, load and transport for 500 km, unload and immediately weigh. The second was to muster on day 1 at 3 p.m., weigh and turn out to graze. Muster on day 2, weigh at 8 a.m., load and transport for 500 km unload and immediately weigh. The third was as in treatment 1 but stock was provided with *ad lib* pangola hay over night before the 8am weighing. This was carried out in February and repeated in March with the steers in treatments 2 and 3 being changed over to provide an unreplicated Latin square design. Each treatment comprised six steers of 325 kg average weight.

Ridley (1997e) found there was a significant difference in the weight loss between treatment 1 and treatments 2 and 3 (-18 kg vs. -34 kg and -31 kg), with no advantage to the group fed pangola hay overnight.

2.7.9 Fertility

Fertility is another aspect of cattle production which has been investigated at DDRF in conjunction with studies in other areas. The low re-mating conception rates in lactating first calf heifers has been recognised as one of the biggest areas of inefficiency in northern Australian breeding herds. The project "Understanding and improving heifer fertility in the NT" commenced in 2004 will be discussed in more detail in Part 3.

2.8 FARMING SYSTEMS RESEARCH

Research on farming systems was initiated in 1988 to identify sustainable farming systems on Blain soils in the Douglas Daly Basin. It was believed that the development of mixed farming operations was necessary for the viability of the grain industry in the Douglas Daly.

This work comprised a series of research projects aimed at integrating crops, cattle and pastures to include the best system that combined the relevant technologies in terms of crop, animal and pasture production.

The predominant farming system used in the Douglas Daly region has evolved based on beef production with fodder crop production used in rotation with grazing pastures.

2.8.1 Cattle/buffalo on sorghum

In 1988 the LWGs and carcasses of cattle and buffalo after grazing sorghum stubble were studied. A combination of buffalo and cattle were randomly assigned to recently harvested sorghum paddocks at a stocking rate of 1.4 head/ha and rotated between paddocks over three weeks for 18 weeks.

Initially growth rates tended to be higher in buffalo than cattle, but buffalo had a lower carcass dressing percentage (46 vs. 49%), less fat cover (3 vs. 4 mm) and smaller eye muscle area (39 vs. 52 cm²). The mean comparable carcass prices in the NT for 1989 were \$2.00 per kg for trade steers and \$1.70 for 200 kg buffalo steers.

Rann (1991) found cattle gained more (0.31 vs. 0.10 kg/d) over the trial period, but most of their weight gains occurred in the first six weeks (25.7 v 10.8 kg/head). It was observed that cattle actively selected regrowth and late maturing heads while the buffalo did not. Over the whole trial cattle proved more profitable.

After six weeks the quality of the stubble had declined and the amount of available regrowth and sorghum heads had become negligible. For the last 12 weeks of grazing (July-October) the buffalo showed the benefit of their better feed conversion of low quality roughage and out-performed the cattle (9.5 v 2.3 kg/head). For this period the value of the buffalo carcass increased by \$7.43 compared with only \$2.25 for cattle.

2.8.2 Pasture/cereal/cattle

From 1994 to 2000 a longer term farming system trial was carried out to evaluate a sustainable agricultural system which integrates a pasture phase grown in rotation with a cereal crop phase and incorporates cattle production. Legume ley pastures, sorghum grain production, stubble mulch, organic matter management and conservation tillage are keys to the development of a sustainable farming system in the Top End.

N fertiliser is the single largest input required to produce grain sorghum and quality feed for cattle and in order to reduce the cost, legumes are used. The objective of this trial was to develop a self regenerating pasture legume/cattle/cereal/no-tillage system that would not only provide quality dry season feed for cattle, but would also improve soil fertility, soil moisture conservation and the system's sustainability.

It was shown that in the dry season, the best LWG/ha and per head were achieved from sorghum stubble paddocks while the Cavalcade only pastures generally gave the least LWGs. Shotton (2001a) found the higher stocking rates (2.25 head/ha) gave the best LWG/ha while the lower stocking rate (1 head/ha) generally gave the better LWG per head. On a few occasions, the higher stocking rate paddocks had to be de-stocked earlier due to depletion of feed. Higher grain sorghum yields were generally achieved following Cavalcade only pastures.

2.9 OTHER RESEARCH PROJECTS

Over the years other organisations and individuals have carried out a wide range of research projects on the property. For example, many detailed studies have been carried out on feral pigs, Kori Bustards, pig-nosed turtles and snails found around the rivers. NASA carried out a study on the nature of lightning strikes. NRETAS Water Resources have been monitoring the rivers and bores for a number of years as well as other organisations monitoring water quality including rain, bore and river quality.

3 RECENT AGRICULTURAL RESEARCH

There has been a dramatic change to the agricultural diversity of the Douglas Daly since the area was opened up in the 1980s. From the early cropping era to the later cattle era, the district has progressed to a broad range of agricultural production. Government restrictions on land clearing within the Daly Basin have added to the diverse nature of the area.

Cattle, mahogany, melons, turf, hay and fodder make up the agricultural diversity of the region. Research at DDRF has also changed to complement this diversity. The focus of research has also been influenced by the structural changes within the NT's Primary Industries Department.

This section will cover studies carried out at DDRF since 2005, including those recently completed or remain ongoing. More detailed information of these trials can be found in Technical Annual Reports and associated publications (see Part 5).

3.1 CROPS

Due to the restructuring of the NT Government's Primary Industry Department the working focus of DDRF has been more centred on animal production over the past five years. Very little cropping research has been carried out during this period.

3.1.1 Biofuels

Pongamia (*Pongamia pinnata*) seeds were planted at DDRF in January 2008 with the aim to assess the growth and potential of the plant for biofuel production. *Pongamia* is a drought tolerant, fast growing tree, producing its first harvest in five to six years. It is anticipated that biodiesel yields of 2.5 – 3.0 t/ha could be achieved.

This project was investigating the establishment of *pongamia* sown as seed at the start of the wet season, with no fertiliser inputs and no additional weed control post seedling emergence. Bennett (2009) found the plants were very slow to emerge regardless of selection.

Weeds were identified as a significant challenge for the emerging *pongamia* seedlings if herbicides or no-tillage techniques are not employed to minimise competition. Both plantings did not survive under non irrigated conditions and have not been replaced at this stage. Research on *pongamia* agronomy continues at CPRS and KRS.

3.2 IRRIGATION

There has been little crop research at DDRF since the irrigated peanut, maize and fodder research concluded in 2007. However, peanut seed production and multiplication for PCA has continued under contract with small trials looking at plant emergence and different varieties.

3.2.1 Peanuts

Variety trials under irrigation (1995-2008) have been carried out to evaluate and identify peanut varieties suitable for the wet season or dry season under irrigation in the NT. The varieties are evaluated on nut-in-shell yield, kernel yield and grade. Disease incidence and severity were also assessed.

This work followed on from several other collaborative projects involving DRDPIFR, QDPI, the Grains Research and Development Corporation and PCA. Each year a number of new peanut lines are sown in

replicated plots to evaluate yield, disease tolerance, kernel yield and the percentage of kernel grades and shell.

The majority of this research is focused on identifying high yielding, disease resistant, high oleic oil varieties suitable for the NT. The market is demanding high oleic varieties due to their increased shelf life and health properties. PCA is phasing out low oleic oil varieties and replacing them with varieties containing high levels of oleic oil. The performance of each is rated on kernel yield/ha and the percent of shell and different grades from each variety.

3.3 PASTURES

Cattle production is still a prominent industry in the Douglas Daly with research continuing to assist producers in pasture establishment and management in order to better utilise properties for maximum production and sustainability.



Figure 14. Buffel grass and leucaena

3.3.1 Pasture species evaluation under grazing

As mentioned in Part 2, this has been an ongoing study since 1972, which continues to evaluate improved pasture species and mixtures under a continuous grazing regime on Blain soil. It aims to identify their persistence, productivity and contribution to the weight gain performance of cattle and to make pasture management recommendations for Top End livestock producers.

An economic assessment of the pasture species trial by Murti (2007) predicted that to the value of adoption of improved pastures by 2020 would be an additional \$100 million for the local economy.

Near infrared reflectance spectroscopy

An extension to the pasture species evaluation was an additional study initiated in 2005: "to monitor the consumption of companion pasture legumes with improved grass species using Near Infrared Reflectance

Spectroscopy (NIRS)". This was a collaborative project between QDPI and DPIFM using NIRS technology to further investigate the consumption of pasture legumes, the dietary crude protein, dietary digestibility and the faecal N concentration of each group of animals sampled.

Although the pasture composition, yield of grass, legumes and other plant species can be estimated using established methods, the level of actual consumption of the grass and non-grass species by cattle was unknown. Dixon and Coates (2008) explain that by using the NIRS method to analyse dung samples the percentage of grass and legumes in the diet could be determined as well as the dietary crude protein, faecal N, dietary digestibility, the grass and percent of ash. LWG can also be predicted from NIRS values, in conjunction with pasture and management information, location and rainfall.

This method can be used to improve pasture and cattle management, supplementation requirements and the selection of pasture species to introduce. The information can also assist in marketing decisions and identifying sustainable carrying capacity of the pasture.

Shotton (2006) and Lemcke (2009) found that the consumption of legumes (*Leucaena* and *Ooloo*) ranged from less than 5% to over 45% depending on availability and time of year. The consumption of Wynn cassia was low when the pasture was green but then higher when the pasture dried off.

The dry matter digestibility (DMD) and the dietary crude protein (CP) of the consumed pastures improved with rainfall. The dry season pastures of buffel, pangola and sabi with *leucaena* and buffel with *Ooloo* fell to around 53% DMD in August to November then rose to 65 to 78% after the start of the wet in December. CP was recorded as low as 4.5% during the late dry season to over 16 % during the wet.

Pasture species evaluation under grazing—buffel/legume

This program's objective was to monitor the value of companion pasture legumes with buffel grass in terms of N availability, pasture quality, quantity and persistence of legume species. The project (2000-06) follows a non-grazed plot trial in 1996-1998 that evaluated the benefits of six tropical pasture legume species as companions to buffel grass.

Over time it has become apparent that the wetter seasons appear to favour the legumes. *Verano* continues to produce lower proportions of legume biomass yearly with Wynn continuing to produce reasonable amounts of legume biomass (1-9% total paddock biomass) and is spreading outside the original plots. During the last three years no *Milgara* has been found in any of the treatment areas.

Early pasture composition indicated that the greater the legume content, the higher the overall yield, although in one season, grass yields in the *Ooloo* treatments were lower which implied that the *Ooloo* legume was competing with buffel grass.

Over eight years this has not remained the case, with *Ooloo* now showing a promising performance of producing a good ratio of legume to grass (over 10% of the total biomass in the wetter seasons, down to 1% in drier years). In the higher legume biomass years, buffel appeared darker green and flowered earlier, creating a denser-looking stand of pasture.

The hard structures of the seed, climatic conditions, insect pests, and palatability of legumes have long-term effects on the pasture mix. Different management techniques of the pasture, such as non-grazing to allow seed to set every second or third year improve sustainability of pasture legumes.

Shotton (2007) found a limitation of this trial was that the animals could selectively graze plants of preference, which could result in over-grazing and depletion of some legumes, allowing the less palatable to survive or dominate.

3.4 AGROFORESTRY

From 2005 investment companies purchased large areas of land for mahogany production in the Douglas Daly district. These tree investment companies now own approximately 50% of the agricultural land within the Douglas Daly region in 2010 so research into mahogany production continues at DDRF and on producer properties.

3.4.1 African mahogany tree improvement program

This program was initiated in 2000 to improve stem straightness, to produce diverse, second-generation progeny, to establish a series of clone tests for the identification of superior genetic lines for further deployment and commercial up-take, to match *Khaya senegalensis* to sites and determine optimal silviculture, nutrition, management regimes and wood improvement needs. These objectives are important to the newly established tree investment properties in the Douglas Daly.

There are now nine clone tests established at CPRS, DDRF and KRS (Reilly 2009) and also on commercial properties from Melville Island in the north to the Douglas/Daly region and Katherine in the south. An additional aim was to determine the suitability of clones to various sites, in order to understand interaction between clones and the environment to better meet commercial requirements and suitability of genetic lines to a particular set of site conditions.

3.5 CATTLE

In the mid 2000s DDRF became a pastoral production research facility due to the restructuring of the Primary Industries Group. The main cattle research continues with cattle breeding, management and virology.

3.5.1 Virology

DDRF has maintained a sentinel herd since 1984, for NAMF which is an integrated national program jointly funded by industry and governments to monitor the spread of economically important insect-borne viruses of livestock and their insect vectors.

The program has three objectives – to support trade by providing information essential to the development of export protocols, provide bluetongue early warning by the dynamic surveillance of the northern bluetongue endemic areas and risk management by providing epidemiological advice on the seasonal distribution of arboviruses. Data from this program is recorded on a web based national database from which information on the current Australian situation can be retrieved by stakeholders for trade negotiations.

3.5.2 Short duration grazing demonstration

This demonstration (Shotton 2009) was to monitor a rotational cattle grazing system on introduced pastures to determine the benefits to plant composition and cattle performance compared with traditional grazing (set stocked) systems.

The basic method of short duration grazing is to divide the pasture grazing area into a series of smaller paddocks where cattle are rotated from paddock to paddock, spending from one to five days in each paddock. This allows cattle to continually graze quality feed, allows more even grazing distribution and allows pasture to rest before being grazed again. The comparison of cattle LWG between the set stocked and rotationally grazed paddocks varied slightly with no evidence of marked differences.

Plant composition and pasture yield varied throughout each paddock and year with total plant biomass in each paddock ranging from 3.5 to 8.5 t/ha in May each year. The lower yield was due mainly to flooding of some of the lower paddocks during the wetter seasons.

Shotton (2009) found that sabi remains the dominant grass species with summer and other grasses increasing in some paddocks. In most paddocks, there had been an increase in Cavalcade yield over two years and an increase of broad-leaf weeds, mainly senna and sida in all paddocks.

No herbicides were applied after the first year which resulted in a large weed burden in all paddocks. This has indicated that short duration grazing with no herbicide treatment does not control broad-leaf weed invasion, which contributes to the decrease in grass yield.

3.5.3 Multi-breed composite assessment and Brahman improvement

The multi-breed composite trial commenced in 1999 to measure the relative growth, reproductive performance and carcass characteristics of interbred progeny of some tropically-adapted multi-breed crossbred bulls mated to Brahman cows, compared with progeny of Brahman bulls mated to Brahman cows. The Brahman improvement objective is to maximise Brahman performance in reproduction and growth while minimising mature weight.

A composite make up of 56.3% Brahman, 12.5% Africander, 12.5% Tuli, 6.3% Shorthorn, 6.3% Hereford and 6.3% Charolais is being compared with the improved Brahman at DDRF and with a standard Brahman breeder herd at Beatrice Hill Farm (BHF). The Brahman cows are run at Victoria River Research Station (VRRS) and steers and heifers up to three years of age are run at DDRF. This trial was modified in 2009 with all the composite breeders now located at BHF and run with a comparison group of standard Brahmans (except at mating time).

The success of the Brahman improvement program is shown by the average days to calving and scrotal circumference for the herd (reproduction traits) – and EBV. The DDRF Brahman herd is one of the best achieving herds on the Brahman group Breedplan for reproduction traits.

Jayawardhana (2007) found the first cross composites were born lighter than the Brahmans but gained weight faster. Their weight and reproduction figures were consistently superior to those of Brahmans. Initial carcass figures indicate that eye muscle area per kg carcass weight is superior in the composites. The composites also have good resistance to ticks and buffalo flies.

The second-generation data indicated second cross composites were consistently heavier. They are mostly showing superior reproduction, particularly an ability to get in calf at lighter weights. This could be due to gene segregation bringing out some of the characteristics of the light African breeds. Some of the heavier empty animals could be due to the same reason (character of later-maturing European (Charolais)). This second-generation performance is more important than that of the first cross as heterosis loss in a composite occurs between first and second generations.

The composites achieved high pregnancy rates at very light weight ranges (160-179 kg). The newer Brahmans also seem capable of becoming pregnant at lighter weights than the original Brahmans as a result of selection for fertility.

3.5.4 Understanding and improving heifer fertility in the NT

This program ran from 2004 to 2008 to establish the relationship between body weight/condition and conception rates for the first two joinings of Brahman heifers (joined first as yearlings and as two year olds) in northern Australia. The aim was to be able to produce simple charts from this data showing the conception rates that can be expected from different weights. It could also demonstrate and document the target weights and subsequent fertility that could be achievable under high and low input management systems in different pastoral zones of the NT, and to document the costs.

Each year 100 maiden Brahman heifers were joined either as two year-olds (VRRS) or as yearlings (DDRF). Heifers pregnant with their first calf were split into two treatment groups. One group (control) would graze pasture as normal in the pre-calving dry season, while the other (high nutrition) were managed with the aim of gaining an extra 50 kg before calving. This gave heifers a range of weights/body conditions at their second joining.

The data from this joining (over several years) could allow the generation of a model that predicts the pregnancy rates likely from mating lactating first-calf heifers at a range of pre-calving weights, P8 fat depths and condition scores. From the model a simple chart could be produced showing the conception rates that would be expected from mating first calf heifers at different weights. Data collected throughout the project could also enable the production of similar charts for maiden heifers (mated first as yearlings and as two year olds).

After the third year, Schatz (2009) showed, at DDRF, that the conception rates of yearling mated high grade Brahman heifers increased with joining weight; however, their fertility is not high enough at this age (only about 30% conceive) to justify the expense of transporting them from other regions of the NT for the purposes of yearling mating. This project is well on the way to producing the data required to generate equations (and then tables) that predict conception rates from pre-joining weights and fatnesses for Brahman heifers at their first two joinings in the NT.

3.5.5 Cell grazing for better productivity and carbon sequestration

A five year trial of time-controlled (cell) grazing of improved pastures commenced in 2009. It will comprehensively test the benefits of cell grazing management compared with continuous grazing in beef cattle production, sustainable growth of improved pasture and uptake of soil carbon. The research findings of this trial are directly relevant to farmers in the Douglas Daly and Katherine regions of the NT to assist in their choice of a grazing system that is resilient to climate change and quantifying their carbon trading potential in a carbon offset market.

Schatz (2009b) states the main benefits of rotational grazing are likely to be in the form of higher sustainable carrying capacity rather than improved individual performance. The trial will consist of 32 (8 x 4) x 6 ha paddocks of which six will be used as the control set stocked paddocks and 28 for rotational grazing. The trial site is on sandy-loam Blain soils with relative low soil organic carbon content (0.5-1.0%).

3.5.6 Senepol crossbreeding project

This project (Schatz 2009a) will be conducted in two phases and will run from 2009 to 2018. In the first phase, the young F1 Senepol x Brahman animals will be bred and aspects of their performance up to the age of three years will be studied. In the second phase, the performance of F1 Senepol x Brahman and high grade Brahman cows will be compared when they are run together in the same paddocks and mated to Brahman bulls.

Male progeny studies (Brahman vs. F1 Senepol x Brahman)

After weaning (mid 2010), all male progeny will be transported to DDRF where they will be processed (castration, dehorning etc) and post-weaning studies of growth on improved pasture will be conducted.

Meat quality studies

After grazing improved pasture at DDRF for about one year post-weaning, 50 Brahman and 50 F1 Senepol x Brahman steers selected to represent a range of sires, will be transported to a feedlot near an abattoir in Queensland where they will be fed for approximately 60 days. They will then be sent to a halal accredited abattoir where they will be slaughtered and carcass measurements will be recorded. After aging for seven

days, a strip-loin from each carcass will be removed and sent to the meat testing laboratory at the University of New England for tenderness studies.

3.5.7 An auto-drafter on-farm demonstration

This demonstration was set-up at DDRF in 2010 to demonstrate an improved herd management system. Cattle walk through the auto-drafter and depending on the parameters that have been entered in the computer, they are weighed and automatically drafted according to the parameters. This demonstrates a management system which can reduce man-hours that would otherwise be involved in the mustering and drafting of cattle.



Figure 15. F1 Senepol x Brahman steer

3.6 OTHER RESEARCH PROJECTS

Several organisations (NRETAS, CDU and Monash University) are carrying out research, in and around DDRF. This research is mainly focused on aspects of the river systems, soil erosion and the effects of land clearing on fauna and flora. NRETAS is currently monitoring soil condition through a National Land and Water Resources audit.



Figure 16. Mobile weather station used during a study of methane production from grazing cattle

3.6.1 Weather observations

The Bureau of Meteorology's Douglas River weather station continues to operate recording data through an automatic weather station as well as manual recordings. Manual meteorological observations of pan evaporation and rainfall are carried out daily. The automatic weather station records wind run, wind speed, gusts and direction, wet and dry bulb temperatures for humidity and dew point, minimum and maximum temperatures, rainfall amount, intensity, soil temperature and moisture and barometric pressure.

Weather data has been collected at DDRF (Douglas River) since 1968 and provides valuable data for BOM predictions and monitoring; for all kinds of agricultural research and for the district's agricultural planning and management, particularly for irrigation.

3.6.2 Tropical rivers and coastal knowledge (TRaCK)

The project, "Towards understanding the impacts of land management on productivity in the Daly and Flinders rivers", is part of the Tropical Rivers and Coastal Knowledge consortium and was carried out from 2007 to 2010.

One of the project's aims is to understand the nutrient cycles that drive plant growth and underline the food-web. Specifically, the objective is to obtain knowledge of how much N and P reaches the rivers, how this affects plants and algae in the rivers, and what might happen if N and P sources change due to changes in the way the river is managed or the surrounding land is developed.

Robson (2009) showed that nutrient concentrations are naturally quite low in the Daly River, and suggest that rain and dust might be important nutrient sources. If so, this would be another way in which the river is quite different from those in southern Australia.

3.6.3 Continuously operating reference station

This station was established at DDRF in October 2009 as part of a national network of Global Navigation Satellite System (GNSS) base stations measuring the scale and manner of movement of the Australian continent.

Over the last two decades, GNSS has proved to be a very accurate and efficient method of measuring the tectonic motion of the continents. By collecting geodetic data from the GNSS stations, Geoscience Australia is able to measure the relative locations of points up to several thousand km apart with accuracy within a few mm.

The data generated from this station will be used to improve the accuracy of Australia's mapping datum, as well as to allow Australian scientists to investigate pressing questions such as sea-level variation.

This reference station has been built by AuScope with funding from the National Collaborative Research Infrastructure Strategy, which forms part of the Federal Government's Backing Australia's ability – Building our future through science and innovation program.

3.6.4 Native regrowth control

The NT Agricultural Association (NTAgA), together with producers, is currently conducting a project looking into the control of native regrowth on cultivated land. A steering committee made up of members of NTAgA, DoR and industry stakeholders have been meeting trialling and discussing issues related to the project. Informative soil conservation and sucker regrowth workshops have been held in the Douglas Daly to improve producer knowledge. This project is due for completion in 2011.

3.6.5 Long term effects of agriculture on soil quality

A collaborative project between NRETAS and DoR, which commenced in August 2010 will be looking at the long term effects of agriculture on soil quality in the NT and the identification of a suite of soil quality parameters for monitoring and development purposes. Earlier trial data and soil analysis from various trials carried out previously on DDRF will be utilised in the project.

3.6.6 Charles Darwin University – School for Environmental Research

Tree clearing impacts on land-atmosphere exchanges in the Daly catchment

This project is measuring carbon, water and energy exchange from savannah vegetation and soil water dynamics under various forms of land condition within the Daly catchment, namely: (i) native savannah; (ii) recently cleared areas and (iii) long-term cleared areas. The objective of the project is to assess what effect

increased agricultural development, which includes clearing of native deep-rooted trees, has had on the Daly River region of the NT.

DDRF soil/rock sampling

This work uses the fallout tracer plutonium-239 (^{239}Pu) released in the atmospheric nuclear weapons tests of the 1950s and 1960s, to obtain a quantitative assessment of rates of soil loss at DDRF. It involves investigating the (very low) concentrations and inventories of this tracer in top soil using the ultra-sensitive technique of accelerator mass spectrometry.

Soil cores 40-50 cm deep have been collected from fields with various land uses which occur at DDRF. This includes cores from past LAMSAT and CERP erosion plots, and from peanut and cattle grazing fields. In addition, four 40-50 cm deep cores have been taken to determine reference tracer fallout. The reference cores have been taken from the upper sections of a series of 2-m deep pits in undisturbed and unburnt areas on the farm which are open eucalypt woodland.

By comparing the deficit (or excess at accumulation sites) of tracer relative to that of the reference sites the soil loss rates are being established. Since DDRF land use practice is similar to the commercial properties in the area, it is likely that the measured soil rates will be indicative of soil loss rates on agricultural land over the Daly basin as well. Preliminary results from the erosion plots show yield erosion rates that are in accord with LAMSAT and CERP measurements.

3.6.7 CSIRO livestock industries -- measuring methane production from cattle grazing buffel grass pastures

Enteric methane from farmed ruminant livestock accounts for approximately 10% of Australia's total greenhouse gas emissions. Cattle grazing pastures characteristic of northern Australia are considered to have higher emissions compared with production systems based on temperate and improved pastures.

CSIRO is working with industry and government to develop the technology, measurement and modelling frameworks, and facilitating adoption pathways to enable the northern beef industry to monitor, manage and mitigate methane production from grazing cattle. However, direct emissions for extensive beef production systems across northern Australia are yet to be reliably quantified.

Part of the current work managed by MLA and funded by the Department of Agriculture, Forestry and Fisheries is validating the use of open path lasers to measure methane production from grazing systems. This approach uses micrometeorological modelling based on atmospheric turbulence data and line averaged concentrations of enteric methane to provide herd emission data for livestock grazing pastures typical of northern Australia.

Data has been collected for Rhodes grass pastures in Queensland and in October/ November 2010 methane emissions from mature Brahman cows grazing buffel grass pastures at DDRF were collected over a two week period. Four staff from CSIRO Townsville and one scientist from the University of Melbourne have been involved in this project. Direct support has been provided by staff at DDRF. This work will be repeated in 2011 to capture seasonal fluctuations resulting in contrasting available forage biomass and digestibility; variables that also influence methane production from grazing cattle.

This work will support national inventories, which require accurate methane emission measurements from whole farm systems based on geography, management (including mitigation strategies) and seasonal influences.

4 FUTURE RESEARCH AND DIRECTION

DDRF is a well established research facility which can be utilised for a wide range of research and scientific investigations. As the emphasis on natural resource management and the environmental effects of agriculture increases, the role of DDRF is likely to broaden to service a wide range of agencies and departments. It has appropriate research infrastructure in place such as irrigation, stock and domestic bores, fences, cultivation and farming equipment, sheds and accommodation. The different soil types, bordering rivers and close proximity to towns enable many organisations and government departments to carry out detailed and specific research and development studies.

Some of the plans for future research were discussed at a meeting of local producers and department staff at DDRF on 2 April 2009.

4.1 PASTORAL PRODUCTION

Important future issues facing the NT pastoral industry that could be addressed through research at DDRF include improving the industry's ability to access alternative markets, backgrounding to optimise the performance of NT cattle in South-East Asian feedlots, mitigating carbon emissions and initiating involvement in the carbon economy, improving productivity and production efficiency to maintain profitability under a continuing cost/price squeeze and researching the sustainable development of agricultural and pastoral land.



Figure 17. Producers and researchers in collaboration on current and future issues

4.1.1 Cattle

Program for 2011 onwards

A number of projects at DDRF have recently started and will form the main research for the next few years. These include the rotational grazing trial described in Section 3.5.5 and associated studies on soil carbon sequestration, evaluation of post-weaning growth in Senepol cross steers (as described in 3.5.6), studies of the heifer phase of the selected Brahman and Composite projects (3.5.3) and demonstration of the potential uses of the auto-drafter (3.5.7). The sentinel herd program will also continue as it plays a vital role in protecting sensitive cattle markets.

Future program

Among the important areas proposed for future cattle research at DDRF are enhanced studies on breeding and nutritional management to help the industry adapt to changing market requirements, such as the 2010 changes to Indonesian import permits which led to most heavier stock being sent to an Australian abattoir rather than to live export. From this crisis, many in the industry have concluded that the NT product has to be better suited to a wide range of markets and not just target a single export destination.

The genetic programs already commenced are likely to continue for some time, looking at heavy selection for fertility traits and early maturity, which is advantageous in the breeding herd but undesirable in Asian feedlots where over-fatness is an issue. Another probable direction for breeding research is comparison with other groups through the nucleus herd program.

Whether for South-East Asian or Australian feedlots, there is scope to improve the performance and reputation of NT steers through a better understanding of epigenetic and backgrounding effects on later steer performance.

The management and economics of exporting entire male feeders has also been raised as a possible area for research.

DDRF has been proposed as a suitable site for studies on rumen development in order to better utilise pasture and reduce greenhouse gas emissions (notably methane).

Another developing field of interest to NT producers is the manipulation of grazing behaviour through training or diet augmentation to get cattle to eat a wider range of selected plants. In other parts of the world, cattle have been taught to eat weeds, providing a useful addition to their diet as well as a neat method of pasture management. An important local example is Wynn cassia which in parts of the Douglas Daly has been extensively planted as a pasture legume, but palatability has often proved very low.

4.1.2 Pastures

Future program

The long-running improved species trial is being reviewed. It is now proposed to replicate the top-performing grass and grass-legume pastures to enable future results to be analysed statistically and add replicated treatments for new pasture releases and dry land fodder crops.

There is interest in better utilisation of native pastures in the Douglas Daly district, with research planned on best practice management of savannah woodland and possible over-sowing with legume.

There is increased interest in leucaena research, including the design of a leucaena/ grass system, research on suitable companion grasses, soil nutrition, water use and economics.

In all these possible future pasture research programs, soil carbon investigations may also be included.

4.2 PLANT INDUSTRIES

The Douglas Daly district is a good example of agricultural diversity with many industries being found in a relatively small area. Further research into plant industries would be beneficial to the area as well as the Top End.

4.2.1 Crops – irrigated and non-irrigated

Due to the diverse clientele of the Douglas Daly district, more research into horticulture could be warranted with alternative irrigated crops being trialled, such as passionfruit, bananas, table grapes, citrus and export nursery products. Bananas have an advantage in winter as long as diseases are managed. The same can be said for passionfruit and lemons. The markets are small and the window of opportunity sometimes is narrow but the industry does have potential.

Wet season and irrigated alternative crops, such as poppies, a pharmaceutical crop, could be assessed for their viability with the NT having an isolation advantage from major populations making it easier to police production areas. Vegetable seeds could also be grown in the dry season to supply seed stocks for the industry.

4.2.2 Irrigation

The use of irrigation during the dry season has increased over the past decade so further research on how to utilise irrigation to benefit the industry could be instigated.

Leucaena and Rhodes grass

Irrigated grazing pasture systems such as leucaena and Rhodes grass could be investigated to ascertain potential cattle LWG, financial benefits, efficiency of water and the effects on soil nutrition and carbon sequestration.

Farming systems research

Preliminary discussions on a long term (10 to 20 year) farming systems research program to explore and evaluate the impacts, implications and benefits of irrigated farming in the Top End have been held between the NT Government, the Grains Research and Development Corporation and major commercial farming companies. DDRF could play a major role in such a program due to its strategic geographic location, climatic pattern and mix of natural resources and infrastructure.

4.2.3 Grain and forage

Grain and forage production could be investigated further, especially if animal industries, such as pigs and poultry, develop. Cattle feedlots may also demand grain and forage, with live export still in demand and the possibility of the opening of Katherine meatworks at some time in the future.

4.3 ENVIRONMENTAL PROTECTION

The property is very diverse with cleared/uncleared areas as well as native and introduced pasture areas. This makes it an ideal location for research and development of the semi-arid tropics such as soil and water monitoring studies to better identify soil health and water requirements under different crops and management regimes.

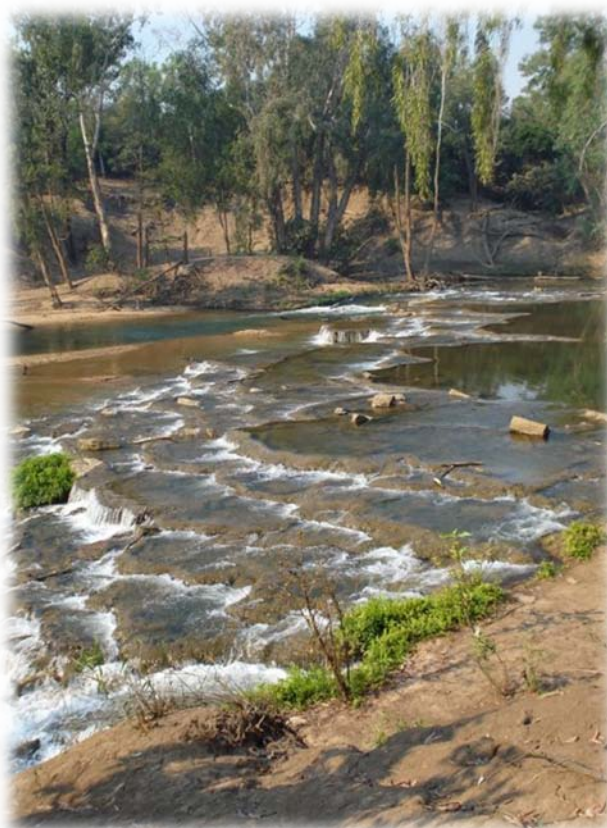


Figure 18. Crystal Falls on the Douglas River (dry season)

4.3.1 Soil

The Daly River basin is a sensitive area so further studies into soil fertility to find a cost effective way of maintaining optimal soil fertility (biological and chemical) would assist sustainable agriculture.

Soil carbon and nutrient analysis of different soils under different crops, pasture species and management systems would also assist in the knowledge database for environmental management.

4.3.2 Water usage

The hydrology of the Douglas Daly region needs to be studied further to ensure that degradation of this river basin does not occur. Pasture legumes put N into the soil and it is unclear if any of this is being leached into the water systems. Forestry stands could be monitored to see how much water the introduced trees need and what effect they have on carbon sequestration and water systems.

4.3.3 Weed control

Further work on weed control and the prevention of woody weeds such as Sida, Senna, rubber bush and native timber re-growth is required. Determining at what stage it is cost effective to control weeds needs to be investigated by examining the threshold of effective crop or pasture competition to weeds.

4.3.4 Clearing and control of regrowth

Following changes to clearing legislation and the lifting of the Daly basin moratorium, NTAga initiated research on methods of successful clearing and control of native vegetation regrowth funded by the national Landcare program. Work of this nature is likely to continue.

4.3.5 Native animals

Wallaby numbers have increased to near plague proportions, particularly by the river boundaries (at least 50 wallabies/ha on Paddock 1 at DDRF). Producers within the Douglas Daly region have noticed the number of wallabies doubling in the past six years to unsustainable levels. There is a need to determine the effect of over-population on conservation corridors and grazing production areas.

5 REFERENCE TABLE OF REPORTS AND PUBLICATIONS OF ALL TRIALS

5.1 CROPS – NON-IRRIGATED

Program	Year	Objective	Keywords and remarks	Reference
All crops	1981	Recommendations for growing crops in the Douglas Daly.	Maize, grain sorghum, peanuts, soybeans, lablab, pearl millet, siratro, stylo, sabi, pests, diseases.	Anon 1981 DPIFM 2007b
ANSTO	1999-2003	Soil to plant uptake of radioactivity.	ANSTO, radioactivity uptake, grain sorghum, soybeans.	Shotton and Twining 2003 Twining et al. 2003
Cassava	1979-1981	To evaluate eight varieties of cassava for yield potential.	Cassava, yield.	Schultz 1981b
Cashew	1990s	Variety, cultivars and agronomy.	Cashew.	DPIFM 2007b, p. 8
Cavalcade	1996-2000	Evaluation of hay production on Blain soils and the effects of soil nutrition over time.	Cavalcade, sorghum, soil properties.	Thiagalingam 1997c
Chickpeas	1987	To evaluate chickpeas.	Project leader: P Watson.	No data presently available
Douglas Daly field crops	1991-1992	Overview of the field crops research at Douglas Daly.	Seasonal conditions, production, pests.	DPIF 1992a
Entomology	1989-1990	Monitoring of field crop pests.	<i>Heliothis</i> sp, <i>Spodoptera</i> sp.	DPIF 1991, p. 120
Economics	1988	Gross margins for field crops in the Douglas Daly region.	Economics, field crops, Douglas Daly.	Tamblyn 1990 Murti 1991 Murti 1992 Murti 1993b
Fibre crops	1989-1990	Sesbania and sunn hemp evaluations.	Sesbania, sunn hemp, fibre crops.	DPIF 1991, p. 105
Fodder	1979-1981	Forage sorghum evaluation.	Forage sorghum, varieties, populations.	Schultz 1981c
Guar	1985	Crop and environment studies.	Guar.	Bennett, 1986
Hay	1996-2000	Evaluation of hay production on Blain soils and the effects of soil nutrition over time.	Cavalcade, sorghum, soil properties.	Thiagalingam 1997c
Kenaf	1987-1990	Fibre crops program.	Kenaf.	DPIF 1988, pp. 53-54 DPIF 1991, pp. 104-105
	1987-1988	Plant pathology.	Kenaf, <i>Phoma</i> sp, <i>Coniella</i> sp, <i>Macrophomina phaseolina</i> .	DPIF 1988 p 73 DPIF 1991, p. 124
	1990-1991	Effect of split nitrogen applications.	Kenaf, nitrogen.	Martin 1991b
	1990-1991	Influence of varying soil water.	Kenaf, water.	Martin 1991a
	1988-1992	Kenaf in the NT – production on commercial farms.	Kenaf	DPIF 1991, p. 105 Martin 1991c
	1989-1990	Varietal evaluation and seed increase.	Kenaf, harvesting, seed.	DPIF 1991, p. 105
	1989-1990	Entomology during 1990 season.	<i>Chrysodeixis argentifera</i> .	DPIF 1991, p. 120
	1991	Economics of Kenaf production and potential return to a pulp mill in the NT.	Kenaf, economics, pulp mill.	Ngo 1992

Program	Year	Objective	Keywords and remarks	Reference
Lablab	1980-1981	Lablab production.	Lablab.	Schultz 1981a
Maize	1987-1988	Plant pathology.	Maize, downy mildew.	DPIF 1988, p. 73 DPIF 1991, p. 124
	1989-1990	Effect of stubble cover on no-till maize.	Maize, no-till, stubble cover.	DPIF 1991, pp. 105-106
	1981-1992	Elite maize hybrid evaluation.	Maize, Barker, Hycorn 80.	Hausler (1991- 1993)
	1991-1992	Maize varieties for Douglas Daly district.	Maize, Kumbyechants, Douglas Daly.	NTG (D) Roberts 1987 Price 1992a
	1981-1992	Maize germplasm. Collaborative with QDPI (Ian Martin).	Maize, characteristics, resistance for Java downy mildew.	Hausler 1991
	1985-1993	ROTGUT trial – No-till vs. conventional till.	ROTGUT, no-till, conventional till, maize.	Thiagalingam et al. 1996
Millet	1980-1981	Katherine pearl millet production.	Katherine pearl millet.	Schultz 1981d Anon 1987
Mung beans	1987-1988	Time of sowing.	Mung beans, sowing.	DPIF 1988, p. 48
	1987-1988	Mung bean plant pathology.	<i>M. phaseolina</i> , <i>Xanthomonas campestris</i> <i>pv phaseoli</i> .	DPIF 1988, p. 73
Mung beans	1983-1992	Genetic improvement and seed production.	Mung bean genotypes, cv. Putland.	Yeates 1991 Kahl and Yeates 2003
	1990-1992	Mung bean research.	Mung beans.	DPIF 1992b
	1990-1995	Weed control in zero till mung beans.	Mung bean, weed control, zero till, Garabaldi.	Yeates 1992
Navy beans	1987	Evaluate cultivars.	Navy beans.	Anon 1988
Nutrition	1986 - 1999	Crop nutrition, advice and monitoring for the Douglas Daly.	Nutrition, fertiliser, management.	DPIF 1988, p. 52 Thiagalingam 1988 Thiagalingam (1993)
	1991	Fresh tissue nitrate nutrient monitoring.	Crops, nutrients, fresh tissue nitrate.	Price 1992e
Pathology	1989-1990	Field crop disease surveys.	Pathology, crop disease.	DPIF 1991, p. 124
Peanuts	1978-1982	Peanut research program; trial abandoned 1982 due to flooding.	Peanuts, herbicide, population, cultivar, fertiliser.	Anon 1979a DPP 1982, p. 28
Pigeon peas	1987-1988	Cultivar evaluation.	Pigeon pea.	DPIF 1988 p50
Pongamia	2008	Assess growth and potential as a bio-fuel production plant.	Pongamia, bio-fuel.	Bennett 2009
Potato	1990s	Field potato trials.	Potato.	DPIFM 2007b, p. 11
Seeds	1967-2000	Breeders, pre-basic and basic seed production.	Buchanan soybean, Ingrid pearl millet, Katherine pearl millet, French bean, grain legumes.	DPIF 1988, pp. 43-44 DPIF 1991, pp.109-112 Shotton 1992 Shotton 1993 Ham 2000
	1989	Seed production of <i>Stylosanthes hamata</i> cv. Verano in the Douglas Daly district NT.	<i>Stylosanthes hamata</i> cv Verano.	Norton et al. 1992a Norton et al. 1992b

Program	Year	Objective	Keywords and remarks	Reference
Sesame	1987-1997	Time of sowing and harvest, weed control, plant populations and row spacing.	Sesame, sowing, harvest, plant populations, row spacing, weed control, mulch cover.	DPIF 1988, pp. 47-48 Bennett (1991-1997)
	1987-1991	Effects of nitrogen and phosphorus on sesame.	Sesame, nitrogen, phosphorus.	DPIF 1988, pp. 47-48 Thiagalingam 1991c
	1993-1995	Effects of phosphorus and potassium on sesame seed yield.	Sesame, seed yield, phosphorus, potassium.	Bennett 1994b Thiagalingam et al 1995
	1990-1993	Sesame harvesting trials.	Sesame, harvest.	Oemcke 1992a DPIF 1992b
	1990-1996	To identify and register cost effective herbicides for use in sesame.	Sesame, herbicides, weed control.	Bennett 1992a Martin 1996
	1990-1997	Development of improved sesame cultivars.	Sesame cultivars.	Bennett 1991a Bennett 1991b Bennett 1992b Bennett 1993a Bennett 1993b Bennett 1994a Bennett & Martin 1994 Bennett 1996 Bennett 2003
	1991-1993	Potential of desiccants to reduce harvest loss in sesame.	Sesame, harvest, desiccants.	Oemcke 1992
	1991	Harvester modifications to reduce sesame harvest losses.	Sesame, harvest, machinery modifications.	Oemcke 1991
Soil fungus	1987-1988	Vesicular Arbuscular mycorrhizae (VAM) studies.	Vesicular arbuscular mycorrhizae, Oolloo soils, maize, phosphorus, zinc	DPIF 1988 p52
Soil	1956-1985	Classification of soils for the Douglas Daly basin for crop production.	Crop production, soil classification, Douglas Daly.	Stewart 1956 Van der Graaf 1965 Aldrick and Robinson 1972 Day 1977 Lucas 1983 Price and Garside 1985 Lucas et al. 1985
	1990	Nutrient studies on sandy red earths in the Douglas Daly.	Sandy red earths, Douglas Daly, nutrients.	NTG (C) Ross and Calder 1990
	1995	Fertility of yellow earth soils in the Douglas Daly.	Yellow Earth soils, fertility, Douglas Daly.	Cameron 1995

Program	Year	Objective	Keywords and remarks	Reference
Sorghum	1989-1994	Effect of residual nitrogen on sorghum.	Sorghum, nitrogen.	Thiagalingam 1991b
	1990-1994	No-till sorghum under Cavalcade.	Sorghum, no-till, Cavalcade.	Thiagalingam 1991a
	1990-1996	Interaction between weeds and sorghum yield.	Sorghum, yields, weeds.	Martin 1993 Martin 1996a
	1990-2005	Grain sorghum varieties for the Douglas Daly district.	Sorghum varieties, Douglas Daly, Theyona.	Anon 1979b Anon 1987 Price 1992b Price (1995-1997) Shotton 1999a Shotton 1999b Shotton 2001 Shotton and Price 2000 Shotton 2000c Shotton 2001a Shotton 2002a Shotton 2002c Shotton 2004 Shotton 2005a
	1991-1992	Boron nutrition in sorghum on Blain soil.	Sorghum, boron, nutrition.	McNamara 1992
Soybeans	1981-1982	Research on soybean with field experiments on weed control, plant population and nutrition.	Soybeans, weed control, plant population, nutrition.	DPP 1982 p 28 DPP 1986
	1985-1993	ROTGUT trial – No-till vs. conventional till.	ROTGUT, no-till, conventional till, soybean.	Thiagalingam et al. 1996
	1987-1988	Cultivars for wet season.	Soybean cultivars.	DPIF 1988 p46
	1987-1988	Plant pathology.	Soybean, <i>Macrophomina phaseolina</i> .	DPIF 1988 p 73
	1990-2000	Preliminary soybean evaluation.	Soybean.	O’Gara 2000
	1990-1992	Soybean research.	Soybean.	DPIF 1992b
Sunflower	1982-1985	Variety and cultivar evaluation.	Sunflower.	DPIFM 2007b p10

5.2 IRRIGATED CROPS

Program	Year	Objective	Keywords and remarks	Reference
Agronomy and extension	1993–2003	Identify important issues such as crop options and rotations for irrigation, agronomy, crop management advice, nutrition and weed control strategies and long-term sustainability.	Agronomy, nutrition, irrigated crops, weed control.	O'Gara (2001 Ham 2003a Ham 2003b O'Gara 2008
Cotton	1994–2000	Cotton industry development. Varieties of cotton were trialled under trickle irrigation and yields recorded.	Gene equivalency trial - To determine the expression of the Bt gene in selected INGARD [®] varieties.	Martin 2000
Entomology	2003–2004	Sample and identify insect species found on irrigated field crops to determine their pest status and where possible to give advice on IPM options.	Pests found on sesame and peanuts at DDRF are documented at the Katherine Research Station.	Hoskins 2004
Fodder	2003–2005	Determine the yield potential, agronomic requirements and viability of forage crops under centre pivot irrigation.	Forage sorghum, lucerne, Rhodes grass, maize, forage oats.	O'Gara 2004 O'Gara 2006
	2003–2004	Fodder trial in rotation with peanuts.	Fodder, peanuts, rotation.	Ham 2003a Ham 2003b
	2004–2007	Identified species which have potential for commercial production and highlighted agronomic issues.	Blain soils, Rhodes grass, forage sorghum, maize, lucerne and forage oats.	O'Gara 2006 O'Gara 2007c
Kenaf	1989–1990	Water and nitrogen extraction.	Kenaf, rain-fed, irrigation, CSIRO, water, nitrogen.	DPIF 1991, p. 105
	1989–1990	Plant density.	Kenaf, irrigation, plant density.	DPIF 1991, p. 105
Maize	1998–2007	The evaluation of irrigated maize and demonstration of yields that can be achieved on sandy surfaced soils in the Daly Basin. The identification of serious pest and disease issues and effective control practices.	Maize, irrigation, pest and disease, pest control methods, Blain.	O'Gara 2001 O'Gara 2003a) O'Gara 2007a O'Gara 2007b
Pasture	1994–1996	Evaluation of selected pasture species under dry season irrigation.	Irrigation, forage sorghum, Guinea grass, Cavalcade, bundy, blue pea, Maldonado, signal, Jarra.	Beumer 1995a O'Gara 1997

Program	Year	Objective	Keywords and remarks	Reference
Peanuts	1980-2004	Peanut production research.	Peanut.	DPP 1982, p. 15 Flint 1995 DPIF 2001 Ham 2001a Ham 2004a
	1996	Monitor for peanut mottle virus freedom.	Peanuts, peanut mottle virus freedom, PMV-free seed.	Conde 1996
	1998-1999	Fertiliser placement and its effect on yield and quality of irrigated peanuts.	Peanuts, yield, quality, fertiliser placement.	Martin 1999
	1998-2008	Identify suitable peanut varieties for production in the NT.	Peanut varieties.	Ham 2000a Ham 2004 Shotton 2006b
	1998-2000	Identify herbicides suitable for peanut production, evaluate efficacy on a range of weeds and observe possible negative crop interactions.	Peanut, Herbicide efficacy, herbicide negative crop interactions.	Ham 2000b Ham 2004
Peanuts	1998-2000	Management system for diseases of peanuts.	Peanuts, management systems, diseases.	Bellgard 2001 Ham and Bellgard 2004
	2000-2001	The entomofauna of peanuts (<i>Arachis hypogaea</i>).	Peanuts, <i>Arachis hypogaea</i> .	Brown 2001
	2000-2001	Examination of varying rates of three macro elements for peanuts on ruby Blain soil.	Peanuts, Ruby Blain soil, potassium, magnesium, calcium, kernel development, yield.	Ham 2001b
	2001-2002	Evaluation of an expert management program (Exnut) for irrigated peanuts.	Peanuts, Exnut evaluation.	Ham 2002
	2001-2004	Identify insect species found on peanut crops and determine their pest status.	Entomology, peanuts.	Connolly 2003
	2005-2007	Management of leaf spot disease in peanuts.	Fungicide, Leaf spot, peanuts.	Bhuiyan 2007
	2003-2004	Seed issues temperature and humidity in transit. Cool room trial DDRF.	Seed temperature, humidity in transit, cool room.	Ham 2003a Ham 2003b

5.3 PASTURES

Program	Year	Objective	Keywords and remarks	Reference
Blue pea	1988-1993	<i>Clitoria ternatea</i> evaluations.	Ruby Downs, Kumbyechants, blue pea.	DPIF 1991, p. 43 Cameron 1991b
Cavalcade	1987-1988	Nutritional requirements.	Cavalcade, nutrition.	DPIF 1988, p. 13
	1988-1992	<i>Centrosema</i> evaluations.	Ruby Downs, Kumbechants, <i>Centrosema</i> spp.	DPIF 1991, pp. 42-43 Cameron 1991a
	1989	Cavalcade grazing management.	Cavalcade, grazing, management	DPIF 1991, p. 47
	1989-1992	Productivity of Cavalcade under various grazing systems.	Cavalcade, grazing, persistence, dry matter yield, livestock production.	Rann 1992a
	1989-1990	Tolerance of <i>Centrosema pascuorum</i> to glyphosate.	<i>Centrosema pascuorum</i> , Glyphosate.	DPIF 1991, p. 113
Leucaena	2010	Valuable browse shrub legume production for cattle in the Top End.	Legume, leucaena.	Lemcke and Shotton 2010
Nutrition	1990s	Nutrients of pasture grasses and legumes.	Nutrition, grasses, legumes.	Cameron 2001a Cameron 2001b
	1994-2000	Fertiliser response evaluation.	Pasture, fertiliser, nutrition, Cavalcade, sabi, buffel.	Thiagalingam 1995c
	1996-2000	Pasture nutrition when companion legumes are planted with buffel.	Pasture legumes, buffel, nitrate, non-grazed.	Thiagalingam 1997a
Pastures	1981-1985	Pasture plant introduction in the 600-1500 mm rainfall area of the Top End.	Pasture, 600-1500 mm rainfall areas, plant introduction.	Cameron et al 1984 Cameron 1985
	1988-1996	Evaluation of new pasture introduction at Middle Creek Station, Douglas Daly.	Yellow earth, <i>Amigo stylo</i> , <i>Aescgymonene histrix</i> , <i>Aeschynomene paniculata</i> , <i>Digitaria milanijana</i> , <i>Digitaria swynnertonii</i> .	Cameron 1994 Lemcke 1995a Cameron 1997a
Pastures	1994-1995	On-farm demonstrations of improved pasture species.	Pasture establishment, fertiliser rates, productivity.	Beumer 1995b Lemcke 1995c
Pasture legumes	1987-1988	Pasture legume cutting trial to determine yield and quality at DDRF and BARC.	Pasture legumes. DDRF trial abandoned due to establishment problems.	DPIF 1988, p. 14
	1991-1998	Evaluation of the residual value for pasture legumes of a new phosphorus and sulphur fertiliser SR 13.	Pasture legumes, fertiliser SR 13, Middle Creek.	Cameron 1994 Lemcke 1995b Cameron 1997b
	1991	Residual value of phosphorus and sulphur.	Phosphorus, sulphur, Theyona.	Price 1992d
	1996-2000	Evaluate the response of nitrate level on buffel grass when six companion pasture legume species are planted to the pasture – non-grazed.	Pasture legumes, buffel, nitrate, non-grazed.	Thiagalingam 1997a Shotton 1998a Shotton 2000a Shotton 2001a
	2000-2006	Pasture species evaluation under grazing at DDRF – buffel/legumes.	Pasture legumes, buffel, nitrate, grazed.	Shotton 2000b Shotton 2004 Shotton 2007 Shotton 2009a
	2000-2006	Pasture species evaluation under grazing at DDRF – consumption of leucaena and pasture legumes.	Pasture legumes, buffel, leucaena, grazing.	Shotton 2006 Dixon and Coates 2008 Lemcke 2009

Program	Year	Objective	Keywords and remarks	Reference
Seed	1967-2000	Breeders, pre-basic and basic seed production.	Cassia, Centrosema, Leucaena, Stylosanthes, Pennisetum, Glycine, <i>Arachis</i> , <i>Macroptilium</i> .	DPIF 1988 p43-44 DPIF 1991 p109-112 Shotton 1992 Ham 2000
Seed	1989-1990	Certified seed production by private growers. – weed seeds.	Garibaldi, <i>Cassia obtusifolia</i> , Cavalcade.	DPIF 1991, p. 114
Soil fertility	1987-1988	Trials of phosphorus, sulphur, molybdenum and zinc in Verano.	Soil Fertility, Verano, phosphorus, sulphur, molybdenum, zinc.	DPIF 1988, p. 13 DPIF 1991, p. 46
	1987-1991	Effect of added phosphorus, sulphur and zinc on Verano at Fenton Downs and Ceres Downs.	Soil fertility, Verano, phosphorus, sulphur, zinc.	NTG (B) DPIF 1988, p. 14 DPIF 1991, p. 46
Species	1972-2010	Pasture species evaluation under grazing at DDRF.	Gayndah buffel, Nixon sabi, Wynn, Verano, Cavalcade, leucaena, pangola, blue grass, gamba grass, Maldonado.	DPIF 1991, p. 45 Rann (1991-1994) Zuill 1997 Lemcke 2001 Lemcke 2004 Lemcke 2007 Murti 2007 Lemcke 2009 Shotton 2010
Stylo	1981-1982	Comparison of <i>Stylosanthes scabra</i> and <i>Stylosanthes hamata</i> .	Stylo, DDRF, VRRS.	NTG (A) DPP 1982, p. 34
	1989-1990	Time of harvesting trial – Verano stylo.	Verano, harvesting.	DPIF 1991, p. 113
Wynn	2001 - 2003	The evaluation of Wynn cassia as a pasture and fodder crop for the Douglas Daly district.	Wynn cassia, pasture, fodder, Douglas Daly.	TAR 2002 – 03, p. 18
	2001-2003	Producer initiated research and development project – evaluation of Wynn cassia as a pasture and fodder for Douglas Daly area.	PIRD, Wynn cassia, pasture, fodder, Douglas Daly.	O’Gara 2003b Shotton 2003 O’Gara 2005

5.4 WEEDS

Program	Year	Objective	Keywords and remarks	Reference
Atrazine	1995-1996	To determine toxic levels of Atrazine to sorghum in Blain soils and identify movements of Atrazine in the soil profile.	Atrazine, sorghum, soil profile.	Eastick 1997
Bay 11	1996-1999	Weed management strategy demonstration site.	No-till sorghum, slashing, Atrazine, sabi.	Eastick 1999 Hill 2001
Cavalcade	2003-2004	Pre-wet season herbicide management in Cavalcade.	Flame®, Spinnaker®, Cavalcade.	Eastick 2004a Eastick 2005b
	2003-2004	Herbicides for use in Cavalcade pastures.	Falcon®, Fusilade®, Fusion®, Verdict®, Cavalcade.	Eastick 2004b
	1996-2004	Demonstrate a “best bet” pasture rehabilitation/weed management strategy on a severely weed infested Cavalcade paddock.	Cavalcade, pasture rehabilitation, weed management.	Eastick 1999 Hill 2001 Eastick 2002b Eastick 2004c
Herbicide wiping	1991-2003	Weed control using herbicide wipers.	Herbicide wipers, “Zacher”, broadleaf weeds.	Price 1992c Price 1995a Shotton 2000b Shotton 2004 Price and Shotton 2006
	2001	Performance of 11 chemical mixtures for control of grass and broad-leaf weeds in grass/legume pasture.	Herbicide wipers, grass, broadleaf weeds, grass/legume pasture.	Shotton 2001d
	2001	Trial and monitor the short and long term effectiveness of weed control methods in pastures using herbicide wipers and slashing techniques.	Herbicide wipers, slashing, Ruby Downs Glyphosate, BrushOff®, Grazon®.	Shotton 2002b
Native regrowth	1981-1982	Control of native woody species.	Herbicides, Tordon 60®, Tordon 1040®, Roundup.	DPP 1982, p. 45
Sida	1981-1982	Sida herbicide and management trial.	Verano Stylo, <i>Sida acuta</i> , slashing, 2,4-D amine.	DPP 1982, p. 46
	1984-1996	Biological control of sida.	Sida, biological control.	Flanagan 1992
Sucker control	1995-1997	Sucker control using basal herbicide spray.	Sucker control, Access®, Garlon®.	Price 1996a
	1994-2005	Sucker regrowth control in improved pastures.	Sucker control, improved pastures, herbicide roller.	Price 1995 Shotton 2005b
	2005-2006	Sucker control in newly-sown Jarra Grass pasture.	Tipperary Station, sucker control, Jarra grass.	Hartley 2006
Weeds	1999-2000	Weed study of dryland and irrigated crops and pastures for the Top End.	Douglas Daly, GRASS check®, dry-land, irrigated crop, weeds.	Hill 2000
	2000-2001	Identification of weed species development under pivot irrigation system.	Weeds, intensive cropping, weed management.	Schultz 2001
	2001-2007	Broadleaf weed control in grass pastures.	Kumbyechants Station, perennial grasses, broadleaf weeds.	Eastick 2002a Eastick 2005a Hartley 2007)

5.5 TILLAGE METHODS

Program	Year	Objective	Keywords and remarks	Reference
Cavalcade	1996-1997	Evaluate the effects of no-tillage and conventional tillage on the yield of Cavalcade hay and its long-term effects on soil properties.	No-till, conventional till, Cavalcade hay, yields, soil properties.	Thiagalingam 1997b
CERP	1984-1989	Croplands erosion research project.	Surface runoff, soil and nutrient losses, farming systems.	Dilshad et al. 1996
Engineering	1987-1988	Planter development – Blain and Tippera soils.	Mason Maxistrike, Nordsten, fertiliser, Blain soil, Tippera soil.	DPIF 1988, pp. 52-53
Entomology rotgut	1995-1997	Insect damage on conventional and zero till plots.	No-till, conventional till, insect damage, ROTGUT.	Young 1998
General	1990-1994	No-till cropping trials.	No-till crops.	Thiagalingam et al. 1994 Thiagalingam et al. 1996 O'Gara 1995 DPIF 1992b
Integrated farming	1987-1988	Cattle grazing crop stubble with supplementation to improve returns from cropping.	Integrated farming, cattle, crops, supplementation.	DPIF 1988, p. 7
LAMSAT	1990-1995	Land management of the semi arid tropics (LAMSAT) to test and calibrate existing erosion prediction models.	LAMSAT, stocking rates, live weight gain, improved pasture, native pasture.	Dilshad 1991 Cameron 1993 Jayawardhana 1995c Jayawardhana 1998a
Maize	1984-1998	Evaluate the effects of no-tillage and conventional tillage on the yield of Maize and its long-term effects on soil properties.	No-till, conventional till, maize, yields, soil properties.	Thiagalingam 1992 Thiagalingam et al. 1994 Thiagalingam et al. 1996 Shotton 1998b
Maize	1989-1990	Stubble cover, tillage and fumigation.	Maize, no-till, conventional till, fumigation, productivity.	DPIF 1991, p. 106
ROTGUT	1984-2000	Evaluate the effects of no-tillage and conventional tillage practices on yield of an annual grain and grain legume rotation and its long-term effects on soil properties.	Mung bean, no-till, conventional tillage, yields, soil properties, ROTGUT.	Thiagalingam et al. 1991 Thiagalingam et al. 1994 Thiagalingam 1995b Thiagalingam 1996b Thiagalingam et al. 1996 Thiagalingam 1997b Shotton 1999c Shotton 2001b
	1996-1998	Insect damage on conventional and zero till plots.	Insect, no-till, conventional tillage.	Young 1988
Sorghum	1990-1994	No-till sorghum under Cavalcade.	No-till, sorghum, Cavalcade.	Thiagalingam 1991a
	1993-2000	Study of nitrogen nutrition for no-till sorghum following grazed leys.	Sorghum, no-till, grazed ley, nitrogen, nutrition, farming systems.	Thiagalingam et al. 1993 Thiagalingam 1995a Thiagalingam 1996a
Soybeans	1984-1993	Evaluate the long term effects of tillage practices.	No-till, conventional till, soybeans, Buchanan, Leichhardt.	Thiagalingam 1993b Thiagalingam et al. 1994 Thiagalingam et al. 1996

Program	Year	Objective	Keywords and remarks	Reference
Weeds	1992-1995	Management of soil vegetative cover prior to sowing on weed competition in no-till sorghum.	Sorghum, no-till, Glyphosate, weed competition, vegetative cover.	Yeates 1994
	1995-1997	Phytotoxicity and movement of Atrazine under conventional and no-till sorghum.	Phytotoxicity, Atrazine, Dual®, no-till, conventional till, sorghum.	Eastick 1997

5.6 AGROFORESTRY

Program	Year	Objective	Key words and remarks	Reference
Agroforestry	1997-2005	Research, development and extension.	Overview of industry.	Reilly 2001 Reilly 2002 Reilly 2004a Reilly 2005
African mahogany	2000-2009	Strategy and progress of a tree improvement program.	<i>Khaya senegalensis</i> , African mahogany, African mahogany Australia.	Reilly 2004b Reilly 2006 Reilly 2007 Reilly 2009
Fodder trees	1995-1996	Fodder tree introduction for increased production in grazing/ browsing cattle.	Fodder trees, nitrogen fixing trees, cattle production	Reilly 1995a
Shade and timber	1995-1999	Shade and timber tree.	Shade, timber, timber production parameters, plant spacing, watering regimes.	Reilly 1995b Reilly (1998 -1999)
Teak	1998-2003	Evaluation of teak, propagation methods for planting on a Blain soil type.	Teak, propagation methods, Blain soil.	Reilly 2003
Tropical hardwood	1998-2000	Top End regional tropical hardwood forestry.	Species evaluations, long and short term rotation.	Reilly 2000
	2000-2010	Genetic Improvement of hardwood.	Clone tests, genetic improvement, hardwood.	Reilly 2008

5.7 CATTLE

Program	Year	Objective	Keywords and remarks	Reference
Buffalo/cattle	1988-1990	Performance of cattle and buffalo grazing sorghum stubble.	Brahman, buffalo, sorghum, performance.	Anon 1991b Rann 1991 DPIF 1991 p 35
Calf mortality	1994-1995	Calf deaths at DDRF – 8% pre-weaning calf mortality.	Mortality, colostral immunoglobins, shade, high body temperatures.	DPIF 1995 p116 Pinch 2003
Cell	2005-2009	Short duration grazing demonstration.	Cell grazing, soil health, plant composition, cattle performance.	O'Brien 2007 O'Brien 2008a Shotton 2009a
	2009-2014	Cell grazing for better productivity and carbon sequestration.	Cell grazing, productivity, carbon sequestration.	Schatz 2009b
Composite	1999-2010	Multibreed composite assessment.	Multibreed composite, increased productivity.	Jayawardhana 1999 Jayawardhana 2002 Jayawardhana (2004) Jayawardhana (2007)
Crossbreed	1993-1997	Boran/Tuli crossbreeding evaluation.	Brahman, Boran, Tuli, South East Asia live feeder.	Rann 1993 Jayawardhana et al 1994 Jayawardhana 1995a Jayawardhana 1998b Jayawardhana (2000)
	2007-2011	Weaned progeny from incorporating tropically-adapted Taurus breeds into a VRD breeding herd trucked to DDRF.	Belmont Red-Brahman, Tuli-Brahman, VRRS, DDRF, progeny.	Huey 2007
	2009-2018	Senepol crossbreeding project.	Brahman, Senepol, meat quality, VRRS, DDRF.	Schatz 2009a
DDRf breeder herd	1986-2010	Examine production parameters maintaining a breeder herd on improved pastures and supplementation.	Breeder herd, Brahman, improved pastures, supplementation, production parameters.	DPIF 1988 p5 Anon 1991a DPIF 1991, pp. 36-38 Jayawardhana 1995b McCool 1994 Jayawardhana 2000
	1996-2010	Selected Brahmans – improvement of the fertility through use of Breedplan EBVs and selection.	Brahman, breeder herd, Breedplan, EBV, selection, fertility.	Jayawardhana 2007 Golding 2009
	1994-2000	Effect of yearling mating on herd productivity.	DDRf breeder herd, yearling mating, herd productivity.	Jayawardhana 1995b Jayawardhana 2000
	1995-1998	Effect of early weaning.	DDRf breeder herd, early weaning.	Jayawardhana 1995b
	1995-1998	Home bred bull demonstration.	DDRf breeder herd, Breedplan, EBV.	Jayawardhana 2000
	1994-1997	Effect of an extended mating period.	DDRf breeder herd, extended mating period.	Jayawardhana 1995b Jayawardhana 2000
	1995-2000	Productivity of aged cows.	DDRf breeder herd, aged cows.	Jayawardhana 2000
	1994-2010	Bull performance and parentage determination.	DDRf breeder herd, "Bull power", fertility, DNA.	Jayawardhana 1995b Jayawardhana 2000
Economics	1992	Economics of cattle production in the Douglas Daly 1992.	Economics, cattle production, Douglas Daly.	Murti 1993a

Program	Year	Objective	Keywords and remarks	Reference
Feeders	1991-1996	A production system for the live export steer and local table beef markets.	Live export steer, table beef, live-weight changes, weaners, VRRS, DDRF, SE Asian market.	Rann 1992b
	1992-2003	Meeting post weaning market specifications for the live cattle export trade to South East Asia. - Feeder steer production system.	Post weaning studies, feeder steers, market specifications, live cattle export, South East Asia.	Ridley 1995 Ridley 1997a Ridley 2004 Ridley and Schatz 2005
	1993-1994	Meeting post weaning market specifications for the live cattle export trade to South East Asia; a scenario for the northern NT beef industry.	Post weaning studies, feeder steers, market specifications, Live cattle export, South East Asia.	Ridley 1994
	1995-1996	Transport weight loss to the wharf.	Loading regimes, transport weight loss.	Ridley 1996 Ridley 1997e
	1995-1998	Effect of bovine ephemeral fever (BEF) vaccination on live-weight gain in weaner steers and heifers.	Bovine ephemeral fever (BEF), live-weight gain, weaners.	La Fontaine 1997
	1996-1997	Stocking rate (4) x genotype (2) on live weight gain.	Stocking rates, genotypes, live-weight gain, supplementation.	Ridley 1997b Ridley 1999b
	1996-1999	Surplus weaner heifer utilization.	Growth rate, 2 nd 1 st year weaner heifers.	Ridley 1997f Ridley 1999a
	1997-1999	Effect of castration/ short scrotum treatments on pre/ post weaning weight.	Castration, short scrotum treatments, pre and post weaning weight gain.	Ridley 1999d
	1997-2000	Genotype (3) x sex (3) on live weight gain.	Genotype, sex, live weight gain.	Ridley 1997c Ridley 1999c
	1997-1999	Response to dry and wet season supplement.	Seasonal live-weight gain, annual live weight gain, supplementation.	Ridley 1997d Ridley 1999c
Fertility	2004-2008	Understanding and improving heifer fertility in the NT.	Brahman, heifer fertility, yearlings, two-year olds.	Schatz 2004 Schatz 2007 Schatz 2009
Insect monitoring	1990-2010	Insect monitoring in association with sentinel herds.	Sentinel herd, insects, culicoides, <i>C. actoni</i> , <i>C. brevitarsis</i> , mosquitoes.	Hunt 1993, 1995
Nutrition	1980-1981	Maize stubble grazing.	Unsupplemented weaners, maize stubble, animal performance.	DPP 1982, p. 15
	1993-1999	Techniques for assessment of nutrient deficiencies.	NIRS, cattle nutrient deficiencies, DDRF, KRS, VRRS.	MacDonald 1999
Virology	1984-2010	National arbovirus monitoring program.	Arbovirus, sentinel herds, Bluetongue, akabane, ephemeral fever, Palyam, Simbu, epizootic haemorrhagic disease.	DPIF 1988, pp. 35-36 DPIF 1991, p. 17 Melville 1999 DPIF 1995, pp.115-116 Melville 2004 Melville 2006
	2001-2002	Identify the duration of viraemia in cattle following natural infection with bovine ephemeral fever (BEF) virus.	Viraemia, bovine ephemeral fever.	Melville 2003

5.8 FARMING SYSTEMS

Program	Year	Objective	Keywords and remarks	Reference
Fodder	1995-2002	Ley farming systems. Evaluate a sustainable farming system which integrates pasture, crop and cattle production.	Ley farming, pasture, crop, cattle production.	O'Gara 1994 Eastick 1999 Shotton 2001b) Shotton 2002
Cattle	1994-2000	Integration of grazing into ley farming systems.	Ley farming system, sorghum, Cavalcade, Brahman.	Zuill 1996b
Extension	1995-2000	Farming systems research plan – extension and monitoring.	Farming systems, extension, Douglas Daly.	Price 1996b
Farming systems	1994-2000	Research to develop sustainable agricultural production systems for the Top End.	Systems research, sustainable agriculture, mixed farming.	Thiagalingam 1995a
Blain farming system	1989-1992	Legume/crop grazing rotation on Blain soil.	Sorghum, cattle, pasture.	DPIF 1991, pp.38-39 Bateman 1991
Modeling	1995-2000	Development of pasture and livestock production simulation models for the semi-arid tropics.	Pasture, livestock, climatic recordings, growth simulation, Cavalcade, sabi.	Bange 1995
Nutrition	1989-1994	Nutrition in farming rotations to establish a nitrogen management regime.	Nitrogen, sorghum Cavalcade.	Thiagalingam 993b
	1994-2000	Study of nitrogen nutrition for no-till sorghum following grazed leys.	Sorghum, no-till, grazed ley. Nitrogen, nutrition, farming systems.	Thiagalingam 1995a Thiagalingam 1996a
Nutrition	1996-1997	Preliminary evaluation of soil profile nutrients under various management systems.	Sabi, Cavalcade, soil profiles, virgin bush, no-tillage, conventional tillage.	Thiagalingam 1996c
Pasture grasses	1994-2000	Ley farming systems. Evaluate a sustainable farming system which integrates pasture, crop and cattle production.	Ley farming, Cavalcade, Sabi, cattle.	Thiagalingam 1993a Thiagalingam 1994 Lemcke 1997 Eastick 1999 Shotton 2001
Sorghum	1991-1994	Grain sorghum/pasture legume farming systems development.	Sorghum, legumes, rotation, nitrogen, no-till.	Thiagalingam 1993a DPIF 1992b;DPIF 1993, pp.123-124
Weeds	1992-1995	Broadleaf weed control in a cereal/legume pasture ley farming system.	Broadleaf weed, cereal/legume, Glyphosate, 'Zacher' herbicide roller.	Price 1992c Price 1996
	2000-2001	Trial and monitor and record the short and long-term effectiveness of weed control methods in pastures using herbicide rolling and slashing techniques.	Systems research, weed control, herbicide rolling, slashing.	Shotton 2001c
	1992-1996	Develop weed management strategies for ley farming systems.	Ley farming, sustainable agriculture, weed management.	Thiagalingam 1996d

5.9 OTHER RESEARCH PROJECTS

Program	Year	Objective	Keywords and remarks	Reference
Charles Darwin Uni	2007-2010	Impacts of development on the environment.	Clearing, erosion, soil sampling.	www.cdu.edu.au/ser/ImpactsOfHumanActivityAndClimateChange.htm
CORS project	2009	Continuously operating reference station.	GNSS, Auscope.	www.auscope.org.au
DDRF	1962-2010	Agricultural research and extension.	DDRF, research, extension.	NTA 1968, p. 21 Anon 1980 DPP 1982, pp. 54-55 Saunders 1983 DPIF 1991, pp. 133-135 Bagley 1995 Cameron 1996 DBIRD 2004, pp. 175-176 DPIFM 2005, p. 142 DPIFM 2006, p. 71 DPIFM 2007a, p. 153 O'Brien 2008b
DDRF weather	1966-2000	To record and maintain daily weather information for the DDRF manual and automatic weather station.	Douglas River, weather.	Bagley 1995 Shotton 1999 Shotton 2004c Shotton 2006a Shotton 2009b
DrumMuster	2004-2010	To be a receiver property to collect, inspect and pack for recycle empty chemical drums under the DrumMuster guidelines.	DrumMuster, chemical drums.	Agsafe 2010
Entomology	1999	Identification and bionomics of wireworm species.	Wireworm.	Brown 1999a
	1999	Survey of insects in field crops to determine economic thresholds.	Sorghum, Cavalcade, peanuts, maize.	Brown 1999b
Environment	2001	Conservation plan for the Daly Basin bioregion.	Conservation, Daly Basin.	Price et al. 2001
	2007	Land use change and greenhouse gas balance and nutrient dynamics.	Land use change, bio-sequestration of carbon, greenhouse gas.	Livesley et al. 2008 Williams et al. 2005
Extension	2005-2006	Pastoral production extension – Top End.	Extension, Douglas Daly.	Hausler 2004 Hausler 2005 Hausler 2006
Feral pigs	1988-1990	Tracking feral pigs to reduce crop damage.	Feral pigs, crop damage, fencing.	Caley (1993a, b, c) Caley 1999
	1994-1995	Age specific prevalence of porcine parovirus antibodies.	Feral pigs, age specific, porcine parovirus, antibodies.	Caley et al. 1995
Kori bustard	2002-2003	Ecology and conservation of a nomad – A case study using the Australian Bustard.	Kori bustard, bush turkey, Douglas Daly.	Ziembicki 2003
Methane production from grazing cattle	2010	Measuring methane production from cattle grazing buffel grass.	Methane, cattle, grazing, CSIRO.	CSIRO 2010
Pig-nosed turtles	1980-2000	Pig-Nosed turtles—breeding, habitat and distribution.	Pig-nosed turtle, Daly River.	George et al. 2000

Program	Year	Objective	Keywords and remarks	Reference
TRaCK	2007-2010	To investigate tropical rivers and gain coastal knowledge.	Daly River, Flinders Rangers, River health, sedimentation.	Robson 2009
Water quality	2005-2010	Assess water quality in the Daly river.	Daly River, water quality.	Wilson et al. 2006 Risby et al. 2009

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ACRONYMS AND ABBREVIATIONS

BARC	Berrimah Agricultural Research Centre
BHF	Beatrice Hill Farm
BOM	Bureau of Meteorology
Ca	Calcium
CERP	Crop Erosion Research Project
CPRS	Coastal Plains Research Station
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBIRD	Department of Business, Industry and Resource Development
DDRF	Douglas Daly Research Farm
DLPE	Department of Lands, Planning and Environment
DoR	Department of Resources
DPP	Department of Primary Production
DPI	Department of Primary Industry
DPIF	Department of Primary Industry and Fisheries
DPIFM	Department of Primary Industry, Fisheries and Mines
DRDPIFR	Department of Regional Development, Primary Industry, Fisheries and Resources
EBV	Estimated breeding values
GNSS	Global Navigation Satellite System
GRDC	Grains Research and Development Corporation
K	Potassium
KRS	Katherine Research Station
LAMSAT	Land Management Strategies for the Semi Arid Tropics
LWG	Live weight gain
Mn	Manganese
N	Nitrogen
NAMP	National Arbovirus Monitoring Program
NCRIS	National Collaborative Research Infrastructure Strategy
NIRS	Near Infrared Reflectance Spectroscopy
NRETAS	Natural Resources, Environment, The Arts and Sports
NTAgA	Northern Territory Agricultural Association Inc
P	Phosphorus
PCA	Peanut Company of Australia
QDPI	Queensland Department of Primary Industry
TRaCK	Tropical Rivers and Coastal Knowledge
VRRS	Victoria River Research Station
Zn	Zinc

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