# North Australia Program

## 1998 Annual Peer Review

**of**

## Introduced sown pasture species development

**and**

## Legume dominance and soil acidification projects

**Edited by Barry Walker**

***NAP Occasional Publication No. 6***

*(Meat & Livestock Australia logo)*

# PREFACE

Since its inception in mid 1986, the MLA's North Australia Program has supported a substantional number of introduced pasture projects and activities. The aim of this sown pasture work is to assist landholders in increasing production and profitability by better management, while maintaining or improving the soil resource, through the application of improved knowledge and understanding gained from research and development. The work emphasises practical outcomes and developing effective links between property managers, extension and research staff and agri-business.

**Part 1** of this report provides a brief description of the North Australia Program. **Part 2** provides a description of sown pastures in northern Australia and outlines the NAP sown pasture work, as well as details of projects, publications and workshops conducted so far.

Within Phase 3 of the North Australia Program (1996-2001) the reporting and monitoring of projects has changed from each project having a number of detailed milestone reports, to a brief annual report and a peer review process. The review process is via a brief presentation of the objectives, methods, outcomes and communication activities of the projects and projected work for the year ahead, to an audience of fellow researchers/ investigators from other sub projects within the sub-program, plus a small number of interested producers.

These annual workshops provide a valuable opportunity for researchers and sub program coordinators to review and revise both their individual projects and the sub program as a whole. They also provide an opportunity to further develop linkages between projects.

In July 1998 there were two workshops on introduced pasture species work. One workshop reviewed current NAP plant introduction and evaluation work and was held at the QDPI's Animal Research Institute, Yeerongpilly, Brisbane. A report on this workshop is given in **Part 3** of this report.

**Part 4** deals with the second workshop in Marreeba on NAP work on legume dominance and soil acidification and includes progress reports on on-going projects, jointly funded by the Meat Research Corporation and Land and Water Resources Research and Development Corporation.

**Appendicies I to IV** provide details of project final reports, workshops, conferencesand publications relating to NAP projects and activities. **Appendicies V to VI** give details of the two 1998 Peer Review meetings.

The MLA's North Australia Program works in partnership with producers, state departments, CSIRO, universities, Cooperative Research Centres, agribusiness and other R&D corporations. NAP Management wishes to acknowledge their help and contributions to the North Australia Program.

**Barry Walker**

# Part 1. THE NORTH AUSTRALIA PROGRAM

The MRC's coordinated investment in on-farm research, development and extension in northern Australia commenced in 1986 with the initiation of the first North Australia Program (NAP1). That five year program was followed by NAP2 (1991-1996).

The corporation's activities in this area have now evolved into its third phase, that is NAP3 (1996-2001 ). The focus of NAP3 is on the advancement and refinement of past achievements and their consolidation in an integrated management context. The program is also fully cognisant of the demands and direction that the expansion of the export of live feeder cattle to south east Asia is imposing on the northern beef industry.

NAP3 covers the beef producing areas of Queensland, the Northern Territory and the Kimberley and Pilbara regions of Western Australia, encompassing a broad diverse range of agri-ecological zones from the highly fertile fattening and grain producing brigalow country of Queensland to the arid desert regions of the Northern Territory and Western Australia. Rainfall is also extremely variable but is predominantly summer, monsoon influenced with a pronounced, relatively short lived growing season and an extended dry season.

NAP3 is focused on the needs of beef producers in northern Australia. These 24,000 beef producers account for about half the Australian beef herd; 40% of national beef production and 60% of beef exports. Of these northern producers, 15% of beef establishments carry about 70% of the cattle on about 85% of the beef lands. There is great variability across northern Australia in climate, infrastructure and markets.

The core issues which face the meat and livestock industry in northern Australia are continued deterioration in terms of trade, variable but generally low profitability, increased focus on the need for ecological sustainability and the capability and structures of the meat processing and marketing sectors.

The overall Goal of NAP3 is to enhance the productivity and sustainability, both ecological and economic, of the beef production sector in northern Australia and, by incorporating those enhancements in integrated property management, to improve its profitability and international competitiveness.

NAP3 is comprised of four interdependent sub-programs, each directed towards adding value to other sub-programs and all directed towards achieving the overall program goal of improving profitability, international competitiveness and ecological sustainability. The four sub-programs are -

<u>Sub-program 1</u> Meeting market requirements
<u>Sub-program 2</u> Improving resource management
<u>Sub Program 3</u> Improving property management
<u>Sub program 4</u> Improving program delivery

Details of all four sub programs are provided in the Meat Research Corporation's NAP3 Business Plan, published in October 1997. Projects and activities with introduced pasture plants form parts of Sub-programs 1 and 2.

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## Disclaimer

# Part 2: NAP SOWN PASTURE WORK

## 2.1 Background to NAP sown pasture activities [1]

The introduction of pasture plants to northern Australia has been very successful for the beef industry, which is the main user of sown pastures and forage crops. Sown pastures produce more feed of better quality than native pastures, and this has enabled them to make a large contribution to improving productivity and assisting the beef industry to meet a wide range of market requirements. A recent estimate of the net present value of introduced pasture plants to beef production in northern Australia is $712 million, with a return on investment of 6.5%. The annual gross benefits from all introduced pasture plants in northern Australia, assuming all pastures were used for beef production, were estimated at $80 million in 1995 (P. Chudleigh personal communication).

The gross potential area for introduced sown pastures species in Queensland is estimated at 41 m ha (Walker and Weston 1990) and for the rest of northern Australia at 6 m ha (Weston and Harbison 1980a). In Queensland there is an easily attainable sown pasture potential of 22.1 m ha and a further 0.5 m ha for the Northern Territory, the Kimberley and Pilbara regions of Western Australia. To date only 5.1 million hectares have been developed to sown pastures in northern Australia (P. Chudleigh, personal communication), with over 95% of the development occurring in Queensland. Some introduced plants have also naturalised a further 5 m ha (Walker and Weston 1990). Introduced pasture species presently occupy c.3.5% of the grazing lands of northern Australia.

Present annual development of sown pastures is around 350,000 ha, but when areas of pastures going out of production are taken into account, the average net increase is 210,000 ha, indicating that there are substantial areas of sown pasture going out of production or being re-sown each year. Most pasture development has taken place with grasses on the fertile brigalow and clay soils. Of the total area of sown pastures, 70% are sown to grasses only and the balance to legume based mixtures (Walker and Weston 1990).

Buffel grasses (*Cenchrus ciliaris*) comprises more than 75% of the area sown to tropical grasses, with rhodes (*Chloris gayana*), panic (*Panicum* spp.), setaria (*Setaria sphacelata*), signal (*Brachiaria decumbens)* and purple pigeon (*Setaria incrassata*) grasses also making a major contribution. Main legumes are Seca shrubby stylo (*Stylosanthes scabra*) and Verano and Amiga stylos (*S. hamata*). Glenn and Lee american joint vetch (*Aeschynomene americana*) and Wynn cassia (*Chamaecrista rotundifolia*) are increasing in importance. Twining or scrambling legumes such as siratro (*Macroptilium atropurpureum*), centro (*Centrosema pubescens*), desmodiums (*Desmodium* spp.) and glycines (*Neonotonia wightii*) are still used, but to a lesser extent, mainly because they require high levels of fertiliser and improved grazing management. Sowing of leucaena, (*Leucaena leucocephela*) a valuable browse legume for finishing beef cattle, has steadily increased, particularly on fertile soils in central Queensland, where it is estimated that 50,000 ha have been sown. However, a psyllid insect (*Heteropsylla cubense*) limits its contribution in the more humid coastal areas.

Tropical pasture plants are complemented by a lesser number of temperate plants, mostly legumes, either selected from introductions or bred mainly in southern Australia. These comprise both summer and winter growing plants and are confined in their adaptation to the cooler sub-tropics of southern Queensland or higher elevation tableland environments in the tropics. Temperate legumes having the most impact are annual medics (*Medicago* spp.) and lucerne (*Medicago sativa)*, with the latter grown for both hay and grazing.

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[1] See the following paper for more detail - WALKER, B., BAKER, J., BECKER, M., BRUNCKHORST, R., HEATLEY, D., SIMMS, J., SKERMAN, D.S. and WALSH, S. (1997) Sown pasture priorities for the subtropical and tropical beef industry. *Tropical Grasslands* 31: 266-272.

In addition to the area sown to permanent pastures, around 500,000 ha of forage crops are sown annually (Walker 1991). Forage oats is the major forage crop, but substantial areas are also sown to Silk and other forage sorghums, millets and the legume lablab (*Lablab purpureus*).

It is foreshadowed that the main areas for pasture development over the next decade will continue to be on the more fertile soils in the above 600 mm AAR areas, mainly south of Townsville (Walker 1991). For the live cattle trade, it is envisaged that in far northern Australia there will be increasing use of strategic areas of legume pastures based largely on *Stylosanthes* species, with some hay production from other legumes such as *Centrosema pascuorum* and *Clitoria ternatea*, particularly in the Northern Territory.

## 2.2 Review of the main sown pasture issues

### 2.2.1 Availability of pasture cultivars

For over 100 years improved pasture plants have been introduced to northern Australia (Eyles and Cameron 1985) and there are now a far greater number and diversity of cultivars available than in any other tropical or sub-tropical country. Of the total 137 cultivars so far developed for northern Australia (Eyles and Cameron 1985, Hacker 1997), 72 are grasses and 65 are legumes. Commercial quantities of seed of 29 grasses and 35 legumes are available (Table 1).

Table 1. Annual tropical pasture seed production for 1995 (W.J. Scattini, personal communication)

| GRASSES | tonnes | No. of cultivars | LEGUMES | tonnes | No. of cultivars |
|---|---|---|---|---|---|
| Silk sorghum | 400 | 1 | Shrubby stylo | 165 | 2 |
| Buffel grass | 400 | 3 | Caribbean stylo | 85 | 2 |
| Rhodes grass | 350 | 3 | Joint vetch | 50 | 2 |
| Panicum spp | 190 | 4 | Glycine | 30 | 2 |
| Brachiaria | 130 | 2 | Siratro | 20 | 2 |
| Setaria spp | 80 | 3 | Cassia | 10 | 1 |
| Purple pigeon | 50 | 1 | Leucaena | 10 | 3 |
| Creeping bluegrass | 30 | 1 | Desmanthus | 7 | 3 |
| Urochloa | 25 | 1 | Arachis | 3 | 1 |
| Paspalum | 20 | 1 | Others | 12 | 18 |
| Others | 24 | 8 | | | |
| **Totals** | **1,699** | **28** | | **392** | **36** |

In developing priorities for the North Australian Program, an assessment was made in 1996, in conjunction with research and extension workers, of the availability of pasture cultivars and their associated technologies, for the main agro-ecological zones (Table 2; Map1). These zones are based on the communities and local pasture units mapped and described by Tothill and Gillies (1992) and are similar to those used by Weston and Harbison (1980b) for Queensland. These 9 main zones contain 93% of total area, 93% of the domestic livestock and 96% of sown pastures for northern Australia.

For the mitchell grass, mulga and spinifex zones, the lack of sown pasture cultivars is clearly constrained by low rainfall. In the *Aristida/Bothriochloa* zone grass cultivars are available for the more fertile soils. For the 5 higher rainfall zones, there is a good range of introduced grasses available.

**Table 2.** Assessment of level of available sown pastures technology for the major agro-ecological zones[2]1.

| Agro-ecological zones | Grass cultivars | Legume cultivars | Manage -ment | Beef production | Integrated management systems | Economic viability |
|---|---|---|---|---|---|---|
| Tropical Tallgrass | **** | *** | ** | *** | ** | ** |
| Northern Speargrass | *** | **** | ** | **** | * | * |
| Southern Speargrass | *** | ** | ** | *** | * | * |
| Brigalow/Gidgee | **** | ** | ** | *** | ** | **** |
| Bluegrass on clays | **** | *** | ** | *** | ** | ** |
| Aristida/Bothrichloa | ** | ** | ** | ** | * | * |
| Mitchell grass | * | 0 | ** | 0 | * | * |
| Spinifex | * | 0 | * | * | * | 0 |
| Mulga | * | 0 | ** | 0 | * | * |

[2] Available technology rated from (0) to very high (****)

Suitable pasture legumes are available for the tropical tallgrass, northern spear grass and southern bluegrass on clay zones, whereas for the southern speargrass, brigalow/gidgee, northern blue grass on clay soils and *Aristida/Bothriochloa* zones there are fewer well adapted tropical legumes available. However, for these latter 4 zones, several recently released legumes, such as *Stylosanthes* sp. aff. *S. scabra*, *Desmanthus virgatus* and *Clitoria ternatea* cultivars, can grow well and fulfil an important role. Some new legume cultivars could also be developed from the current "Legumes for clay soils" project (Clem *et al.* 1996), which is being partially funded by the MRC. Furthermore, the severe drought over the last 4 to 5 years (the duration varying between regions), and the recent down turn in beef prices, have restricted the sowing and commercial assessment of many of the newer cultivars.

Before the potential of some of the current legumes can be realised, a number of technical problems need to be overcome. These include the development of effective root nodule bacteria and associated inoculation techniques for the drier areas and establishment techniques for the newer legumes, such as the more recently released *S.* sp. aff. *S. scabra* and the *D. virgatus* cultivars. Nutritional problems in these legumes, especially with *D. virgatus* on blue grass on clay soils, also need to be addressed.

Of the large number of legumes available, which are well suited to a range of soil/climate associations, only a few, such as shrubby and caribbean stylos, are being extensively used. For others, such as fine stem stylo (*S. guianensis* var. *intermedia*), miles lotononis (*Lotononis bainesii*), wynn cassia, bargoo joint vetch (*Aeschynomene falcata*), siratro, lucerne, medics and leucaena, there are many commercial successes, but there is only limited development with them. We need to know why they are not being used more extensively? What are the real constraints to their adoption?

Although we do not judge it to be of the highest priority, we consider that the most important plant introduction need is for new legumes for the southern speargrass and clay soils.

So we pose the question, how much more effort should we put into introducing and developing new plants, until the present cultivars have been thoroughly assessed by beef producers, in conjunction with pasture agronomists. We conclude that for most areas, which are not constrained by low rainfall, there is an adequate range of grasses and legumes available, so there is presently no high priority area for new cultivar development. However, we do endorse further work on solving technical problems associated with some of the more recently developed legumes.

### 2.2.2 Assessing risk of stylos to anthracnose

There is now a range of *Stylosanthes* cultivars available that are adapted to a wide range of soil and climatic conditions and over 1 million hectares of northern Australia have been planted to them (Partridge *et al.* 1996). The main threat to continued stylo development is from the anthracnose fungus (*Colletotrichum gloeosporioides*) which devastated Townsville stylo (*S. humilis*) and Schofield stylo (*S. guianensis*) in the mid 1970's. The present range of cultivars are resistant or partially resistant to the present races of anthracnose in Australia. The most immediate problem is to assess the risk to the present cultivars and new germplasm to the much wider range of South American races of anthracnose.

### 2.2.3 Pasture or forage legumes for cropping systems

Soil fertility is declining appreciably in the dry land pasture and cropping areas of central and southern Queensland. Most of this decline is associated with the depletion of soil nitrogen reserves (Spackman and Garside 1995). The ability of pasture legumes, such as lucerne and medics, to restore soil fertility in cropping systems has been clearly demonstrated in sub-tropical areas of southern Queensland and northern New South Wales (Lloyd *et al.* 1991). On the cropping soils of central Queensland, where lucerne and medics are poorly adapted, preliminary work by Armstrong *et al.* (1997) has demonstrated increased grain yields, after the use of tropical legumes. Of the currently available commercial legumes, lablab has shown most promise (Spackman and Garside 1995) and the development of superior cultivars in terms of yields and persistence by breeding should be pursued. As noted previously, a range of promising tropical and sub-tropical legumes for these soils has been identified by Clem and Hall (1994) in the MRC's "Legume for clay soils" project. On-farm studies (Conway *et al.* 1996) evaluating these legumes in a commercial context is strongly supported.

### 2.2.4 Fodder crops

Fodder crops make an enormous contribution to the northern beef industry. There is a good range of oats, sorghums and pearl millet cultivars available. Further work on developing disease and pest resistance and better agronomic material is seen as being largely the domain of commercial seed companies, who have the resources, expertise and international connections to control the development of suitable commercial cultivars.

### 2.2.5 Soil acidification caused by pasture legumes

Although legume based pastures can increase soil fertility, recent work on *Stylosanthes* based pastures (Noble 1996, McIvor *et al.* 1996) and with leucaena (Noble and Jones 1997) have shown serious declines in soil pH, mainly on light textured soils. This brings into question the long term productivity and stability of tropical legume based pastures. There is an immediate need to develop best practice guidelines, on present available information, to manage this problem. Research activities are further planned to monitor soil pH changes, assess the risk of acidification under various soil, climate and pasture production systems and develop strategies and practices to further refine the management guidelines.

### 2.2.6 Stability and management of sown pastures

There is relatively little information on management of sown pastures and native pastures oversown with legumes (McIvor *et al.* 1996), particularly for long term stability (Table 2). This is clearly an area that should be addressed.

We question the long held expectation, and until recently the commonly held belief by many research and extension workers, that stable and persistent sown pastures, or native pastures oversown with legumes, can be developed and maintained over long periods of 20 or more years, with few management inputs. This is clearly not the case. There are many areas of such pastures that are deteriorating in composition and vigour. Examples are, declining legume contents, pasture grass decline in the brigalow region, increases in weeds (eg parthenium *(Parthenium hysterophorus*) and giant rats tail grass (*Sporobolus pyramidalis* var. *pyramidalis*) and degradation of native pastures oversown with stylos.

No overall assessment of the health and stability of commercial sown pastures is being undertaken There is also little information on where, why and how they decline or what areas of sown pastures are in various states or condition classes. We therefore have no information on the magnitude of the problems.

### 2.2.7 Native pasture cultivar development

There is considerable variation within native grass species, and it is possible to select superior ecotypes for re-vegetation, amenity and environmental uses. For the beef industry, the main use of native grasses is for re-vegetating degraded areas.

In the less harsh environments, either introduced pasture species are available, or more success can be achieved from resting and allowing remaining native grasses plants to seed down and regenerate, rather than trying to harvest seed and sow into degraded areas. Such practices would be less costly and chances of success greater than developing and using native grass cultivars.

The demand for seed of native grasses is mainly for arid or semi arid areas, where the native pastures have been destroyed by overgrazing and there is usually associated soil degradation. For these areas introduced grasses are not available and efforts have been directed to developing native grass cultivars. However, in the semi arid areas, there are considerable technological problems of cultivar development and maintenance, seed production and establishment and the chances of success are very low. Chances of successful establishment in harsh environments are governed by occasional climatic events and a number of establishment attempts may be needed. This will make the costs of revegetation much higher than the value of the land. Where possible, strategic resting and management of degraded areas will offer a greater chance of success, providing there are a few desirable grass plants remaining. Sowing of selected native grass cultivars will also reduce biodiversity.

If native grasses are required for revegetation, then the most appropriate strategy is probably to harvest wild stands of native pastures. This not only will help to maintain biodiversity, but will provide locally adapted plants and be less costly. There is a need to do more work on developing appropriate techniques for harvesting wild stands of native pastures and establishing them.

However, we maintain that most emphasis should continue to be placed on managing deteriorating pastures, especially where opportunities still exist for management to restore desirable native grasses. Where degraded native pastures have been restored to a desirable composition, it is imperative that they are well managed to avoid further deterioration, otherwise it is a waste of money or effort to embark on costly restoration practices.

#### 2.2.8 Beef production systems

Due to large variations in climate and soil, there is a diverse range of beef production systems across northern Australia, from extensive low input breeding operations to on property feed lot fattening enterprises. Production systems in relation to geographic regions have been described by Gramshaw and Lloyd (1993). Rainfall and soils are the main drivers for good beef production. There is an encouraging trend for improving efficiency from many beef producers, who are moving towards increased stratification. They are optimising their management systems in relation to their production environments, with extensive breeding being undertaken in harsh areas and fattening and finishing being carried out in more favoured areas.

In the more favourable environments, the combination of pasture legumes and grasses, fodder crops and fodder conservation strategies make weight gains of over 300 kg per year attainable. In conjunction with feed lots, these strategies have the capacity to meet all markets, particularly if they are well managed and integrated into whole year feeding and husbandry systems.

The live cattle trade to the ASEAN region will remain the key driving force behind the projected increase in Australia's total live cattle exports from 750,000 head in 1996-97 to 890,000 in 2001-02 (Abdalla 1997). Most of these cattle will come from northern Australia and this will require the use of additional areas of legume based pastures for grazing and fodder conservation.

Although there is a lot of information available on the direct effects of introduced pastures on beef cattle production (Table 2), there is less on how to integrate them into feeding systems and whole property management. Except for the brigalow/gidgee zone (Table 2), there is also little information on the economics of sown pasture development in a whole property context. These deficiencies need to be addressed.

#### 2.2.9 Providing sown pasture information to beef producers

There is a lot of information on sown pastures available in scientific publications, books, manuals, reference notes and fact sheets, but little of this information is in a form which is useful to, or easily accessible to, beef producers. There are also many producers who have successfully managed sown pastures and their experience and knowledge have not been captured, documented, packaged or related effectively to other producers.

The most urgent priority for the beef industry is to collate this existing information on sown pastures in a form that can be readily and easily accessed and used by beef producers. Such information needs to be clearly presented in a way that it is applicable to producers in a local context. There are a variety of ways of doing this, from printed material to various forms of electronic communication. In this context, a recent computerised decision support systems has been very effective in Tasmania (Gillard *et al.* 1992).

Accompanying this information collation and dissemination activity, there needs to be a vigorous pro-active campaign by extension and research staff, agri-business and the beef industry in general to promote the responsible and economic uses of improved pastures.

## 2.3 NAP sown pasture projects and activities

The North Australian Program has funded many projects covering a wide range of sown pasture issues and problems (Appendix I). NAP has also facilitated and/or funded a number of workshops, conferences, coordination meetings, exchange visits, tours, etc and has generally assisted in creating a dynamic and rewarding relationship between producers, researchers and extension workers (Appendicies II and III).

Since 1994, the MRC's North Australia Program has sponsored annually the MRC/Tropical Grasslands Pasture Award to a beef producer for outstanding contributions to the use and development of tropical pastures. The Award is made on a rotational basis within the Northern, Central and Southern regions of northern Australia and there have been five awards to date (see Appendix IV). These awards and the field days have stimulated considerable interest and debate in the respective regions.

## 2.4 NAP publications

Since NAP was initiated in 1986, much data, information and knowledge has already been collated, published and used by producers. Lists of publications detailing the work by scientists and technical and extension staff, as well as beef producers, are given in Appendicies III and IV.

## 2.5 NAP achievements

Principle sown pasture achievements from the NAP program have been –

- **Developing new pasture legume, leguminous shrubs and grass cultivars** by the classification of species and genera; testing of a wide range of plants introductions at a range of sites; and screening for disease and pest resistance.

- **Developing sown pastures** through agronomic and animal studies; plus work on pasture establishment, soil nutrition, root nodule bacteria, mycorrhiza and seed production.

- **Improving pasture management** through agronomic, plant dynamics and grazing studies.

- **Developing management guidelines to minimise the effects of legume dominance and soil acidification.**

- **Improving cattle nutrition** through pasture and cattle nutrition and dietary studies.

- **Producer participation in sown pasture development and management** through the use of on property producer development sites.

- **Collating and packaging information.** Through its many projects and other activities a considerable amount of information has been collected, collated and synthesised into management packages by researchers, extension workers and producers. Producers have also become increasingly involved in projects and have been responsible for contributing a lot of management information.

- **Extension of sown pasture technology** through traditional extension methods and various group and action learning activities including PDS's, PIRDS, study tours, farm walks, field days and workshops.

## 2.6 NAP Sown pasture priorities

During Phase 2 (1991-96) of NAP, substantial funding (27% of the NAP budget) was provided to government agencies for the development of new pasture and fodder crop cultivars. In the development of Phase 3 (1996-2001) of NAP, this work was externally reviewed; reviews from other agencies were also considered and discussions took place with the North Australian Beef Research Council, producers, researchers, extension staff and other funding agencies. Sown pasture work was also assessed against other on farm beef industry priorities.

From this review process it was decided that in Phase 3 there would be less emphasis on the development of new pasture plants. Following more than 100 years of successful plant introduction and evaluation, over 140 grass and legume cultivars have been released to the north Australian pastoral industries. There is now a range of pasture plants available for most areas, where low rainfall is not a major constraint. Until these have been commercially assessed, then further development of new cultivars is a low priority.

More attention would be paid to commercially assessing the large number of cultivars that are available, resolving technical issues, developing management systems and more effectively extending this information to beef producers.

Clearly, MLA resources do not permit NAP coverage of all these issues. Even so, a substantial number of the important issues have and are being addressed by the North Australia Program. Reports on the current work are covered in **Parts 3 and 4** of this report.

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# Part 3. 1998 REVIEW OF CURRENT SOWN PASTURE SPECIES DEVELOPMENT PROJECTS

## 3.1 Introduction

Since 1986, the NAP program has provided funding for a substantial number of species development projects, most of which have now been completed(see Appendix I). Although all present NAP sown pasture projects were due to conclude on 30 June 1998, there had been requests to extend four of the projects for one more years. In addition, a former project has still some grass evaluation data to report on and "stylo reversion" has emerged as a problem for stylo seed production. Before any of these requests could be approved, NAP Management required a review of these projects to be conducted.

A one day workshop was held on Tuesday 14th July in Brisbane to review these on-going projects and requests. The program and list of participants attending the meeting are given in Appendix V.

For the review a short annual report was prepared and circulated to workshop participants beforehand. Project teams then presented their reports at the workshop.

## 3.2 Projects and activities to be included in the review

The following projects were considered at the workshop.

1. Legumes for clay soils (NAP3.103) – R.L. Clem and R.M. Jones
2. Back up legumes for stylos (DAQ.083) – H.G. Bishop and B. G. Cook
3. Alternative delivery systems for the inoculation of new strains of stylo (CS.273) – D.A. Date
4. The reversion problem in shrubby stylo seed production – J.M. Hopkinson
5. Evaluation of selected shrub legumes under grazing cattle (CS.187) - B. Palmer and C.H. Middleton
6. Evaluation of grasses for heavy grazing - Grass evaluation work from 3 sites from the project "Development of new legumes and grasses for the cattle industry in northern Australia (CS.185/DAQ.081)" – I.B. Staples and C.H Middleton

In addition, a paper on 'Elimination of unwanted introduced pasture plants' - by H.G. Bishop and J.M. Hopkinson was presented and discussed.

Annual reports and a record of the individual discussions are given in the following section, together with a record of the general discussion.

# Legumes for Clay Soils

**MRC Project No:** NAP3.103

**Project Duration:** NAP2 - 01/07/92 - 30/06/96
NAP3 - 01/07/96 - 30/06/99


**Principal Investigators:** R L Clem
QDPI, Brian Pastures Research Station
PO Box 118, Gayndah Qld 4625
Phone: (07) 4161 1602 / Facsimile: (07) 4161 1954
R M Jones
CSIRO Tropical Agriculture
306 Carmody Road, St Lucia Qld 4067
Phone: (07) 3214 2351 / Facsimile: (07) 3214 2288

**Co-Investigators:** N.J. Brandon, M J Conway, C R Esdale, T B Hilder, Kay Taylor and T J Hall


## Project Objectives:

By June 1999 to,

1. Develop and provide interim guidelines that will allow producers to successfully establish and manage *Desmanthus virgatus* and *Stylosanthes seabrana* pastures.
2. Quantify the liveweight gain from established *Desmanthus virgatus* demonstration areas.
3. Demonstrate the cost effectiveness of planting *Desmanthus virgatus* and *Stylosanthes seabrana* in a beef grazing enterprise.
4. Have sown 10,000 ha of *Desmanthus virgatus* in Queensland.
5. Identify the production and persistence of *Clitoria ternatea* cv. Milgarra, *Vigna trilobata, Macroptilium bracteatum* and *Macrotyloma daltonii* in clay soils.

## Summary:


Tropical pasture legumes that could improve forage quality and animal performance on grazing land and maintain soil fertility in cropping soils were tested in a co-operative (QDPI, CSIRO, UQ, MRC) project. Studies from glasshouse experiments to grazing trials at sites on brigalow and downs soils in southern and central Queensland were undertaken.

Desmanthus and more recently Caatinga stylo have been successfully established with strong perennial grass and desmanthus has marginally improved liveweight gains of grazing stock.

Testing legumes "on farm" has confirmed the persistence and productivity of *Indigofera schimperi*, desmanthus and Caatinga stylo and demonstrated the value of Lablab, Milgarra butterfly pea and *Macroptilium bracteatum*.

Results of testing and experiences gained from understanding the establishment and nutritional requirements of legumes have been communicated by newsletters, displays and field days.


## Report:

### Guidelines for sowing and managing Desmanthus and Caatinga stylo and quantifying animal weight gain

***Desmanthus grazing demonstrations***

*Desmanthus* has been established by sowing with buffel grass (*Cenchrus ciliaris*) on brigalow clay soils at 2 "on property" sites at Wandoan and Middlemount, at Brigalow Research Station and with purple pigeon grass (*Setaria incrassata*) on a black earth at Brian Pastures.

*Desmanthus* has developed slowly at the 2 research station sites and the legume density and yield in the pasture is low in comparison with the other sites. Soil seed has increased to high levels, equivalent to 40 to 120 kg of seed per ha, which should ensure future seedling recruitment (Table 1). Stock graze all year at a stocking rate of 1 steer/2 ha except at Brian Pastures (1 weaner/ 1.2 ha). Liveweight gain on the *desmanthus* pastures at the 2 research station sites, which are the oldest established pastures, show an improvement over grass only pastures. At the "on property" sites there is no advantage to the *desmanthus* pastures, but these are newer pastures and liveweight gain is high (over 200 kg/head/year).

**Table 1.** Pasture yield and composition, legume density, soil seed and steer liveweight gain for 1997/98 at the grazing sites.

| | | Brian Pastures | Brigalow | Wandoan | Middlemount |
|---|---|---|---|---|---|
| Liveweight Gain | - Grass | 0.38 | 0.40 | 0.56 | 0.62 |
| (kg/head/day) | - Grass + *Desmanthus* | 0.47 | 0.43 | 0.55 | 0.63 |
| Pasture Yield | - Grass | 2459 | 5230 | 3784 | 3698 |
| (kg/ha) | - Grass + *Desmanthus* | 2288 | 4061 | 2750 | 3187 |
| % *Desmanthus* | | 10 | 6 | 18 | 10 |
| Legume Density plants/m$^2$ (seedlings/m$^2$) | | 1.7 (10.9) | 4.0 (0.2) | 21.1 (16.2) | 6.4 (1.8) |
| Soil seed/m$^2$ | | 1620 | 2040 | 3495 | 1170 |

***Contribution of desmanthus to the diet***
To estimate the proportion of grass and "non-grass" in the diet of grazing animals dung samples have been collected from the 4 sites over the last two years and the ratio of carbon isotopes measured. In these pastures desmanthus is the dominant "non-grass". Levels of desmanthus in the diet have been low at the two research stations, probably because of low desmanthus yields. At Wandoan, at least when the samples were taken, dietary levels of desmanthus were also low. This is surprising in view of the percentage of desmanthus in the pasture and the obvious grazing of desmanthus. Samples collected from Middlemount in autumn 1997 suggested that there was some 25% desmanthus in the diet.

***Inoculum and nutritional requirements of desmanthus***
Although an effective strain of *Rhizobium* is commercially available, there was concern that it may not survive "dry" sowing under conditions where there is often a delay between sowing and the next "germinating" rains. In co-operation with the University of Queensland eight clay soils from southern and central Queensland were studied to see if there were native rhizobia that could form effective nodules with desmanthus. A pot trial showed that there were effective native rhizobia present in four soils. However, in four soils there was a response to inoculation and in two soils there were no nodules on the uninoculated controls. A field trial at four sites showed that inoculation improved first year growth at three sites and growth at one site in the second year. Based on these results inoculation is recommended but effective nodulation from native rhizobia is likely to occur.

Nutritional studies were conducted to investigate causes of desmanthus "yellowing". Pot trials on soils from Brian Pastures showed that desmanthus responded to applications of both sulphur and molybdenum. Following application of these nutrients to the desmanthus pasture there was a noticeable improvement in plant colour and vigour. In another trial 7 soils were tested for a range of nutrients. Responses to sulphur were obtained in 4. Suggested critical levels of soil and plant sulphur were determined. Follow-up assessments of the effect of sulphur are being made in the desmanthus plots in the "on-farm" field trials.

***Nitrogen fixation by desmanthus***When clay soils are cultivated, nitrogen is mineralised. As newly sown legume plants will take up this soil N, rather than fix atmospheric nitrogen, it is possible that there will be some delay in fixation. Further, if there are no adapted native rhizobia there is a possibility that desmanthus may not be meeting the desired objective of improving soil nitrogen status.

The presence of effective fixation in legumes can be documented by analysis of the different ratios of nitrogen isotopes of the legumes and "non-fixing" plants. Hence, plant samples have been collected from the 4 grazing sites since 1996/97. Some samples are still to be analysed. All samples from Wandoan and Brigalow in 1996/97 and 1997/98 indicate the nitrogen in desmanthus is almost all derived from fixation. In the first samples collected in March and May 1997 from Middlemount, some 2 years after sowing, effectively all nitrogen was from soil mineral nitrogen. In the next sample (August 1997) one-third of the nitrogen was from fixation. It is anticipated that that it will now be similar to Wandoan and Brigalow with fixation being the main source of N.

***Depth of sowing***

Pot trials have shown that desmanthus should not be sown deeper than 3 cm. Legumes with larger seeds, such as siratro, were able to emerge from 5 cm depth.

***Caatinga stylo demonstrations***

Paddocks of 3.5 to 12 ha of *Stylosanthes seabrana* (cvv. Primar and Unica)/grass pastures have been established to demonstrate its grazing value at "on property" sites at Fernlees, Baralaba, Wallumbilla and Surat. There is also a buffel grass paddock adjacent to the stylo/buffel paddock at Baralaba.

Except at Fernlees, density of both cultivars has increased but legume yield is low with the best being 150 kg/ha (or 5% of pasture yield) at Baralaba (Table 2).

**Table 2:** Density of *Stylosanthes seabrana* at "on property" sites and pasture yield and liveweight gain at Baralaba.

| | | Fernlees | Baralaba | Wallumbilla | Surat[1] | Surat[2] |
|---|---|---|---|---|---|---|
| **Legume Density** | | | | | | |
| (plants/m$^2$) | | | | | | |
| - Unica | 1997 | 2.3 | 1.9 | 5.6 | 1.4 | 3.3 |
| | 1998 | 1.3 | 3.5 | 14.5 | 2.9 | 12.5 |
| - Primar | 1997 | 2.3 | 3.3 | 7.5 | 0.9 | 4.7 |
| | 1998 | 2.3 | 4.9 | 27.5 | 1.5 | 16.5 |
| **Pasture Yield** | grass | - | 2275 | | | |
| (kg/ha) | grass + stylo | - | 2887 | 2500 | - | 2000 |
| **% stylo** | | - | 5 | - | - | - |
| **Liveweight gain** | grass | - | 0.49 | - | - | - |
| (kg/hd/day) | grass + stylo | - | 0.54 | - | - | - |

**"On Farm" comparisons of grazing and ley legumes**

A range of commercial and "best bet" experimental legumes were sown in 1994 at 5 sites (Clermont, Springsure, Biloela, Theodore and Wandoan) and in 1995 at 6 sites (Capella, Middlemount, Bauhinia Downs, Acadia Valley, Roma and Chinchilla). Bauhinia Downs was resown in 1996. Large plots (20m x 12m) were sown in 2 replicates into land prepared for cropping. Perennial grasses were oversown at all sites. Grazing has occurred at all sites usually in association with grazing crop stubbles, but has been limited at some sites.

Establishment of legumes was satisfactory, but more variable with smaller seeded legumes, desmanthus and stylo. In the year of sowing, lablab produced the most forage with yields from 1 - 5 t/ha, depending on soil moisture and rainfall. Yields of *Vigna trilobata* CPI 13671 and *Macroptilium bracteatum* CPI 27404 were also higher than longer term legumes. Lablab did not regenerate and although Vigna did emerge often in large numbers, second year yield was low. *M. bracteatum* yields were high in the second and third season, but by 1998 had declined except at Biloela where it yielded 1 t/ha (5$^{th}$ year) and Bauhinia Downs 3 t/ha (3$^{rd}$ year).

Forage yields of *Glycine latifolia* varied between sites and seasons with high yields in 1998 only at Biloela (1 t/ha) and Acadia Valley (3 t/ha). The persistent and productive legumes were *Indigofera schimperi*, Milgarra butterfly pea, desmanthus, Caatinga stylo and Aztec (Table 3).

Indigofera produced high yields on both brigalow and downs soils. Seedling recruitment was initially slow but soil seed levels and seedling density are increasing.

Milgarra butterfly pea maintained high legume densities and high forage yields except at Wandoan, Roma and Chinchilla. These 3 sites are the most southern and are on brigalow soils.

There has been a substantial renewal of interest in Milgarra with production of seed probability exceeding 50 tonnes and several thousand hectares being sown mainly in the central highlands. This interest has been substantially enhanced by promotion of results from LCS project and field days at the "on farm" sites.

Desmanthus has generally grown better on the brigalow soils and Marc populations have been improved through seedling recruitments. Soil seed levels are extremely high for Marc, but are lower for Bayamo and Uman suggesting their longer term survival may be at risk.

Caatinga stylo performance has been variable with high forage yields at downs sites and very high seedling recruitment (up to 110 seedlings/$m^2$) at Theodore. Soil seed reserves are low despite high seed production and seedling regeneration. This suggests that a high proportion of seed is soft and population maintenance is dependant on survival of seedlings.

**Table 3:** Legume and seedling density, forage yield and soil seed levels of the most persistent and productive legumes in 1998.

| | Downs | | | Brigalow | | |
|---|---|---|---|---|---|---|
| | Legume density (plants/$m^2$) | Yield (kg/ha) | Soil Seed ( /$m^2$) | Legume density (plants/$m^2$) | Yield (kg/ha) | Soil seed ( /$m^2$) |
| Milgarra | 13 (27) | 2250 | 0 | 8 (4) | 970 | 0 |
| Marc | 4 (1) | 603 | 3910 | 17 (25) | 627 | 24190 |
| Bayamo | 4 (3) | 375 | 210 | 6 (8) | 553 | 1740 |
| Uman | 2 (1) | 341 | 0 | 3 (1) | 232 | 890 |
| I. schimperi | 5 (2) | 2675 | 4150 | 5 (3) | 1065 | 2720 |
| Aztec | 4 (1) | 569 | 30 | 3 (1) | 729 | 210 |
| Seca | 1 (2) | 64 | - | 1 (5) | 136 | - |
| Unica | 32 (41) | 1994 | 90 | 10 (10) | 423 | 150 |

Leucaena, sown in a sward, and Aztec had high yields at Acadia Valley and Biloela but, all legumes have grown well at these sites with deep, fertile soil and limited grazing.

Lucerne sown at some sites failed or yielded poorly except at Chinchilla in the first season.

***Comparisons of legume quality***
Quality of promising legume accessions was measured to see if there was a consistent ranking independent of site. Ten legumes were sampled at four sites (Arcadia Valley, Wandoan, Biloela and Mundubbera). The samples were taken of the last 15 cm of shoot during periods of active growth when there was little or no flowering. The 15 cm was selected to represent the "grazed layer". The samples were separated into leaf and stem. Samples from two sites were checked for any unusual concentrations of "other" elements. Acid detergent fibre was used as the key index of quality.

Quality of leaf was far higher than stem, with the mean stem ADF (38.3) being 62% higher than the mean leaf (23.6). This would suggest a difference of about 15 units of *in-vitro* digestibility (55 -70%). The % of leaf was consistently lowest in Seca and Unica stylo. The lowest leaf ADF levels were in all 3 desmanthus cultivars and Milgarra (18-20%) and the highest in Seca (30%). Seca also had the lowest N% in the leaf. Differences between quality of stem from the different accessions were still significant, but much smaller.

The main differences in "other" elements were in the far higher sodium level of Seca and *Indigofera schimperi*, about 10 times the levels in the other accessions, the higher calcium levels in *I. schimperi* and, to a lesser extent, the higher S levels in desmanthus.

These results linked with similar studies in "Back-up legumes for stylo" and in a dairy funded project on legumes for coastal pastures will give a wider picture of legume quality.

***Herbicide tolerance/susceptibility***
The effect of 23 broadleaf and 5 grass herbicides applied post emergence on Milgarra, glycine, indigofera, *Macroptilium bracteatum* and *Vigna trilobata* were compared in glasshouse experiments. Previously a larger range of chemicals including some common to both experiments were tested on desmanthus. The responses of the legumes to broadleaf herbicides varied from highly susceptible to tolerant which should provide chemicals suited both to weed control in legume crops and removal of the legumes if necessary. All legumes were tolerant to the common grass control herbicides.

**Small plot trials**
These trials examined a much wider range of legume accessions than could be examined in the "on-farm" trials. Over 150 accessions were sown at 3 sites (Narayen, Brigalow and Emerald Research Stations) over 3 years (1992/93 to 1994/95).

***Legumes for permanent pastures***
The results again highlighted the superior long-term persistence of desmanthus, indigofera and Caatinga stylo. Indigofera was outstanding, but although it was well grazed on some occasions there were others where it was not grazed. Two accessions of desmanthus (TQ90 and CPI 90750) showed promise for use in permanent pastures as they have a more appropriate balance of herbage yield for animal grazing and seed set for persistence. Some late flowering lines have potential for leys where seeding is a liability. This points to a need to properly evaluate the representative set of desmanthus accessions which have now been selected, along with assessment of their requirements for Rhizobium. Although several accessions of Caatinga stylo have persisted, none shows any consistent advantages over Unica and Primar.

***Legumes for ley pastures***
No accessions outyielded lablab in year one, but several accessions, especially *M. bracteatum* showed promise for 2 to 3 year leys. Only one accession (CPI 27404) was widely sown in these trials, but another line (CPI 55769), sown in the last sowing at Narayen and also in evaluation trials of ley legumes funded by GRDC, is even more promising. A wider range of ley legumes including a number of *M.bracteatum* are being evaluated in the GRDC project.

***Annual medics***
Annual medics can make a useful contribution in southern Queensland to winter feed and soil nitrogen in years with good cool season rainfall. However, the occurrence of winter rain declines in central Queensland so to persist accessions must be able to maintain a seed bank through a run of dry years. A range of 17 medics was sown at Narayen, Jambin, Brigalow and Emerald in 1993. There was a good initial seed set at Narayen and Jambin, but there has been very little seed set since. Despite this, there was still good seedling emergence in autumn of this year at Narayen with 6 lines having over 50 seedlings per square metre and one line of disc medic still had a seed reserve of 1270 seeds/m$^2$. Depending on its seedbank from other sites and results from other studies, this accession may be put forward for release.

**Communication achievements**
Trials on 15 properties and 4 research stations from Roma to Middlemount has required a high level of cooperation between property owners and staff and research and extension officers. Many local groups such as the Brigalow Floodplain Management Group at Chinchilla, Landcare and Catchment Care groups have used sites for field days and discussion groups creating a very large network of producers, agri-business, extension and research personnel.

There have been 16 Legumes for Clay Soils newsletters produced and with a circulation of about 200 it has expanded the network of people interested in these legumes. It is anticipated that the group researching legumes for ley systems will continue to circulate the newsletter at the conclusion of the MRC funded project.

Field days have always attracted interest. Displays of plants, posters and publications have been manned by project staff at Ag shows in Toowoomba, Bundaberg and Emerald, Meat Profit Days at Chinchilla and Emerald, Beef 97 and agricultural shows. Radio and newspaper coverage has been extensive. Fact sheets on the agronomy and management of desmanthus and butterfly pea have been produced and the Caatinga stylo sheet is in preparation.

Scientific posters and papers have been presented at the Tropical Pastures Conference, Australian Agronomy Conference and Australian Institute of Agriculture Science seminars.

## Plans for 1998/99

1. Final measurements of medic soil seed levels to be completed at the 4 medic sites.

2. Small plots at the 3 research station sites will be terminated and the indigofera plots and any remaining in the old Narayen grazing trials will be sprayed.

3. Desmanthus and Caatinga stylo grazing demonstration sites will be maintained to:-
   - measure liveweight gain, yield and composition, legume density and soil seed.
   - allow isotope analyses of legume for N fixation and of dung for diet composition.

4. On farm legume sites will be progressively terminated. Sites will be returned to co-operators and some are likely to be cultivated. *Indigofera schimperi* has been sprayed out.
   - Indigofera will be monitored and eradicated at all sites.
   - Isotope analyses are proposed on Caatinga stylo growing at selected sites.
   - At sites used for cropping it is proposed to measure crop yield and grain protein content from selected legume plots.

5. Management and funding arrangements for legume grazing trials at Brian Pastures, commenced in 1998 to complement this project, will be negotiated.

6. Economic analysis of using desmanthus, Caatinga stylo and Milgarra butterfly pea will be pursued. Better estimates should accrue from 3, 4 and 5 above.

7. Publication of the Caatinga stylo fact sheet will proceed and results from other studies will be progressed towards publication in journal and other media (brochures etc).

## Discussion/Comments

1. There were some points of clarification and questions that were raised and addressed during the presentation. These were in relation to methodology of establishment (how best done, costs and risks), stocking rates, legume quality and economic benefits of using legumes.

2. Milgarra butterfly pea was sown into a rather hastily prepared paddock at Warwick. The subsequent weed problem probably justified spraying but no herbicide recommendations could be found.

3. Weeds have also been a problem in experimental sowings especially on old cultivations and information is limited but is being developed. Don Loch has tested the tolerance and susceptibility of Milgarra and also desmanthus, indigofera, glycine, *Macroptilium bracteatum* and *Vigna trilobata*, to a range of herbicides. Milgarra is reasonably tolerant to 8 to 10 broadleaf herbicides, but effectiveness on the target species also has to be taken into account. Vicki Osten at Emerald has some information on field use of herbicides in legumes leys. Normal grass killers have been used to good effect in seed crops of Milgarra.

4. *Is the experience of high seedling numbers but low soil seed banks in Caatinga stylo widespread and is it recognised by the seed industry?*
   It was generally believed (based on CSIRO work at Townsville) that this stylo had lower levels of hard seed than Seca and there was a suggestion of a stronger interaction with environmental conditions prevailing during seed development. The effect of these characteristics on legume development and grass/legume dynamics is not yet known but it was likely that Caatinga based pasture would behave differently perhaps with shorter term fluctuations in grass/legume composition than Seca which increased sometimes slowly but generally reliably over time. (Bob Clem, Harry Bishop, Dick Jones)

5. *In respect to the objective to have 10,000 ha sown to desmanthus, how much seed has been sold and is there any idea of the area sown commercially?*
The area sown is not known. Some 30 tonnes of seed were produced initially and 7 to 10 tonnes were sold. Wrightson Seeds operations have now been reduced in Queensland and seed remains in store. There is no current seed production in north Queensland.

6. Bruce Pengelly outlined the GRDC funded ley legume project. This project has evaluated a diverse range of mainly annual and short term perennial legumes from the ATFGRV stocks. Some of the *Macroptilium bracteatum* lines in particular show promise with high forage yields in the first and second years although never out-yielding lablab in year 1. Seed of some of the best lines has been increased by John Hopkinson and areas will be sown for grazing this summer in central and southern Queensland.

   The desmanthus collection of over 400 accessions has now been grouped, with a sub-set of about 70 representing the main species. These could be useful in both leys and permanent pasture and a co-ordinated approach to testing is needed especially to ensure rhizobium requirements are met and that lines are tested across a range of environments.

7. *Is the impact of legume likely to be through gain/head or gain/ha. If gain/ha then quantity of feed is critical?*
In permanent grazed pasture systems persistence is a key characteristic, particularly on clay soils where grasses are often very competitive and rainfall highly variable. Initial benefits of legumes are likely to be mainly through improved feed quality.

   When legumes are used as forage crops (or leys) between grain cropping, then more productive legumes are needed to maximise nitrogen accumulation in the soil and to improve livestock production either through higher liveweight gain or higher stocking rates. The economics of using legumes will be dependant on the range of factors including the state of the current pastures and the extend of "rundown", but if legumes can stop nitrogen drain then there should be a real benefit in the longer term.

### Acknowledgements
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# Backup Legumes for Stylos (BULS)

| | |
|---|---|
| **MRC Project No:** | **DAQ.083** |
| **Duration:** | **NAP2 - 01/07/92 to 30/06/98**<br>**NAP3 - 01/07/96 to 30/06/98** |
| **Principal Investigator:** | **Harry Bishop (Project Leader)**<br>**DPI, PO Box 668, Mackay 4740**<br>**phone (07) 49518731/Fax (07) 49514509**<br>**Email** bishop@dpi.qld.gov.au |
| **Co-investigators:** | **Bruce Cook, Terry Hilder, John Hopkinson,**<br>**Don Loch, Col Middleton, Bob Walker (DPI),**<br>**George Rayment (DNR), Cam McDonald (CSIRO).** |

## NAP2 Project Objectives (01.07.92 to 30.06.96)

(i) By July 1995, to study and understand the general agronomy and ecology of three well adapted legume cultivars (particularly from *Aeschynomene* and *Chamaecrista* (*Cassia*) species) and develop commercial management practices to speed integration into the grazing industry.

(ii) By July 1995, to demonstrate the animal production potential of the three new cultivars.

(iii) By October 1995, to produce a minimum of 100 kg of seed of the three new cultivars.

(iv) By October 1995, to determine field nutritional requirements and responses and develop appropriate seed technology packages for each new cultivar.

(v) By June 1996, to release the three cultivars to complement and back-up currently used legume cultivars (particularly for the *Stylosanthes* species).

(vi) By June 1996, to select five new legumes for pre-release.

## NAP3 Objectives (01.07.96 to 30.06.98)

(i) By July 1998, to provide sufficient agronomic details to the Queensland Herbage Plant Liaison Committee to allow for the release of *Aeschynomene brasiliana* CPI 92519 and at least one further *Chamaecrista rotundifolia* accession.

(ii) By July 1998, to select five new legumes for pre-release.

## Project Summary


A network of 13 pasture legume adaptation sites, three live weight gain sites and three phosphorus response sites was established across northern Australia from Gayndah in south-east Queensland to Katherine in the Northern Territory. Target soils were the lighter acid soils most suitable for stylo growth with target rainfall 650 to 1000 mm (26" to 40"). 55 legumes were sown over the three summers, 1992/93, 1993/94 and 1994/95.

Four to six years' evaluation of 5 stylo and 50 non-stylo legumes, including 14 existing cultivars, has more clearly defined adaptation, performance and development options for existing and new pasture legumes and has progressed the application of sown pasture technologies in northern Australia. Below average and poorly distributed rainfall at most sites in the establishment years highlighted lines tolerant of harsh conditions. Animal production, objective 2, and field nutritional requirements, objective 4, were only partially achieved due to drought conditions. The two extra years of monitoring has clarified the status of pre-release lines and new and existing cultivars. The new *A. villosa* cultivars Reid and Kretschmer were marketed as a mixture called "Villomix" in 1997/98. *A. brasiliana* CPI 92519 continues to persist but palatability is a problem at some sites. The late flowering "Cassia" lines do not appear better adapted to climate or soil than Wynn and have similar palatability to Wynn. Adaptation and performance results have been presented at 14 "pasture walks" and four conferences, plus numerous press articles and radio talks. Guidelines for future management of on-farm evaluation sites are being developed in consultation with property owners

## Results and achievements

**1. Objectives NAP2 (i), (iii), (v) and NAP 3 (i)**

This project contributed valuable information supporting the release of Reid and Kretschmer villose jointvetch (*Aeschynomene villosa*) for coastal speargrass communities receiving greater than 900 mm (36") rainfall. These cultivars have been commercialised under PBR and for the 1997/98 summer were retailed as "Villomix" at $12/kg.

Information packages for *Aeschynomene brasiliana* CPI 92519 and *Chamaecrista rotundifolia* CPI 85836/86172 are being prepared for the August 1998 Queensland Herbage Plant Liaison Committee (QHPLC) meeting. However these will be "non-release cases" with a recommendation that these accessions not be released but "lie in storage" for some future date when they may be needed.
*A. brasiliana* 92519 is well adapted to harsh conditions (next best to the stylos) but has a sticky exudate on the stems and leaves and at some sites has not been readily grazed. Although it is fairly well grazed at some sites no live weight gain data are available due to drought in the first 3 years at the Mt Garnet grazing evaluation site. The 1997 QHPLC meeting requested that it be eradicated from all sites.
*C. rotundifolia* 85836/86172, although slower to establish than Wynn (probably due to higher hardseed content) now has equal or higher sward density, dry matter yield and soil seed reserves. Palatability is similar to Wynn and being higher yielding they have the capacity to "dominate" in native pasture situations. Again no comparative weight gain data (with Wynn) are available due to the grazing evaluation site being at Mt Garnet.

**2. Objective NAP2 (ii)**

The grazing evaluation sites for *A. brasiliana* and *C. rotundifolia* ("Sugarbag" and "Lamonds Lagoon"), Mt Garnet, experienced three years of drought and have been discontinued. Reid and Kretschmer jointvetch are readily eaten by cattle, but cattle weighings on two producer demonstrations near Gympie have been interrupted by periods of drought. In another producer demonstration near Mackay steer weight gain slightly favoured Glenn jointvetch (0.49 kg/day) over Lee jointvetch (0.45 kg/day) over a 600 day period stocked at 1.5 steers/ha.

**3. Objective NAP2 (iv)**

Response of Glenn, Lee and Reid to applied phosphorus, relative to Seca stylo, has been documented but less information is available for *A. brasiliana* 92519. Glenn, Lee and Reid require higher soil phosphorus for optimum growth than does Seca stylo but this also means the former have potential for greater yield, quality and digestibility in higher input situations. Soil analysis of evaluation sites in year six indicates that *A. brasiliana* 92519 is adapted to low soil phosphorus but no information was gained on its response to increasing P due to failure of the response trial at Mt Garnet due to 3 years of drought. Similarly no response data were obtained for *C. rotundifolia* 85836, 86172 or Wynn. Seed production packages for Reid and Kretschmer jointvetch have now been commercially tested and involve a combination of direct and suction harvesting. Although the stickiness of *A. brasiliana* 92519 causes some difficulties with seed harvesting, commercial seed production is possible with backup from suction harvesting. Seed production for "cassia"legumes poses no problem. The results of a herbicide tolerance/susceptibility screening trial conducted by Don Loch, Gympie, are currently being processed for use by commercial seed producers or for control of legumes in weed situations.

**4. Objective NAP2 (vi) and NAP3 (ii)**

*A. histrix* is very palatable with few environmental concerns and performance of the three late flowering pre-release lines (93599, 93636, 93638) has been sufficient to "flag" further evaluation of recent introductions which are earlier flowering. The earlier flowering *A. americana* 93624 has considerably better regeneration/persistence than Glenn at Miriam Vale and Gympie and a case will be submitted for pre-release pending further monitoring of its performance and investigation of co-marketing arrangements with commercial production of Glenn seed.
Good performance of *Desmanthus virgatus* lines at "Granite Vale", St Lawrence, indicates it is adapted to some duplex soils. Selections AC 10/AC 11 from naturalised desmanthus at Alligator Creek, Townsville (made by Bob Burt, then of CSIRO Davies Lab, Townsville) performed well in series 2 plantings at "Granite Vale", Narayen and Brian Pastures and series 3 at "Granite Vale", "Swans Lagoon" and Miriam Vale. CPI 37538 has persisted well at Brian Pastures, Narayen and Gympie but is a very small plant. These three accessions could be placed on pre-release to stimulate wider evaluation and discussion.

**Additional results and achievements**
Adaptation and production information on 14 current legume cultivars, including 5 **stylos**, has been updated by this project resulting in better management packages for, and greater use of and production from sown pastures in northern Australia. For example current stylo cultivars are being promoted and used more in the Northern Territory and in the southern speargrass zone. **Aztec** atro has persisted for four years at Eton Range, Sarina and Miriam Vale, and **Glenn/Lee** jointvetch "wax and wane" with rainfall but in certain situations make a valuable contribution. **Bargoo** jointvetch has proven a very persistent legume at Sarina, Gympie, Narayen and Brian Pastures. Seed production has been the main restraint to its commercial use. More recently introduced lines may overcome the pod shattering and anthracnose disease problems with Bargoo seed production. The adaptation of **Wynn** cassia is now better defined.
Monitoring of soil seed reserves highlighted the relationship between seed set, seedling regeneration and legume persistence and the importance of management practices to encourage seed set.

Legume quality assessment of tip samples (%N, P and Acid Detergent Fibre) showed considerable variation between legumes and highlighted the productivity potential of certain legumes (Lee, Glenn, Villomix) due to their higher quality forage compared with that of Seca stylo.

## Communication achievements

**1. Communication with producer site owners/managers.**
Evaluation sites have been established on 13 properties. Valuable information exchange occurs during site selection, establishment and ongoing management. Property owners/managers vary regarding interest and participation but most keep abreast of progress results during recording visits and phone calls. The "Glensfield" owner has increased his sown pasture development program over the past two summers sowing 250 ha to mixtures of legumes (and grasses) based on species performance at his Backup Legumes for Stylos (BULS) site. The owners of "Wadeleigh" and "Bethome", Bororen/Miriam Vale, have similarly developed areas based on performance at their sites. Seven properties volunteered demonstration sites for Reid and Kretschmer following an inspection of the BULS evaluation site by the Miriam Vale Rural Science and Landcare Society in May 1996. All properties were officially contacted at the end of year four about continued monitoring and were updated with a results summary for their site and for the overall project. All current properties will again be officially contacted on future management of their sites and updated with a six year result summary. On-site discussions have already occurred with most owners about management of un-released legumes.

**2. Communication with wider rural and RD&E community.**
Eleven producer "pasture walks" plus 3 inspections with producer/agri-business/RD&E interests have been organised. Many site owners and departmental collaborators have organised visits with neighbours and fellow workers. Four poster papers have been presented at conferences. Regular newspaper, newsletter and radio articles and talks have updated progress results. A fact sheet on "Villomix" and a BULS poster were prepared for the Emerald MRC Meat Profit Day.

**3. Networking with RD&E people.**
The interim final report lists 27 principal investigators/technical collaborators plus 5 research stations as involved in various aspects of the BULS project. These collaborators represented DPI, CSIRO, NT-DPI&F and James Cook University. Review and planning workshops in each of the first 3 years stimulated much interchange of ideas and techniques as well as progress reports.

A direct request to the Northern Australian Pasture Plant Evaluation Committee (NAPPEC), to assist with developing guidelines for future management of discontinued evaluation sites containing un-released legumes, led to one day of their 4 day 1998 field meeting being spent inspecting and discussing aspects of the BULS project. The 22 participants represented Queensland, NT and NSW Departments, Department of Environment, CSIRO, University of Queensland and the seed industry.

**4. Reports:**
Scientific publications are listed in Appendix III.

- Bishop, H.G. (1996). Interim final report on project DAQ.083, Backup legumes for stylos. Report to MRC, October 1996

- Bishop, H.G and Hilder, T.B. (1996). *Aeschynomene* accessions evaluated in COPE plantings; in Development of new legumes and grasses for the cattle industry of Northern Australia, Final Report of MRC Projects CS 054/185 and DAQ 053/081 (compilers B.C Pengelly and I.B. Staples). Published by CSIRO and DPI, c/- CSIRO Cunningham Lab., St Lucia, Q 4067, p 155-165.
- Report to DPI by Leone M. Bielig, Dept of Botany and Tropical Agriculture, James Cook University. "Chromosome numbers in the legume *Aeschynomene* L."
- Report to QHPLC by H.G. Bishop and B.G. Cook (6 September 1995). "Proposal for release of *Aeschynomene villosa* CPI 91209 and 93621".
- Cook, B. and Bishop, H. New 1995 pasture releases – Reid and Kretschmer villose jointvetch MRC/NAP news, Issue 2 Autumn 1996.
- Villomix fact sheet, prepared for MRC Emerald Meat Profit Day, April 7, 1998.

**5. Field days and pasture walks (handouts):**
- "Wadeleigh" and "Bethome", Miriam Vale Rural Science and Landcare Society inspected the adaptation sites on 4 May 1994 (100 people) and 1 May 1996 (50 people) as part of half day district tours. Also attended their AGM field meeting on 6 December 1996 and visited evaluation sites on 7 December 1996 with 3 producers and John Rains of Southedge Seeds, Mareeba.
- "Granite Vale", St Lawrence. Inspected and discussed with the Marlborough Landcare group (30 people), 17 May 1995.
- "Sugarbag", Mt Garnet. Grazing evaluation inspected and discussed by 16 people from 7 properties following a "Best Practice" group meeting on 14 March 1996.
- "Sugarbag", Mt Garnet. Grazing evaluation of *A. brasiliana* CPI 92519 inspected and discussed with 60 people on the Atherton Tropical Grassland Conference Field Trip on 29 June 1996.
- "Tedlands", Mackay. Phosphorus response trial and Glenn/Lee grazing demonstration site inspected and discussed with 25 people on a DPI/Mackay Rural Production Society field day on 22 July 1994, and with 40 people on 8 June 1996.
- Cultivars of *A. villosa* (Reid and Kretschmer) in 5 year old plots at "Tedlands" were inspected by John Rains, Southedge Seeds, Mareeba, and John Hughes, Crokers/IAMA, Mackay, August 1996.
- "Glensfield", Sarina. Inspected by COPE/BULS/LCS workshop participants in October 1993 and October 1995. Also various student and DPI groups.
- "Glensfield", Sarina. Inspected by NAPPEC (20 members) and two producers on April 3, 1998.
- "Glensfield", Sarina. Inspected by 12 local producers and CQ DPI Rural Services Co-ordinator (Bob Miles) and Director-General (Roly Nieper) on 19/2/97.
- Katherine Research Station, NT. The BULS site was inspected by NAPPEC group in May 1994.

## Plans for 1998/99

**1. Write up and publish results**

1.1 Release/non-release case on all pre-release lines (*A. brasiliana* 92519, *C. rotundifolia* 85836, 86172, *A. histrix* 93599, 93636, 93638) by August 1998.

1.2 Proposal to QHPLC to place *A. americana* 93624 and several *Desmanthus virgatus* lines on pre-release (by August 1998).

1.3 Commence proposed publications listed later in this report.

1.4 Final report on BULS project (by September 30, 1999).

**2. Further develop and implement communication plan**

2.1 Update or produce client/information fact sheets on the 14 legume cultivars in BULS for the DPI Internet Home Page and CD-ROM Prime Notes. Involve all relevant RD&E people and collaborate with Legumes for Clay Soils and PDS/PIRDS projects.

2.2 Facilitate more producer demonstration sites of "Villomix" along the Queensland coast in 1998/99, in cooperation with PBR licensee Southedge Seeds, Mareeba (John Rains), who has already put his own resources into promoting the new cultivars.

**3. Develop and implement management guidelines for discontinued evaluation sites, in co-operation with owners of sites.**

3.1 Develop and implement program of eradication for non-cultivar lines which are either -
- requested by landowner to be removed

- aggressive in regard to spread (potential environmental weed)
- unpalatable

3.2 Clean-up of sites (remove fences, pegs, etc) where project is finished and no risk plants exist.

3.3 Containment of site (grazing and site management) to allow low risk continued monitoring of evaluation plots.

However, a broader state-wide project encompassing all "recent" sown pasture evaluation work needs to be considerably resourced and implemented. This whole area of "responsible management" of species evaluation sites was a special agenda item at the April 1998 NAPPEC meeting in Mackay. The meeting decided to increase its focus and commitment to developing protocols for plant evaluation in relation to the ongoing implementation of The National Weed Strategy and DNR new Land Protection Bill legislation which targets environmental weeds. In the meantime a sub-project of BULS is currently being developed to handle eradication of non-cultivar "risk" legumes (item 3.1). For more detail on this issue refer to the discussion paper on the *"Elimination of unwanted introduced pasture plants"* on pages X to Y in this publication.

**4. Limited legume monitoring at selected sites.**

4.1 Depending on site owner requirements and outcome of site management guidelines some monitoring will continue, particularly of pre-release and promising lines (*A. americana* 93624, *A. histrix* 93599 and *D. virgatus* AC 10 and AC 11). Detailed soil profile description and analysis will be carried out on the "Granite Vale" (St Lawrence) site where desmanthus is well adapted, relative to a duplex soil site where desmanthus is poorly adapted.

4.2 Assist developing a plan to evaluate recently available *A. falcata* lines with better seed production characteristics than cv Bargoo and early maturing *A. histrix* lines as the lines on pre-release show good promise but are late seeding.

## Discussion / Comments

**1. Effectiveness of evaluation process**

1.1 Drought and/or poorly distributed rainfall over the duration of this project , particularly in the establishment years, affected outcomes and made some results difficult to interpret. However supplementary irrigation would not seem an option.

1.2 Use of large number of sites had advantages (better cover of rainfall variability, better soil / vegetation type cover, contact with more producers and RD&E collaborators) and disadvantages (more seed required and more risk with any environmental weed types).

1.3 Use of large plots (50 m x 20 m in series 1 and 20 m x 5 m in series 2 and 3) gave credibility for producers, more success with species performance and allowed separate grazing of fenced site (series 1 sites were 4 ha or 10 acres in area).

1.4 Seed production of evaluation lines by the Walkamin Research Station team contributed greatly to the evaluation process.

2. Pasture development in the tropics and sub-tropics has relied heavily on the legume genus, *Stylosanthes*, a total of 14 cultivars being released in Australia alone. However, these varieties have not been without problems. At this stage, 8 of the range have succumbed to the fungal disease, anthracnose, caused by *Colletotrichum gloeosporioides*, and are no longer commercially available. Seed crops of Seca shrubby stylo are suffering from a condition referred to as reversion, possibly caused by a phytoplasma, which is markedly reducing seed yields and may be affecting growth in pastures. Seca plantings, particularly in north Queensland have, under current management practices, led to legume dominance, reducing biodiversity and contributing to soil acidification. Further, stylos are best adapted to low input extensive systems and may not meet expectations of higher input intensive systems. This project aimed to identify legumes that were less subject to the above weaknesses, and to develop management packages for those elite varieties.

3. *Are people using legumes to graze or for soil improvement?*
Most people are after animal performance. PDS work has shown that we need improved pastures to meet targets. Legumes help maintain feed protein levels through the season, thus increasing growth rate. In favourable environments, legumes help in maintenance of soil fertility, but in less favourable environments, their main role is for feed.

This project did not find an alternative to Seca stylo. Glenn and Lee american jointvetch and "Villomix" have higher nutritive value than Seca, but are not as widely adapted as the stylos. There is a fair choice of legumes down to about 750mm AAR, but below that, choices are limited and Seca predominates. The grazing "Cassias" are doubtful alternatives to stylo.

4. *MLA funded the project with an expectation that new varieties would be produced. Brazilian jointvetch was withdrawn from pre-release without formal consultation. Should not MLA and producers have been consulted before the decision to withdraw?*
This is currently largely handled by HPLC and NAPPEC. However, further discussion is necessary.

5. *You mentioned newer varieties of Aeschynomene falcata - do these have potential?*
There are two accessions, both from Paraguay. These have not been assessed in detail, but appear superficially to be superior to Bargoo. Work is necessary to determine if these overcome the seed production weaknesses in Bargoo (anthracnose susceptibility, and early shedding) and at the same time maintaining agronomic quality.

6. *One of the spin-offs of the project is increased knowledge of adaptation of these legumes. How can you capitalise on this knowledge?*
The project has shown that Verano and Amiga are more widely adapted than hitherto thought and that Wynn cassia is not well adapted to hard setting soils. This type of information can be used in updating fact sheets which are now on CD Rom.

7. *Can you briefly outline what you see happening in the next year?*
One of the big time and money issues which will be discussed later is management of sites to be sure there is no threat from unwanted material. We would also want to monitor key sites for performance of A. villosa and the legumes on pre-release. It will be important to work through data as a group to draw out the most useful information for incorporation into fact sheets, and on other publications so information is available to co-workers.

8. *What is your timetable for guidelines for future management as refers to "Villomix"?*
There are a number of properties in the Miriam Vale area that would like to have demonstration areas. I will be discussing a plan with John Rains (current licensee) and Graeme Elphinstone (QBII extension, SEQ) to establish demonstration plots there and in the south east.

## Alternative Delivery Systems for the Inoculation of New Strains of Stylo

**MRC Project No.:** CS273
**Project duration:** 01/1/96 to 30/6/98
**Principal Investigator:**

Dr R.A. Date
CSIRO Tropical Agriculture
Cunningham Laboratory
306 Carmody Road
St Lucia Qld 4067
Phone: (07) 3214 2260 / Fax: (07) 3214 2288
E-mail: Dick.Date @tag.csiro.au

### Objectives:

i) To release suitable strains of root-nodule bacteria (RNB) that demonstrate effective nodulation of *S.* sp.aff. *S. scabra* (now known as Caatinga stylo - *Stylosanthes seabrana*).

ii) To identify alternative delivery systems for establishing effective strains of RNB in soil prior to sowing *S.* sp.aff. *S. scabra.*

### Project Summary:

This project is allied to CS079/CS153 concerning the selection of new cultivars of stylosanthes from the *Stylosanthes hamata* and *S. seabrana* germplasm. Selection of effective nitrogen fixing strains of rhizobia became essential when it was demonstrated that the performance of *S. seabrana* was declining because field grown plants were not nodulating or fixing nitrogen. New strains of RNB collected in Brazil in 1994 (MRC separate funding) proved to be effective and persistent over a three year period. Strain CB3481 was released to industry for the 1997/98 growing season and additional effective and field competent strains have been identified.

"Dry" sowing small seeded legumes prior to the onset of seasonal rainfall is frequently the method of choice of producers in arable land situations. Soil surface temperatures under these conditions frequently exceed 50 °C for 4-6 hr/day and are lethal to rhizobia introduced on the seed. Experiments assessing alternative methods of delivery, indicate that introducing the rhizobia with the cereal crop grown in the season preceding the sowing of the legume may avoid the problem. Additional experience is required to confirm these indications.

The need to inoculate Caatinga stylo and the availability the selected strain of rhizobia have been publicised by newsletter and field day demonstrations.

### Results:

**<u>Selection of Strains of RNB</u>**

Two series of field trials were established. One in January 1995 to assess the then available strains of RNB and one in January 1996 to assess new strains from glasshouse soil-pot screening of new strains collected in Brazil in 1994. In each year experiments were established at the CSIRO field stations at Lansdown (solodic soil) and Narayen (Granite and Brigalow soils) and in a red earth soil near Roma ("Holyrood"). The experiments failed to establish on the Narayen Brigalow soil, but were successfully established and managed over three years at the other sites. Yield (plant dry weight) data and proportion of nodules formed by the test strains (Tables 1, 2 and 3) show that several strains produced 3-5 fold increases in plant dry weight, especially in the 2nd and 3rd growing seasons and that these strains accounted for the majority of nodules formed. Strain CB3481 was released to industry with the new cultivars Primar and Unica in 1997. Data from the trials sown in 1996 are incomplete. Serological typing of nodules has been delayed awaiting preparation of specific antisera for strain identification. Provided these strains form a high proportion of nodules in the third year, thus demonstrating long term persistence, they will be recommended as replacement strains for CB3481.

**Alternative delivery of inoculum strains**

Normal seed inoculation of *S. seabrana* is not a practical methodology for introducing these bacteria since the host plant is most often sown in mid-summer when soil is dry and near-surface temperatures exceed 40 and 50 °C for up to 8 hours per day. These temperatures are lethal to the RNB which survive only 1-3 days under such conditions. (Note: The experiments for selecting the new strains were completed using irrigation immediately after sowing to avoid this restriction).

Experiments established in January 1995 failed to provide satisfactory results since a non-field competent strain CB3480 was used (see Tables 1, 2 and 3). A new series of experiments was initiated in which the bacteria were introduced via inoculation and sowing of a cereal grain in May/June 1995 and over-sown (dry) with *S. seabrana* in January 1996. A non-inoculated cereal plot was included for comparison. Replicated trails were established at Narayen (Granite and Brigalow soils), Roma (red earth and 2 vertisol soils), using strain CB3546 (a sister isolate of CB3481). By this method it was anticipated that the RNB could establish in the soil and rhizosphere of the cereal and develop a sufficient population at a depth that would avoid the lethal temperatures of the summer period. Two treatments were superimposed on the inoculated and uninoculated cereal plots in January 1996. These were surface-sown inoculated seed of *S. seabrana* and surface sown *S. seabrana* with inoculated plastic beads drilled-in 10 cm below the surface.

There were no growth (plant dry weight) differences in samples taken in April/May 1996 nor were there many nodules. However, in April/May 1997 and 1998, there were nodules in samples from the plots sown originally with inoculated cereal. Also, there were dry weight differences in the two less fertile soil sites (Narayen Granite and Roma Holyrood). Serotyping of nodules is incomplete, however, it is anticipated that this will confirm the presence of the original inoculum strain, since no effective strains have been recorded from any of these sites in uninoculated control plots associated with the strain selection trials.

An extension of the project is requested to provide opportunity to -

i) Complete the 1996 sown series strain evaluation serotyping by end of December 1998.

ii) Complete serotyping of alternative delivery samples (from May 1998) by end of September 1998

iii) Maintain alternative delivery plots at the 5 sites throughout 1998/99 growing season and sample in March/April 1999 and complete any serotyping by end June 1999.

Justification is based on the observation that the 1996/97 and 1997/98 growing seasons were unseasonally poor (dry) leading to significantly greater availablity of soil N. The positive response to pre-inoculating the soil via inoculation of cereal suggest that this method may provide producers with a practical way of avoiding the unfavourable condtions at normal sowing time.

## Other Comments:

Soil pot work indicated that *S. seabrana* 1) is not nodulated effectively by native rhizobia, and 2) formation of nodules is very sensitive to available nitrogen, whereby the plant does not nodulate at all until the available N has been used. This observation explains Les Eyde's observations that plants were "turning yellow" and were not nodulated. The implications for introducing new RNB are that they need survive not only the dry high temperature establishment conditions but must survive 1 or 2 growing seasons as free living organisms until soil N levels decline. Data from the strain selection trials suggest that the strains have this capacity.

## Discussion/Comments

*How long can Caatinga stylo rhizobia survive in the soil?*

We are not sure. If plants are nodulated, the data so far from our strain evaluation work indicates a minimum of 4 years, so we would anticipate that they would remain throughout the life of the pasture. If the rhizobia need to live in the soil for one or two years, because the plant does not nodulate until available N is exhausted, then survival may be reduced, however we have evidence that they survive well in the rhizosphere of other plants so we anticipate that inoculation of a previous cereal crop with the Caatinga stylo rhizobia may provide a favourable environment for survival.

*How fast do Caatinga stylo rhizobia move through the soil?*

Like all rhizobia, very slowly. There is some movement with the growing plant root but most lateral movement is by soil transfer with cattle and machinery.

*There were some expressions of concern that cultivars of Caatinga stylo and Jaribu desmanthus were released before associated rhizobial work was completed.*
No this is not completely true. The release of the new cultivars of Caatinga stylo was delayed 12 months until rhizobial persistence was demonstrated. It is true that Jaribu was released before field data on need for inoculation and persistence of the selected strain of rhizobia were available. This situation serves to illustrate the point that it is important to assess, or have assessed, the need for providing specific rhizobia early in selection programs rather than expect rhizobia to be provided for the final selections. It is recommended that cultivar selection include i) the early assessment of rhizobial needs, either directly by selectors or by involvement of a microbiologist, and ii) the inclusion of an N treatment in initial plant evaluation to reduce the number of lines to a "best-bet" group, which then can be assessed for nodulation requirements. It was recognised that N application may incur a grass/weed problem.

*Comments were made to the effect that i) plant selectors/breeders should aim for promiscuous legumes nodulating effectively with native soil rhizobia, and ii) intensive evaluation to assess need-for-inoculation and N treatments were not practicable to do this when selecting plants for extensive area use, as in perennial pastures.*
In general this is not a good philosophy. Selection of only promiscuously nodulating plants incurs the risk that otherwise useful germplasm is discarded and reduces the available diversity from which to select for effective strains of rhizobia, plant yield and persistence and non-weediness. Selection of subterranean clover as used in the extensive pastures developments of southern Australia was/is not affected by the need for providing an effective strain of rhizobia.

*Does quarantine of nodule/soil material create a problem for introduction of new strains of rhizobia, especially in view of potential for introduction of disease such as anthracnose?*
No, there is less risk than through the introduction of the plant germplasm. All material is imported with appropriate quarantine permits (from AQIS), which bind the importer to destroy (autoclave) all materials once the rhizobia have been isolated. Our unit is a certified quarantine laboratory for this purpose.

*Is there a problem of soil acidification with Caatinga stylo?*
Too soon to assess, but we assume that it would be similar to that experienced (measured) with other stylo cultivars.

*Will Caatinga stylo grow on lighter soils?*
Yes, it appears to be adapted. There is a curious anomaly here. Despite the fact that Caatinga stylo is recommended for the neutral to alkaline clay soils of central Queensland it is growing well on moderately acid soils (e.g. granitic, sandy soils derived from granite at the CSIRO Narayen Research Station) when provided with its specific rhizobia. One of our strain evaluation sites is in fact on this soil and has now completed 4 growing seasons without sign of deterioration.

*Will producers inoculate these new cultivars of stylo and will they know why and how to use the inoculum?*
Producers generally understand the "hows and whys" of legume seed inoculation. Promotion of legume cultivars always includes advice on need for inoculation and extension activities such as field days and "Ag Fest" help promote understanding of the benefits and necessity of inoculation of some cultivars with specific strains of rhizobia.

**Table 1. Strain trial 1995. Proportion of nodules formed by inoculum strains**

**Holyrood**

| | <-----------% Nods--------------> | | | |
|---|---|---|---|---|
| | CB3053 | CB3480 | CB3481 | Control |
| Apr-95 | 11 | 0 | 100 | 0 |
| Apr-96 | 34 | 1 | 72 | 2 |
| Apr-97 | 0 | 0 | 75 | 0 |

**Narayen Granite**

| | CB3053 | CB3480 | CB3481 | Control |
|---|---|---|---|---|
| Apr-95 | 25 | 1 | 44 | 0 |
| Jan-96 | 39 | 8 | 96 | 1 |
| May-97 | 78 | 0 | 98 | 0 |
| Mar-98 | 69 | na | 90 | 0 |

**Lansdown**

| | CB3053 | CB3480 | CB3481 | Control |
|---|---|---|---|---|
| May-95 | 31 | 0 | 47 | 0 |
| Jan-96 | 81 | 25 | 86 | 0 |
| May-96 | na | 34 | 81 | 0 |
| May-97 | na | na | 59 | 31 |
| Mar-98 | 11 | na | 67 | 13 |

**Table 2. Relative yield as % best treatment each year**

**Holyrood**

| | <-------Yield (% CB3481)-----------> | | | |
|---|---|---|---|---|
| | CB3053 | CB3480 | CB3481 | Control |
| Apr-95 | 94 | 57 | 100 | 101 |
| Apr-96 | 29 | 29 | 100 | 31 |
| Apr-97 | na | na | 100 | 21 |

**Narayen Granite**

| | CB3053 | CB3480 | CB3481 | Control |
|---|---|---|---|---|
| Apr-95 | <--Lost | to | wildlife | ---> |
| Jan-96 | 54 | 61 | 100 | 25 |
| May-97 | 30 | 8 | 100 | 6 |
| Mar-98 | 22 | na | 100 | 32 |

**Lansdown**

| | CB3053 | CB3480 | CB3481 | Control |
|---|---|---|---|---|
| May-95 | 176 | 150 | 100 | 87 |
| Jan-96 | 23 | 19 | 100 | 14 |
| May-96 | na | 27 | 100 | 30 |
| May-97 | na | na | 100 | 47 |
| Mar-98 | 51 | na | 100 | 55 |

**Table 3. Strain trial 1996. Relative yield (% best treatment each year) and proportion of nodules ( ) formed by inoculum strains**

**Narayen granite**

| Strain | April 1996 | April 1997 | May 1998 |
|---|---|---|---|
| 2152 | 35 | | |
| 3480 | 49 | | |
| 3481 | 31 | 29 (91) | 50 |
| 3483 | | 41 | |
| 3486 | 100 | | |
| 3488 | | 41 (97) | 67 |
| 3489 | 75 | 50 | |
| 3490 | | | 75 |
| 3494 | | 59 (96) | 100 |
| 3495 | 87 | 100 (98) | 109 |
| Control | 57 | 34 | 12 |

**Holyrood**

| Strain | April 1996 | April 1997 | May 1998 |
|---|---|---|---|
| 3480 | 100 | | |
| 3481 | 100 | 77 (63) | 78 |
| 3483 | | 48 | 61 |
| 3488 | | 54 (40) | 78 |
| 3489 | | 74 | |
| 3490 | | | 56 |
| 3494 | | 44 (96) | 56 |
| 3495 | | 100 (96) | 100 |
| Control | 75 | 37 | 33 |

**Lansdown**

| Strain | April 1996 | April 1997 | May 1998 |
|---|---|---|---|
| 3480 | 67 | | |
| 3481 | 90 | 61 (87) | 80 |
| 3483 | | 67 | 90 |
| 3489 | | 61 | |
| 3490 | | | 113 |
| 3494 | | | 100 |
| 3495 | | 100 (96) | 100 |
| Control | 100 | | 60 |

**Table 4. Relative yield as % inoculated cereal crop for alternative methods of delivery of inoculum rhizobia.**

| Site | Year | Inoc cereal | Uninoc cereal |
|---|---|---|---|
| Roma "Holyrood" | 1997 | 100 | 89 |
| | 1998 | 100 | 74 |
| Roma "RRS" | 1997 | 100 | 107 |
| | 1998 | 100 | 120 |
| Roma "Banoona" | 1997 | na | na |
| | 1998 | 100 | 112 |
| Narayen Granite | 1997 | 100 | 60 |
| | 1998 | 100 | 35 |
| Narayen Brigalow | 1997 | na | na |
| | 1998 | 100 | 101 |

# Dr Barry Walker
## Agricultural Consultant

18 December, 1998

Peter Loneragan
NAP Program Manager
Meat and Livestock Australia
Locked Bag 991
North Sydney NSW 2059

Dear Peter

**Peer Review Report for**
**Sown Pasture Species Development and**
**Legume dominance/soil acidification projects**

I enclose a copy of the above report. As you will see I have combined the two peer reviews into the one report. Sorry it has taken so long, but in addition to my illness I found the work exceedingly finicky and detailed. After Christmas I will get Stephen to design a cover and then copies can be sent to project leaders and other interested people.

I hope to complete the second report of the Wandoan and Emerald reviews by mid January.

I am reasonably healthy. Eventually it turned out that I did not have angina or a heart problem. Instead, from one of the many tests they identified a stomach bacteria (*Helicobacteria pylori*), which can cause painful problems similar to stomach and duodenal ulcers. I have had one course of a triple antibiotic treatment and I suspect that another course will be necessary. Anyhow, I feel much better than I did a few weeks ago, but there is still room for improvement.

I wish you Merry Christmas and an enjoyable and happy 1999.

Yours sincerely,

Barry

Barry Walker

**Dr Barry Walker, 3 Mungala Street, BUDDINA, Qld 4575**
**Phone: (07) 5478 0662; Fax: (07) 5478 0921; E-mail: barrywlk@ozemail.com.au**

## The Reversion Problem in Shrubby Stylo Seed Production


Coordinator — **Dr J M Hopkinson**
**QBII, Walkamin RS**
**Walkamin Qld 4872**
**Phone (07) 4093 3733 / Fax (07) 4093 3903**
**E-mail: HopkinsJ@prose.dpi.gov.gov.au**

Co-Investigators — **Dr Karen Gibb (NT University), Stephanie De La Rue (NT University), Raylee Trevorrow (CSIRO) and John Rains (Southedge Seeds)**



### Summary
Reversion in shrubby stylo is a condition in which inflorescences revert to a form of vegetative growth part way through their maturation. It has been present at low frequencies in pastures and seed crops for some years, but in 1997 it caused serious seed yield depression to the point where it threatens the viability of seed production. It is believed to be caused by a phytoplasma (a micro-organism like a bacterium without a cell wall) and to be transmitted by sucking insects. A task force from NT University and DPI and CSIRO in north Queensland has been accepted under the wing of the CRC for Tropical Plant Pathology and has begun an investigation designed to identify the cause of the condition and control its occurrence. Its members are seeking MLA support for the work


### Background
In July 1997 commercial seed crops of shrubby stylo (*Stylosanthes scabra* cv. Seca and Siran) in north Queensland seemed to be on target for good yields. Growers were confident that they could live with the known enemies - *Botrytis*, *Sclerotinia*, *Sclerotium*, anthracnose, little-leaf, frost. Then, as so often happens, trouble came from the least expected quarter.

As crops matured it became increasingly evident that all was not well. Parts of plants, whole plants, in places seemingly whole plant populations, began to behave oddly. Instead of their inflorescences completing flowering, seed formation and seed ripening in the normal way, they began to return to vegetative development, but of an abnormal kind. Flowers and green seeds aborted. Primordial flower buds began to sprout, their individual parts - sepals, petals, ovaries - turning into leaf-like structures. Spike apical meristems, which normally cease to function after producing a number of flower buds, were reactivated, producing vegetative shoots. The normal proliferation of short spikes became an abnormal proliferation of weak, useless, elongating branches - the now-familiar "witch's brooms". Further seed formation ceased, and when this happened before the main seed crop had developed, as was most commonly the case, seed production and yield were dramatically reduced.

The consequence was seed yields of probably below half the expectation. This pushed seed prices up to perhaps 40% above what they would have been, which in turn led to buyer resistance and depressed sales. If the same thing had happened to 1998 crops, the consequence would have been the same. It would have lead individual seed producers to decide that shrubby stylo seed production was unprofitable. They would then have been unlikely to sow seed for 1999 crops. We were thus looking at the possibility of cessation of seed production of our most useful and widespread pasture legume for the dry tropics. We obviously had a problem on our hands, and we had not got long to find a solution to it before its effects become serious.

We called the condition *reversion* as it takes the form of a pathological reversion from the reproductive to the vegetative state, and this has become the familiar word in pasture circles. The term *phyllody*, used by pathologists to describe the same condition in other plants, might in retrospect have been a better choice, especially as they already use the word reversion for a somewhat different condition.

### The causal agent

Early advice was that reversion was probably caused by a phytoplasma, and the likelihood has been reinforced by subsequent investigation. Phytoplasmas are a distinct group of pathogenic micro-organisms different from either viruses or bacteria. They are described as somewhat like bacteria but without a cell wall. Their uniqueness has only relatively recently been recognised, they are still poorly understood, and their investigation remains a knowledge frontier. Little-leaf, so similar to stylo reversion, is a typical phytoplasma-induced condition. Reliance on techniques of molecular biology is necessary for positive detection and identification. Phytoplasmas in plants are only detected in phloem tissues, and only phloem-feeding insects are likely to transmit them. Phytoplasmas tend to have a wide host range, and are believed not to be seed-borne.

Similar symptoms are sometimes caused by viruses in other types of plant. The possibility of a virus causing reversion in stylo cannot wholly be dismissed but is at present considered unlikely by both virologists and phytoplasmologists. However, virus diseases of stylos also occur, and viruses are known to interact with phytoplasmas to increase the severity of symptoms. For this reason viruses must be taken into account in consideration of reversion.

The possibility exists that little-leaf and reversion are caused by the same phytoplasma. However, to reconcile it with the historical record, one must postulate some other change in circumstances, such as greater vector activity over the reproductive period than in earlier years.

### History of reversion

There is photographic evidence of reversion in shrubby stylo at Mareeba in 1990. It may be assumed to have been present for some years before that and is believed to have become progressively commoner. It certainly contributed to the withdrawal of Tully farmers from Seca seed production after 1996. Its occurrence in seed crops of stylo in inland districts (Lakeland and Mareeba) was, at most, uncommon before 1997, but by late 1997 it had seriously affected all seed crops. Once due attention was paid, it was also found to be widely distributed in shrubby stylo in pastures and on roadsides throughout much of northern and central Queensland. A more exact history of its build-up is impossible to reconstruct in retrospect

### Action

Recognition that we had a problem brought together local seed industry members and relevant DPI and CSIRO staff in north Queensland to form a Mareeba-based coordinating group. Prior contact over the similar little-leaf condition with members of the NT University led us to seek their help, with an immediate positive response that resulted in the formation of the Stylo Reversion Group and the planning of a combined campaign to tackle the problem. The Group's plans were then accepted as a project under the CRC for Tropical Plant Pathology. This has provided a structural umbrella and a budget to get the investigation off the ground. It has also given us the opportunity to solicit the cooperation of virologists, entomologists, etc. to broaden the investigation. Donations by Southedge and Heritage Seeds of money for travel have eased the ever-present problems of distance between Darwin and Mareeba.

The joint investigation has two separate agenda. The NT University work, primarily done by a Ph.D. student Stephanie De La Rue and supervised by Karen Gibb, is a segment of a broad-based, long-term investigation of phytoplasmas as a whole - of their taxonomy, identification, distribution, host range, transmission, economic damage, genetics of resistance, etc. The overall investigation that Karen Gibb coordinates includes an ACIAR project with ramifications into a range of crops in various developing countries. Those of us in north Queensland - Raylee Trevorrow of CSIRO (based in Mareeba DPI), John Rains of Southedge Seeds, and myself - are urgently concerned with finding out how to control, or at least coexist with, reversion so as to be able to return to reliable economic production of shrubby stylo seed.

The two sets of agenda are complementary and mutually dependent, and the cooperative arrangement that they engender is working well. It is being extended to include virologists, though so far only in a monitoring and advisory role. The only real problem with the arrangement lies in the urgency of the need for an interim solution to our seed production problems. It means that we shall have to have a disease management strategy in place before we understand enough of the disease to formulate it reliably – an inevitably high-risk situation. Another concern is the lack of an available entomologist in north Queensland to parallel the other investigations with one of the transmission process.

## Progress

With systematic testing being developed and conducted at NTU, the evidence inculpating phytoplasmas continues to accumulate. Plant parts with symptoms of reversion have generally tested positive for phytoplasma, and those without have generally not. Reversion has been observed primarily in shrubby stylo, regardless of cultivar or accession, to a very limited extent in *S. humilis, seabrana* and *hamata*, and not at all in *S. guianensis*. It occurs in legumes of other genera, including *Crotalaria goreensis* (Gambia pea), *Indigofera hirsuta, Aeschynomene americana* (joint-vetch); and in certain weeds of other families growing near infected areas of shrubby stylo (*Sida cordifolia; Mitracarpus hirtus).*

Meanwhile, in the Mareeba district, monitoring of the occurrence and spread of symptoms of reversion, both of shrubby stylo seed crops and generally, and of leaf-hopper populations, has begun. In addition CSIRO is recording occurrence of symptoms in breeding lines and accessions of shrubby stylo sown as part of an investigation of resistance to anthracnose, in order to learn something of the possibilities of obtaining resistance to the reversion organism.

## The future

The provisional model is one of a pathogenic phytoplasma affecting primarily shrubby stylo, transmitted by a leaf hopper, and with a range of alternative hosts that may, along with perennial plants of shrubby stylo surviving either in pastures or as roadside volunteers, provide a reservoir of new infection early each season. The investigation of the background science of this will continue for at least three years at NTU. Meanwhile, in NQ, the NTU effort will continue to be supported, and at the same time means of avoiding severe reversion will be sought. Suggested avoidance strategies include shifts to isolated areas for seed production, crop management to bring seeding forward to an earlier part of the season, extension of crop hygiene, and leaf hopper control. Further effort will be needed to recruit an entomologist to put substantial effort into the epidemiology of the condition. Visitors from CSIRO DTA in Brisbane have recently raised the possibility of their investigating prospects for control of reversion through plant breeding.

## Discussion / Comments

1. *What is meant by the statement that the condition is widespread?*
   We have observed it virtually wherever we have looked for it in northern (mainly) and central Qld. On Wairuna Station (Head of Burdekin) 9000 acres had about 10% of plants affected in late 1997.

2. *Was there evidence of reversion last year in the Wairuna stylo?*
   It was in late 1997 when John Rains and I went out to check it out at Wairuna, and when it was affecting roughly 10% of plants. JimTeitzel (part owner and manager) had only recently noticed it. We had no recollection of seeing it in the newly established population two years before. But it could have been present at any time previously at a low frequency and gone unnoticed.

3. *A question about increasing incidence.*
   The increase in incidence may be connected to increases in vector pressure. Vector populations may reasonably be expected to have increased in the Mareeba Irrigation Area, for instance, now that host crops are grown throughout the year.

4. *Have there been any unusual climatic events that might have led to a build up in the disease through an increase, for instance, in vector populations recently?*
   We have given a lot of thought to possibilities of this kind, but there is little to suggest it. We still don't know if 1997 represented a step in an exponential build-up which will lead to increasing incidence year by year, or if it was an isolated phenomenon with incidence going up and down with the years.

5. *Does it impair seed viability?*
Not so far as can be judged. The plant seems to produce either normal seed or none, so that the effect is on quantity rather than quality.

6. *Is there a chance that it is transmitted by seed?*
Provided it is a phytoplasma we are dealing with, as seems most likely, then the opinions of those who know most are that there is no chance. Early appearance of symptoms is probably due to carry-over in perennating stylo and other host plants. Gambia pea is a weed that comes early and shows conspicuous reversion symptoms, so we are beginning to suspect that it might be a carrier. The condition is very much like little-leaf, which *is* caused by a phytoplasma, and may be described as being like little-leaf coming in at the flowering stage.

7. *Could reversion become a problem in pastures?*
It could. Nobody knows. As yet it appears not to be, and the most it might do is to thin out already abundant plant populations to a trivial degree. In the long term it might also reduce seed reserves in the soil. But it will have to affect a far higher proportion of plants before we regard it as a serious threat, and I am told that a common characteristic of phytoplasmas is that they tend to affect only a relatively small proportion of individual plants in a population. However, the risk exists, and we remain alert to it.

8. *Do affected plants fail to regrow after grazing?*
Often regrowth after grazing or mowing occurs with symptoms of reversion, even when there were no such symptoms in the plants before defoliation. The whole subject of occurrence of symptoms seems very complicated, and is poorly understood. It is possible that asymptomatic infections occur; it is common for symptoms to occur in one part but not another of the same plant, and for the demonstrable presence of phytoplasmas also to show such inconsistencies.

9. *What constitutes paddock hygiene?*
Formerly, when we had only little-leaf to contend with, we found that we could live with it if we eliminated all carry-over perennial plants from the previous season which served as sources of inoculant to infect the seedling plant population. Discing and/or application of Roundup was enough, if done efficiently. This clearly has not worked with reversion, possibly because hygiene would need to extend to a whole range of alternative hosts, possibly for other reasons we do not understand.

10. Another possible complication was the change that had taken place in Seca as it had drifted over the years into a vigorously early seeding type of plant. Reproduction weakens the plant, and possibly raises its susceptibility to disease. This appears to be the case with little-leaf and with a whole range of fungal diseases, and has contributed to the change from treating the seed crop as a perennial to treating it as an annual. If this is so, then it is likely that reversion will remain more of a problem to seed crops than to pastures, in which the reproductive parts are normally being constantly removed by the grazing animal.

11. *Does reversion occur in stylo in other countries?*
There were hints of unconfirmed reports from Brazil that suggest that something similar might have been observed there, but a response to a direct inquiry did not support this rumour.

## Acknowledgment
This report summarises information obtained through the combined effort of all members of the Stylo Reversion Group.

## Evaluation of Selected Shrub Legumes Under Grazing Cattle

**MRC Project No:** CS.187
**Duration:** NAP2 - 01/1/92 to 30/6/96
NAP3 - 01/07/96 to 30/06/99
**Principal Investigator:** Dr Brian Palmer
CSIRO Tropical Agriculture
Davies Laboratory
PMB, PO Aitkenvale
Townsville
Phone: (07) 4753 8528;Fax: (07) 4753 8600
Email Brian.Palmer@tag.csiro.au
**Co-Investigators:** Dr Ray Jones CSIRO (Lansdown)
Dr Ross Gutteridge U of Qld (Mt. Cotton)
Mr Deryk Cooksley QBII (Utchee Creek)
Mr Col Middleton QBII (Rockhampton)
Dr John Hopkinson QDII Walkamin)
Mr Barry Lemcke NTDPI&F (Douglas Daly)

### Objectives:

To evaluate the most promising shrub legumes for beef production in northern Australia.
Specifically to:

- Evaluate beef production under grazing shrub legume / grass pastures.
- Achieve a high enough daily liveweight gain to meet the emerging demand for younger more tender beef.
- Identify agronomically important properties of most promising shrub legumes.
- Build up seed reserves for commercial sowing.

### Summary:

The project is collaborative between the MRC, CSIRO (Lansdown and Utchee Creek), University of Queensland (Mt. Cotton), DPI Queensland (Rockhampton, Utchee Creek and Walkamin) and DPI&F Northern Territory (Douglas Daly). The accessions planted at each location were as follows: At Lansdown *Calliandra calothyrsus* (CPI 115690) (2 areas), *Leucaena leucocephala* cv. Cunningham, *Leucaena diversifolia* (CPI33820), *Leucaena leucocephala* K636 (cv.Tarramba) and *Leucaena pallida* (CQ3439) with inter-row grass and a control of *Urochloa mosambicensis* cv. Nixon; at Utchee Creek *C. calothyrsus* (CPI115690) plus nitrogen fertilised *Brachiaria decumbens* (3 areas), *Arachis pintoi* cv. Amarillo sown with *Brachiaria decumbens* both with and without nitrogen fertiliser and a control of nitrogen fertilised Brachiaria; at Douglas Daly *C. calothyrsus* and *L. leucocephala* cv. Cunningham; at Rockhampton *Acacia boliviana* and at Mt Cotton *Tipuana tipu*, *Albizia chinensis*, *Leucaena pallida* and *Leucaena leucocephala* K636 with a control of *Brachiaria decumbens*.

*Calliandra calothyrsus* (CPI115690) was planted at both Walkamin and Kairi Research Stations for seed production areas. An area south of Mackay was planted to *C.calothyrsus* as an on-farm demonstration plot.

Sites at Lansdown, Utchee Creek and Walkamin are still viable. Other sites and the "On farm" evaluation have been terminated due to poor establishment and inadequate potential for feed supply and animal performance.

At Lansdown the *Leucaena leucocephala* accessions gave the best overall performance with DLWG for the first period in excess of 1.0 kg per day. This trial is to continue until June 1999 and should give a

good comparison of *L. leucocephala* with psyllid tolerant shrub legumes. *Leucaena pallida* and *Calliandra calothyrsus* have not performed well the *L. pallida* not being grazed in the later period.

At Utchee Creek the inclusion of *C. calothyrsus* into the pasture system improved the DLWG by 0.06 kg/hd/day giving an annual advantage of approximately 142 kg liveweight per hectare. This site has been continued by the new owner and should run until November 1998. The recent measurements have shown little advantage for the *Calliandra* in what has been periods of more than adequate grass,

At Mt. Cotton the cattle performed best on the *L. leucocephala* cv. Tarramba. There were no differences between *Albizia chinensis*, *Tipuana tipu* and the grass control. The *L. pallida* in fact supported less production than the control.

At Walkamin Research Station 90 kg of high quality seed of *C.calothyrsus* has been produced.

## Results

### Mt COTTON

A 6.4 hectare site was selected at the University Farm at Mt Cotton. It was divided into eight 0.8ha blocks to which one of the following four treatments was allocated at random in two replications.

(1) *Albizia chinensis* plus signal grass (*Brachiaria decumbens*)
(2) *Leucaena leucocephala* K636 (Tarramba) plus signal grass
(3) *Tipuana* tipu plus signal grass
(4) Signal grass alone plus nitrogen fertiliser at 200 kg N/ha/year

**Cattle Performance**

Liveweight gain of the steers grazing the experimental paddocks has been divided into 4 periods. Period 1 (May - November 1994), period 2 (January - May 1995), period 3 (May - November 1995) and period 4 (March 1996 - March 1997). Period 1 runs from the commencement of grazing of the first draft of test animals until early November 1994 when all animals were removed from the trial because the total dry matter on offer in 5 of the 7 treatment paddocks fell below 800 kg/ha. All animals were grazed on a 4 ha spare area of B. decumbens until early January 1995 when feed on offer in all paddocks had regrown to exceed 1500 kg/ah. The first draft of test animals was replaced in May 1995 with a second draft which continued grazing until November 1995. A third draft of animals commenced grazing in March 1996.

The second replication of *L. leucocephala* K636 was not stocked in May 1994 because tree legume growth in half of this paddock was very poor and it was feared that grazing may destroy these plants.

In November 1994 the inferior rows of Leucaena in this paddock were resown but the resultant growth was still not sufficient to allow stocking in May 1995. This paddock remained ungrazed until March 1996 when the best half of paddock 1 and the best half of paddock 2 were fenced and grazed rotationally as one paddock.

In period 1 liveweight gain was highest for the Leucaena K636 paddock followed by Albizia. The Tipuana and control treatments produced similar liveweight gains (Table 1). In the next period K636 was still superior followed by Albizia and control which were similar. Liveweight from Tipuana in this period was significantly lower than all other treatments. In the third period May - November 1995, liveweight gain in all treatments decreased substantially particularly in the K636. This was quite a harsh period environmentally (cool and very dry) and although it was the same duration as period 1, productivity was quite low. The Albizia and control treatments were similar and the higher yield in the Albizia may have reflected the higher amount of tree leaf on offer at the start of this period compared to the other tree legume treatments. *Leucaena pallida* supported very poor animal performance during this final period. During the period from March 1996 – March 1997 only the Tarramba gave a measurable improvement over the grass control.

**Table 1. Liveweight gain (kg/head/day) of steers grazing tree legume/signal grass associations in Southeast Queensland**

| **Species** | **Liveweight gain (kg/head/day)** | | | |
|---|---|---|---|---|
| | **May-November 1994 (160 days)** | **January-May 1995 (120 days)** | **May-November 1995 (167 days)** | **March 1996-March 1997 (348 days)** |
| *Albizia chinensis* | 0.51 | 0.54 | 0.30 | 0.47 |
| *Tipuana tipu* | 0.42 | 0.35 | 0.19 | 0.52 |
| *L. leucocephala* cv. Tarramba | 0.53 | 0.60 | 0.17 | 0.67 |
| *L. pallida* * | - | - | - | 0.28 |
| Control (Grass alone) | 0.44 | 0.54 | 0.30 | 0.50 |

* *L. pallida* was grazed from March 1996 to October 1996 at a stocking rate of 3 animals/paddock.

<u>**LANSDOWN**</u>

**Cattle Performance**

Steer gains differed widely between treatments. For the first grazing period (35 days) *L. leucocephala* cultivars gave higher gains than the psyllid tolerant lines of *Leucaena* and *C. calothyrsus.* In the second (July 1996) grazing period (27 days) the liveweight gains from both the *L. pallida* and the *C. calothyrsus* were extremely poor. The *C. calothyrsus* leaf had in fact wilted on the plant which may in part account for the poor performance through a lowering of digestibility. For the third grazing period (March 1997) animals were grazed for 41 days after an adaptation period of 29 days, Daily live weight gains for all shrub legumes were in the order of 600g versus a grass control of 360g. In fact the highest gain was with *C. calothyrsus* (pdk 2) and the lowest with *L. leucocephala* cv. Cunningham. However, at this grazing all shrubs were preferentially grazed so that the shrubs never even attained a height of 1 m. This was unexpected as grass is usually preferred in the early wet season.

The average steer liveweight gains (g/day) on the animals periodically grazed the range of shrub legumes during 1996 and 1997 together with data for the period February to May 1998 is given in Table 1.

**Table 1. Liveweight gain (kg/head/day) of steers grazing tree legumes at Lansdown, north Queensland**

| Steer liveweight gains (g/day) on shrub legumes | | |
|---|---|---|
| Treatment | 4 grazings 1996 -1997 | 1998 (Feb - May) |
| *L. leucocephela* - Cunningham | 723 | 769 |
| *L. leucocephela* - Tarramba | 664 | 794 |
| *L. diversifolia* | 532 | 635 |
| *L.pallida* | 423 | 483 |
| *C. calothyrsus* | 410 | 513 |
| Grass control | 381 | 560 |

During the 1998 grazing animals performed poorly on Calliandra and *L. pallida,* with little evidence of the latter being eaten.

## UTCHEE CREEK

The trial site was made up of 6 two hectare paddocks all previously planted to *Brachiaria decumbens* (Brachiaria). Paddocks 1 and 5 had been planted to *Arachis pintoi* cv. Amarillo (Amarillo) in 1991 in rows 1.5 m apart and by 1994 the Armarillo had spread through the whole paddock area. In January 1993 one third of paddock 4 and the whole of paddocks 2 and 6 were sown to Calliandra on a 1 m row spacing and a 3 m row spacing respectively. Paddock 4 was clean cultivated and the seed bed well prepared. The seed was planted with a single row "Bandseeder" which applied 30 kg superphosphate per hectare below and to the side of the sown row and the sown strip sprayed with "Glyphosate" to control re-establishing grass and weeds.

**Cattle performance**
Ten weaners of average weight 168 kg (range 138 - 195) were allocated to each two hectare paddock on November 9th 1994 except for paddock 1 (Amarillo no nitrogen where a lighter stocking rate of eight weaners per paddock was used). All animals had been drenched for internal parasites, dipped and given a 'Compudose' implant. Insecticidal ear tags were used to control buffalo fly. Animals were locked into the Calliandra for several periods to adapt the animals to this new feed. This process was done over a six to eight week period. After it was considered the animals were adapted, they were allowed free access to both the shrub legume and the grass. They appeared to regulate their intake by feeding Calliandra in the early morning and late afternoon while eating grass the remaining time.

Data are presented in Table 3 show the performance of the steers grazing the Calliandra, the Amarillo and the Brachiaria-nitrogen pastures. All measurements are taken after the adaptation period and begin 30$^{th}$ January 1995 and end 17$^{th}$ June 1996. Animals weights were recorded at approximately monthly intervals. The average Daily Liveweight Gain (kg/hd/day) [DLWG] for the base treatment Brachiaria-nitrogen and for Brachiaria-Amarillo were 0.44 and 0.42 respectively. This increased to 0.47 when both Amarillo and nitrogen were included.

**Table 3. Animal performance of steers grazing at the Utchee Creek Site, from 30/1/1995 to 17/6/1996.**

| Treatment (paddock no.) | Average steer weight ± (SD) 30/1/95 | Average DLWG(kg) [Monthly Range] | Average annual weight gain per steer (kg) ± (SD) |
|---|---|---|---|
| Amarillo + (1) Brachiaria (NO) | 243 ± (22) | 0.42 [0.00-0.68] | 154 ± (26) |
| Calliandra(2) + Brachiaria (N) | 214 ± (12) | 0.51 [0.03-0.82] | 188 ± (23) |
| Brachiaria (N) (3) | 225 ± (11) | 0.44 [0.12-0.80] | 162 ± (13) |
| Calliandra(4) + Brachiaria (N) | 207 ± (19) | 0.52 [0.04-1.04] | 187 ± (17) |
| Amarillo(5) + Brachiaria (N) | 223 ± (16) | 0.47 [0.12-0.89] | 176 ± (27) |
| Calliandra(6) + Brachiaria (N) | 225 ± (17) | 0.48 [0.05-0.82] | 172 ± (14) |

When cattle had access to Calliandra and Brachiaria-Nitrogen the Daily Live Weight Gain increased to 0.50 kg. The differential increase over the Brachiaria -Nitrogen treatment was steady over the period of the measurements and gave annual advantage for Calliandra of 30 kg per animal or 150 kg liveweight per hectare. The estimate of daily liveweight gain for the first measurement period (February 1995) was the lowest recorded in each treatment, this may be due to the poor adaptation but is more likely due to the inordinately cloudy and rainy period. During 1997 and early 1998 there has been adequate grass and no significant improvements were shown over the nitrogen fertilised Brachiaria.

**WALKAMIN**

A viable system for seed production of *Calliandra calothyrsus* has been developed and sufficient seed is now stored to meet any future requirements.

**DOUGLAS DALY**

Two unsuccessful attempts were made to establish *Calliandra calothyrsus* at this site. The site has been discontinued.

**ROCKHAMPTON**

*Acacia boliviana* was established at the Raglan site, near Rockhampton. This site has however been discontinued and the site cleared. The material was of low palatability and was considered a potential woody weed of grazing lands. A separate report on this site is given in Attachment I.

**"ON FARM" MACKAY**

A site was planted but did not grow due to lack of rainfall and severe weed infestation.

## Future work 1998/99

Continue the evaluation of Calliandra and the *Leucaena* spp at Lansdown for the next season (1998/99) and also the site at Utchee Creek should be continued for one more year, as this is the only site with continuous grazing of this shrub legume in the tropics.

## Attachment I

Sub-project: Evaluation of *Acacia boliviana (A. angustissima* CPI 40175)

Sub-project Leader: Col Middleton, QDPI, Rockhampton

Objectives:

For *A boliviana*, by June 1996:-

- identify the agronomically important properties
- evaluate beef production
- build up seed reserves for commercial production.

### Background:

During the early 1990's plant evaluation programs (COPE and BROWSNET) conducted by DPI and CSIRO with sponsorship from MRC, had isolated a number of potentially valuable pasture grasses, legumes and shrubs. This included the exotic shrub legumes *Calliandra calothyrsus, Albizia chinensis, Tipuana tipu* and *Acacia boliviana.* The purpose of the project was to assess their suitability under grazing in terms of productivity and sustainability. I was given the charter of evaluating *A boliviana* in central coastal Queensland. *A. boliviana* was collected at La Pasuela, Bolivia (Alt 200 m, AAR 1000 mm, acid soil) in June 1965.

### Methodology:

- A site was selected at Raglan, 50 km south of Rockhampton, 850 mm AAR, old cleared softwood scrub country of moderate fertility. The area consisted mostly of native *Bothriochloa* pasture with a small amount of rhodes grass and indian bluegrass. The area was contour surveyed in February 1992 and fenced into two paddocks.
- In February 1992 acacia seedlings (3,500) were established in 10 cm pots.
- March 1992 the site was deep ripped on the contour (single tyne) at 6 m row spacing and the ripped area chisel ploughed to a seedbed about 2 m wide. A trickle (T tape) watering system (from farm dam) was installed to ensure establishment.
- On 6 April 1992 the acacia seedlings (15-20 cm high) were planted at 90 cm spacing in the rows over 1.4 ha. A fertiliser dressing of 10 g DAP/plant was applied adjacent to each seedling. Irrigation was applied immediately and intermittently thereafter over the next 9 months. Chemical weed control was employed to control weeds for 1m either side of the row.
- A Cunningham leucaena control was planted by seed (similar spacing and fertiliser) on 24 September 1992 over 2.8 ha, irrigated to establish and kept weed-free.
- The acacia was grazed four times in the 1992-93 summer.
- Weight gain recording using brahman cross steers (295 kg liveweight) stocked at 0.47 ha/steer commenced 28 March 1994. The previous 18 months had been droughted for long periods.

### Results and discussion:

The acacia was grazed for a short time by a 'large' group of weaner heifers in November 1992 and May, August and November 1993 while the seed sown leucaena caught up in growth. In the November grazing the inter-row grass was 'dead' due to drought. Reasonable acceptance of acacia occurred with about 1/2 of the leaf removed from the acacia. In May 1993, even though there was very little green grass present, the acacia was only lightly browsed (a small leucaena patch within the paddock was flogged when the gate was opened). In August 1993 most of the leaf was eaten. Not much acacia was eaten when cattle were included in November.

Observations over the drought period indicated that the acacia dropped its leaf much more readily than did leucaena. Leaf samples of acacia were taken for analysis in December 1992 (Table 1).

**Table 1. Chemical analysis of *A. boliviana* pasture components in a dry summer**

| Plant and part | %Ca | %Cl | %K | %Mg | %N | %Na | %P | %S |
|---|---|---|---|---|---|---|---|---|
| Acacia growing tip plus first fully expanded leaf | 0.50 | 0.14 | 1.25 | 0.17 | 4.12 | Trace | 0.32 | 0.22 |
| Mature leaves | 1.19 | 0.25 | 0.85 | 0.25 | 3.08 | Trace | 0.16 | 0.21 |
| Mature dead grass | 0.29 | 0.27 | 0.34 | 0.22 | 0.63 | 0.9 | 0.12 | 0.21 |

The analysis indicates that the acacia has high crude protein levels. Na is low and K and Mg marginal.

Comparative liveweight recordings were done over 50 days (28/3/84 - 16/5/94) and 72 days (16/5/94 - 27/7/94). Over the first 50 days daily liveweight gains were 0.72 kg/steer for leucaena and 0.67 kg/steer for the acacia. Animals run with cattle in an adjoining grass paddock gained 0.52 kg/day. At the end of the period there was no leaf left on the leucaena and the acacia had only been browsed very lightly. In the following 72 day dry winter period there was not much difference between the legumes. Cattle on the leucaena lost a small amount and the acacia gained a small amount.

The small loss on leucaena was not surprising as there was no leaf left on the leucaena after the first grazing period and conditions were cool and dry. During this period about 1/3 to 1/2 of the green leaf on the acacia was removed.

**It was decided to discontinue the experiment at this point as the potential weed potential of the acacia appeared to far outweigh its forage value.**

## Conclusions:

From this grazing demonstration and observations taken at the Rockhampton BROWSNET site and the Parkhurst plant nursery, the following conclusions and recommendations on *A. boliviana* CPI 40175 were reached:

1) It has responded as a typical acacia browse plant. In periods of feed shortage or when the associated grass is hayed off or dead then it is browsed.
2) It was never eaten as readily as leucaena irrespective of the time of year or status of the accompanying grasses.
3) It did not appear to have any special drought tolerance features. In fact it dropped its leaf earlier in drought than leucaena.
4) Its chemical analysis indicated its very high protein content in the leaf. Like leucaena it appeared to have low Na levels. No analysis was done to determine condensed tannin levels.
5) It produces enormous quantities of hard seed and prolific seedling regeneration occurs.
6) It is unaffected by psyllids, which are a periodic serious problem with leucaena in coastal Queensland.
7) It is difficult to control/eradicate with chemicals in inaccessible areas or where non-selective chemical application is used.

**Based on the above it was decided in August 1994 that *A. boliviana* could pose a weed problem if it got into inaccessible areas along creek lines etc. It appeared prudent to discontinue with this plant and have it removed from this and other experimental sites.**

### Control and removal of *A boliviana*:

The possibility of *A boliviana* being rejected as a forage plant and its removal was always part of the project guidelines. From late 1992 when the plants first produced flowers, the flower branches were pruned. Any mature seed was removed from the site and incinerated in Rockhampton.

Control of the 3,000 plants at the site commenced in August 1994 and the process has demonstrated that like some of our native *Acacia* spp., chemical control can be difficult. No doubt blade ploughing would be highly effective but the soil at the site contained too many rocks and sub-surface boulders.

The acacia rows were slashed on 2 August 1994 so that new regrowth could be sprayed in the subsequent months.

- 13/10/94 – overall spray with STARAINE 1:40 in water plus AGRAL wetting agent. 80-90% of plants survived.
- 11/11/94 – resprayed most as above with STARAINE and wetting agent.
- 8/12/94 – spot sprayed with knapsack a section of regrowth from 13/10/94 spraying with BRUSHOFF 1g/15 L water and 25 ml AGRAL/knapsack

The area sprayed twice with STARAINE has had little effect with over 90% recovery of plants. The area sprayed with STARAINE followed by BRUSHOFF has shown about 60% kill.

- 7/2/95 – surviving acacia sprayed with BRUSHOFF at 15g/100L of water plus 200 ml PULSE wetting agent/100L water.
- Spot spraying with VELPAR (2 ml/plant) in 1995 gave >95% kill.
- Parkhurst Nursery. And BROWSNET Sites. Mature plants basal bark sprayed with STARAINE (1:20 in diesel) and gave reasonable kill of 60-70% .

The areas are visited about three times each year to remove (mattock) any surviving plants, the last one being in February 1998. No seedlings have ever been found indicating the de-flowering process was successful.

**Control recommendations:** Based on Rockhampton experience, the following chemical control recommendations for A. boliviana control are suggested.

1) VELPAR is best for spot spraying (2 ml/plant). This method cannot be used if there are other woody plants nearby that you do not want to kill.
2) STARAINE (1:20 in diesel) is recommended for basal bark spraying (ACCESS 1:60 in diesel probably would work also).
3) Small seedlings can be overall sprayed with STARAINE (1:40 in water). GRAZON (not tried) but would probably work as well.

# Evaluation of grasses for heavy grazing

**Co-Investigators**

**I.B. (Ian) Staples**
**QBII, Centre for Tropical Agriculture**
**P.O. Box 1054, Mareeba 4880**
**Ph. (07) 40 928 471 Fax (07) 40 923 593**
**E-mail: staplesi@dpi.qld.gov.au**

**C.H. (Col) Middleton**
**QBII, Tropical Beef Centre**
**P.O. Box 5545, Rockhampton 4702**
**Ph. (07) 49 238 113 Fax (07) 49 238 222**
**E-mail: middletonc@dpi.qld.gov.au**

This report is based on material initially presented in:

PENGELLY, B.C. and STAPLES, I.B. (1996). *Final Report of MRC Projects CS.054/185 and DAQ.053/081: Development of new legumes and grasses for the cattle industry of Northern Australia.* (CSIRO & QDPI, c/- CSIRO, St Lucia 4067),

and subsequent field assessments conducted from 1995/96 through to 1997/98.

## Objective

To identify quality grasses capable of forming a persistent association with Seca stylo.

## Summary and recommendations

Based on a range of grasses sown at three sites in the dry tropics of Queensland in 1991/92 through 1994/95, we have identified stoloniferous accessions in *Bothriochloa*, *Digitaria*, and *Urochloa*, which could make useful sown pasture grasses in association with stylos. Many buffel grass lines also performed well, but as these included the current cultivars we do not see great scope for improvement in this species in these environments. Some accessions with the tufted growth habit more typical of native grasses have also produced well and may be more environmentally acceptable than the stoloniferous forms, but the present evidence for their success and persistence in mixtures with stylos is tenuous.

**Wider evaluation required** While quality grasses which can help overcome the problem of stylo-dominant pastures are needed quickly, new material identified in these small plot evaluations requires testing on a broader scale, in terms of both area and environments, before recommending it for commercial use. Not only do we need to build confidence in users and their advisers, we also need to be sure the associations with stylos are truly stable. There is a moderate risk that some of these vigorous stoloniferous grasses may seriously hinder seedling regeneration of stylos, to the long term detriment of animal production from such pastures.

**Grass establishment** The problem of grass establishment in stylo pastures also needs addressing. Agronomic work is obviously needed on how best to sow into existing legume-dominant pasture for effective and economic establishment. This issue could also become a criterion for discriminating between otherwise similarly performing accessions. We did not address ease of establishment *per se* in this project—we concentrated on identifying productive, persistent material. Perhaps some trade-off of grass productivity for ease and reliability of establishment would be acceptable to achieve a commercially viable outcome?

## Evaluation of grasses for heavy grazing*

(I.B. Staples, QDPI, Mareeba, and C.H. Middleton, QDPI, Rockhampton)

### Introduction

One objective of the former MRC project CS.185/DAQ.081 was to identify quality grasses with the potential to grow in association with Seca shrubby stylo (*Stylosanthes scabra*) under the higher stocking rates achievable on pastures based on this hardy sown legume in the dry tropics of northern Australia. Commercial experience has shown that most tussock grasses, such as the majority of our native species, are incapable of withstanding these high stocking rates, resulting in potentially unstable legume dominant pastures within a few years. This report summarises the evaluation of stoloniferous and other introduced grasses which may be able to withstand such pressures as a consequence of their evolutionary backgrounds.

### Methods

Representative lines from a selected range of genera and species were sown into one metre wide cultivated strips in existing shrubby stylo pasture at three sites in the dry tropics of central and north Queensland: Springmount near Mareeba, Lochwall near Charters Towers and Galloway Plains or Wycheproof near Calliope (Table 1). A new set of lines was sown each season 1991/92 through 1994/95 and selected commercially available cultivars were included for comparison. Plot size was 1 m by 5 m, with a border between strips to permit observation of natural spread into the background stylo pasture. Entries were replicated in two complete blocks and supplementary irrigation was used in an attempt to ensure establishment. The trial areas were open to grazing by cattle, except during establishment and a brief period prior to data recording at the end of the growing season each year.

Each set was monitored for at least three years and performance was judged largely on the basis of persistence, yield, and spread; qualified by observations on seedling recruitment, palatability, phenology, and pests and diseases.

**Table 1. Location and characteristics of the experimental sites**

| | *Springmount* | *Lochwall*[a] | *Galloway Plains*[b] |
|---|---|---|---|
| Latitude | 17° 13' S | 19° 51' S | 24° 10' S |
| Longitude | 145° 30' E | 145° 53' E | 150° 57' E |
| Altitude (m) | 580 | 320 | 100 |
| Annual rainfall (mm) | 800 | 550 | 770 |
| Soil type (Northcote) | Dr2.21 | Gn2.22 | Dy3.43 |
| Climate (Papadakis) | 4.20 | 4.2 | 4.42 |
| Natural vegetation | Woodland | Woodland | Woodland |
| Actual vegetation | Woodland | Woodland | Grassland |

[a b] The 1991/92 plantings were on similar country on nearby Toomba and Wycheproof respectively.

### Results and discussion

Like much of the rest of Queensland, our experimental sites all suffered from periods of serious drought, including during the establishment year of all plantings. The Lochwall site was the worst affected and the surrounding paddock was destocked for much of the time, so the trial plots there were not grazed as consistently as we had intended. Supplementary irrigation proved essential to obtaining at least some establishment, but it could not entirely compensate for the combined effects of heat and low humidity on grass establishment in very low rainfall summers at Springmount and Lochwall. These problems may have eliminated material that could have established and survived otherwise. On the positive side, many lines did establish and were producing well after four to seven years. In some cases, such as Indian bluegrass (*Bothriochloa pertusa*) at Galloway Plains, the stands have improved with time.

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* Based on the report:

PENGELLY, B.C. and STAPLES, I.B. (1996). *Final Report of MRC Projects CS.054/185 and DAQ.053/081: Development of new legumes and grasses for the cattle industry of Northern Australia.* (CSIRO & QDPI, c/- CSIRO, St Lucia 4067). With additional observations in 1995/96 through 1997/98.

**1991/92 series**
The entries in this set were lines of Indian bluegrass and buffel grass (*Cenchrus ciliaris*) with specific control lines cv. Medway and "Bowen" (Indian bluegrass) and cvv. American, Biloela, Gayndah and Molopo (buffel). Bisset creeping bluegrass (*B. insculpta*) and Nixon Sabi grass (*Urochloa mosambicensis*) were included as general controls.

In this season only, plantings were made at Wycheproof instead of Galloway Plains, and at Toomba instead of Lochwall. Establishment at Wycheproof was excellent, but at Toomba it was dismal. The only lines to establish and persist at Toomba were *B. pertusa* CPI 106629 and cvv. Bisset, Molopo, and Nixon. (In fact, Nixon later proved to be naturalised in the immediate locality.) The site was abandoned after three years when property fencing was realigned.

**Wycheproof** Lines were sown into an existing heavy stand of Seca under relatively heavy grazing pressure. All accessions persisted, with bluegrass performing better than the more nutrient demanding buffel which appears to be gradually declining. The former also suppressed Seca more (37% Seca content in the pasture versus 61% with buffel). Several new accessions of Indian bluegrass lines were similar to Medway; Bowen was less well eaten, had lower ground cover (more tufted habit) and was more prone to invasion by Seca; and CPI 104935B, 104642 and 106426 had good ground cover, spread, and legume balance, and were well grazed.

**Springmount** Bluegrass has not done as well as buffel under the more lenient grazing regime here, and appears to be less well grazed during the dry season. Plot to plot variation is high in this natural woodland setting, so discrimination among fairly similarly performing material is difficult. The Indian bluegrass lines CPI 104642, 106426, and 104935B are the best of the new material, but are all performing similarly to Bowen. However, 106426 and 104935B are later flowering than Bowen, which could confer a quality advantage later in the season. Medway performed very poorly at Springmount.

Although buffel grass is persisting and yielding well at Springmount, and is better grazed than the bluegrasses, it is not spreading off the sown strips. This is a common experience with buffel on low phosphorus soils in the dry tropics. Furthermore, with the exception of Molopo, the present commercial cultivars are performing as well as any of the new material. Nixon Sabi grass has performed well, with excellent ground cover, but it seems to be declining gradually relative to the other species.

**1992/93 series**
The main genera sown in this set were *Dichanthium*, *Digitaria*, and *Urochloa*. Specific controls were Premier digit grass, Jarra finger grass, Floren Angleton grass, Petrie green panic, and Nixon Sabi grass (Saraji was included serendipitously as CPI 60128). General controls were Bowen and Medway Indian bluegrass, and American, Biloela and Gayndah buffel.

**Galloway Plains** As a group, Sabi grass performed very well and several lines were as good as or better than Nixon and Saraji: *U. mosambicensis* CPI 46876, 47167, 60151 and 60139, and *U. stolonifera* 47173 and 47178. CPI 46876 was outstanding. It has spread well beyond the sown strip and has kept Seca content down compared with adjoining native pasture.

The best lines of *Digitaria* species were *D. milanjiana* CPI 59787, 59761 and 59828. Premier produced well and was well eaten, but did not spread much. *D. swynnertonii* CPI 59715 also performed well. It was high yielding and well eaten, and resisted Seca invasion. Jarra (as CPI 59745) did not persist, though it performed reasonably well in the first three years.

Bowen and Medway performed very well, but Bowen was not as readily grazed as Medway. *Dichanthium* and *Panicum* species did not persist well except for *D. annulatum* CPI 50819 which was still yielding well after six years. The buffel grass control lines have also faded out.

**Springmount** The site was burnt out in late 1996, but most of the lines which had been doing well to that time survived the fire. Sabi grass lines and their relatives in *Urochloa* have mostly done well throughout the six years since planting. Several are as good as or better than Nixon: CPI 46876, 47167, 60139, 47122, 60123, 60127 and 47178. Of these, CPI 46876, 60123 and 47122 have been outstanding throughout. Saraji has died out.

Many *Digitaria* accessions are doing well. They have formed good swards, are highly palatable, and many are spreading into the adjoining undisturbed Seca pasture. In fact, we have some concern that they may be too competitive. In many cases they have formed pure swards in the planted strips, apparently preventing regeneration of both Seca and native grasses in these lightly cultivated areas.

Jarra has given good performance in recent years, but was slow to start compared with some other lines. All *D. milanjiana* lines except CPI 59777 have given good performance. Jarra has the advantage that it is more "obvious" due to its structure and leaf shape, which puts it into a higher comfort zone than lines with otherwise equivalent or even better performance. Of the other *Digitaria* species, *D. setivalva* CPI 59829 and *D. swynnertonii* CPI 59715 are now yielding well, and the former has been consistently fairly good over time. Premier has not done well.

Gayndah buffel is the best of the general controls and is still good; Biloela buffel started out the best, but is now barely mediocre; American buffel and Bowen Indian bluegrass are only fair; and Medway is insignificant. The *Dichanthium* lines under test all failed.

**Lochwall** All three buffel grass cultivars have given excellent performance, though they are now a bit yellow. Biloela has been consistently the best of them. Bowen and Medway were never much good here, and both appear to have died out.

Given their performance at Springmount, we had high hopes for *Digitaria* species, but they have been disappointing here. The best are *D. milanjiana* CPI 59761 and 59787. In the last three years *D. endlitchii* CPI 59817 has been building up in the sward [as it seems to be doing at Galloway Plains too] but it was poor earlier. Jarra and Premier have failed completely.

With a few exceptions, Sabi grass and relatives have been good at Lochwall. Nixon itself has done well, but other *U. mosambicensis* lines have been as good or better: CPI 46876, 47167, 60139 and 60151. The most consistently good of the *Urochloa* species has been *U. stolonifera* CPI 47178. Saraji has been insignificant.

**1993/94 series**
Most of this large set was made up of *Bothriochloa* and *Paspalum* accessions, with smaller groups of *Dichanthium*, *Ischaemum*, *Panicum* and *Schmidtia*. Specific controls were Bisset creeping bluegrass, Dawson and Medway Indian bluegrass, Petrie green panic, and Rodds Bay plicatulum. Four cultivars of Rhodes grass (*Chloris gayana*) were included to see how they would perform in the dry tropics; and American and Biloela buffel grass were again included as general controls. It was generally a fairly disappointing lot. *Paspalum* species failed throughout, as did the smaller group of *Ischaemum* lines.

**Galloway Plains** The best grass was *Bothriochloa insculpta* CPI 69517 which had high yield and spread, good ground cover, and was well eaten. CPI 125651 and 125652A had high yields, but less ground cover due to their tufted habit, and they were poorly eaten. *B. glabra* CPI 105854, 105909 and 105099 also yielded well but were not eaten as well as other species. Bisset and Dawson were both good in terms of yield, spread, and palatability. Medway grew well but was not eaten so well. Callide Rhodes grass gave consistently good yields too.

**Springmount** The most consistent performers throughout the full five years were the two buffel grass cultivars, American and Biloela. Surprisingly, the *Panicum* lines have done quite well in the past three years, especially cv. Natsuyutaka and CPI 60022. Performance of *Bothriochloa* species has been disappointing and inconsistent. The best are CPI 125652A and 125651. CPI 69517 has not done well here and Dawson and Medway are insignificant.

**Lochwall** Only Biloela buffel has performed consistently over time. Several *Bothriochloa* lines (including CPI 69517) established well, but were not recorded subsequently except for *B. insculpta* CPI 125652A and 125651. However, the native *B. bladhii* var. *bladhii* is often very vigorous over large parts of this site, which makes the identification and assessment of other bluegrasses very difficult.

Two lines of *Schmidtia pappophorides* (CPI 60087 and Q10092) are vigorous and spreading at Lochwall (especially the former). Both are present at Springmount too, but are not impressive there. This is not a genus we have had much previous experience with and, due to the sporadic grazing at Lochwall, we are not sure how palatable these lines are to cattle. They should be treated with caution until this can be clarified.

**1994/95 series**
This was a mixed set of eleven genera. Most interest centred on the ten accessions of *Cynodon* species, but they turned out to be total failures in practice. It is not known what caused the problem, but establishment of all ten lines was effectively nil.

**Galloway Plains** By far the best performances have been from *Bothriochloa pertusa* cv. Medway, and *B. insculpta* CPI 69517, cv. Bisset and CPI 125652A. *Iseilema* sp. CPI 106479 has also grown well and is very well eaten; and *Chrysopogon fulvus* CPI 106035 is persisting with reasonable yields.

**Springmount** Best lines are *Bothriochloa bladhii* CPI 104802A and *B. insculpta* CPI 69517. The present cultivars of these species, Swan and Bisset respectively, are insignificant. Other lines doing well or moderately well are *B. bladhii* CPI 52194, *B. glabra* CPI 108424, *Chrysopogon* sp. CPI 106689, and *Heteropogon contortus* CPI 106536 and Q25363.

**Lochwall** As in the previous series, the native bluegrass has seriously hindered assessment of other *Bothriochloa* lines. *B. insculpta* CPI 69517 and 125652A were both good initially but their current performance is obscured if, indeed, they are still present at all. Bisset is mediocre. With good regeneration of native spear grass in 1997/98, a similar problem has arisen in assessing the experimental *Heteropogon contortus* lines, but Q25363 had been doing well.

Several lines of *Chrysopogon fulvus* are now doing well, especially CPI 104958, 106035 and 105011. They are higher yielding than the native material, and appear to be better eaten; but they are probably equally unlikely to provide a balanced pasture in combination with Seca.

## Summary
We have identified a number of accessions in the genera *Bothriochloa*, *Digitaria*, and *Urochloa*, which would make useful sown pasture grasses to grow in association with stylos (Table 2). A wide range of buffel grass lines also performed well, but so did the current cultivars of this species. Some accessions with the tufted growth habit more typical of native grasses have also produced well and may be more environmentally acceptable than stoloniferous forms, but the present evidence for their success in mixtures with stylos is tenuous.

**Table 2. Best accessions in selected genera and species ranked within sites**

| Genus and species | Accession [a] | Rank within species at indicated site | | |
|---|---|---|---|---|
| | | Springmount | Lochwall | Galloway |
| *Bothriochloa insculpta* | 69517 | 1 | 2 | 1 |
| | 125651 | 3 | 3 | 3 |
| | 125652A | 2 | 1 | 2 |
| *Bothriochloa pertusa* | 104642 | 3 | — | 2 |
| | 104935B | 2 | — | 1 |
| | 106426 | 1 | — | 3 |
| *Digitaria endlitchii* | 59817 | — | 1 | 1 |
| *Digitaria milanjiana* | 59761 | 4 | 1 | 3 |
| | 59786 | 1 | — | 1 |
| | 59787 | 3 | 2 | 2 |
| | 59789 | 2 | — | 4 |
| *Digitaria natalensis* | 59752 | 1 | — | ? |
| *Digitaria setivalva* | 59829 | 1 | — | ? |
| *Digitaria swynnertonii* | 59715 | 1 | — | 1 |
| *Urochloa mosambicensis* | 46876 | 1 | 1 | 1 |
| | 47167 | 2 | 2 | 2 |
| | 60139 | 3 | 4 | 4 |
| | 60151 | 4 | 3 | 3 |
| *Urochloa oligotricha* | 47122 | 2 | — | 2 |
| | 60123 | 1 | 2 | 1 |
| | 60127 | 3 | 1 | 3 |
| *Urochloa stolonifera* | 47178 | 1 | 1 | 1 |

[a] Commonwealth Plant Introduction (CPI) numbers

## Discussion/Comments

1. *Could some additional background be provided on commercial* Nixon Sabi grass?
   In MRC Project CS.152 conducted by Dr Ray Jones, the best material was Nixon urochloa over a wide range of environments.
   Nixon Sabi grass (*Urochloa mosambicensis*) needs to be more strongly promoted.
   *U. mosambicensis (CPI* 46876) has done well in several trials: best in 70s, 80s, 90s from Darwin to Rockhampton.

2. *Do we need another grass and if so for what situation?*
   A tufted blue-grass is urgently needed for Downs-type soils.
   Need to have new grasses "up-your sleeve".
   No other specific needs were identified at the meeting.

3. The main objective in this project was to find new grasses that could grow with Seca stylo and withstand heavy grazing pressures.

4. One suggestion was for a major project with a team on "establishment practices" for grasses. A number of participants dissented from this view.

5. Another suggestion was that there was a need to collate existing information on grass establishment (published and unpublished). Reference was made to the *"Review of stability and productivity of native pastures oversown with tropical legumes"* by John, G. McIvor, Andrew D. Noble and David M. Orr which was published as NAP Occasional Publication No. 1.

6. *To what extent do successes in the project reflect the "successful" establishment techniques used?*
   Genotype performance could be confounded with chance seed quality effects, as seed varies in vigour. Also certain groups of grasses are better at establishing in undisturbed conditions

7. A view was expressed that there is a need for someone to revisit the *S. scabra* collection, to look for lines that are less vigorous than Seca and are also more tolerant of acid soils and have greater anthracnose resistance. The value and usefulness of this approach was strongly challenged. There are already practical ways available for managing Seca stylo dominance.

8. *The major issue is can the 22 accessions listed in Table 2, be reduced to 3 or 4 best bets?*
   There was general agreement that this was a high priority. The selected 3 or 4 best bets could be grown in bigger plots and evaluated under grazing. However, some information on grazing was already available. Plots of many of the accessions are still available and should be monitored.

9. The high price of grass seed, its variable quality, the restricted available seed supply and difficulties with establishment, all restrict producers investing in oversowing pastures with introduced grasses.

## Elimination of unwanted introduced pasture plants - a discussion paper by Harry Bishop and John Hopkinson

**Harry Bishop (Project Leader)**
**DPI, PO Box 668, Mackay 4740**
**Phone (07) 49518731 / Fax (07) 49514509**
**Email -** bishop@dpi.qld.gov.au

**Dr J M Hopkinson**
**QBII, Walkamin RS**
**Walkamin Qld 4872**
**Phone (07) 4093 3733 / Fax (07) 4093 3903**
**Email - HopkinsJ@prose.dpi.gov.gov.au**

### Backround

1. An inevitable undesirable by-product of pasture plant introduction is the persistence of unreleased accessions as potential weeds. The research program must now accept the responsibility for having to get rid of these plants and for ongoing management of discontinued evaluation sites. This acceptance has resulted through professional "duty of care", shifts in community perceptions about introduced plants and pending legislation. The most difficult task is to define which plants are undesirable and unwanted and to make the categorical decision to "remove" them. The obligation falls on the research program:
   - wherever the original owner of the land wants them eliminated:
   - wherever there is good reason for us to see a real risk of the plants becoming weeds.

2. Responsibly introduced plants run the risk of becoming weeds
   - where they are both well-adapted and unpalatable to stock,
   - where they are well adapted in places where stock are excluded, regardless of palatability.

### Proposal

3. Most plants that have passed through formal evaluation show their weed potential before they get beyond the boundaries of evaluation sites and research stations. While their distribution is still so restricted, it is realistic to expect to be able to eradicate them. This is where we are concentrating our attention.

4. The intention is not only to eliminate unwanted plants, but also to develop effective strategies for future elimination and management of sites. We aim to develop a process that can be put in place quickly and effectively as problems arise. The Northern Australian Pasture Plant Evaluation Committee (NAPPEC) is also addressing the situation of potential weeds from plant introduction activities and the April 1998 meeting at Mackay registered its commitment to further assist with developing protocols for pasture plant evaluation (minutes of NAPPEC meeting at Mackay, April 1 to 4, 1998).

5. The strategy developed for BULS is:
   - 5.1 Document all evaluation sites (past and present) sown with non-cultivar legumes. Use the QPASTURES data base as a record of site locations and performance of accessions sown.
   - 5.2 Survey each site for unwanted "risk" accessions and document area and spread, inside plots and away from plots.
   - 5.3 Eradicate "risk" accessions using herbicide recommendations from Don Loch's BULS herbicide trial plus various management procedures applicable to that site.
   - 5.4 Develop guidelines for future management of site in co-operation with landowner.
   - 5.5 Record/document methods/chemicals/management used and results achieved so that effective procedures can be developed and refined.

6. Currently Harry Bishop is coordinating a state-wide eradication activity (under the umbrella of the BULS project) on unwanted plants sown in the BULS and some associated projects. All target plants are legumes, and the particular problem that legumes present is their production of hard seed, which places a time-scale of many years on the process before there is real certainty of success. Current activities are being funded from a BULS carry-over balance. The aim is to initiate a new and wider ranging project for the purpose of " Responsible management of discontinued sown pasture evaluation sites". Funds are being sought to initiate this project.

7. 1998/99 Work plan

7.1 Bob Walker is responsible for off-station eradication in north Queensland, mainly of *Aeschynomene brasiliana* and *Indogofera schimperi*. Specific target sites include Burlington, Wrotham Park, Sugarbag and Lamond's Lagoon.

7.2 John Hopkinson has taken responsibility for continuing attempts at eradication of *Acacia angustissima* on Walkamin Research Station, with the support of John Hardy (Station Manager).

7.3 Terry Hilder is responsible for "on-farm" eradication of *A. brasiliana* at "Swans Lagoon" Research Station, "Sorrell Hills", Duaringa, and "Wadeleigh", Miriam Vale. Plans for "Narrabri", Gympie, Brian Pastures Research Station Gayndah and Narayen Research Station Mundubbera are the responsibility of Bruce Cook, John Mullaly and Cam McDonald respectively. Other discontinued sites to be monitored are "Braceborough", Charters Towers, "Stillwater", Daly Waters, and Katherine Research Station.

7.4 These collaborators will record and report details of activities and help develop a process for future use.

8. A specific management plan has been developed for the DPI Swans Lagoon Research Station, Millaroo, via Ayr, where the BULS evaluation site is adjacent to native pasture paddocks used for breeder herd management trials. The aim is to contain and eliminate invasive sown legumes including Wynn and Seca from this site and with the cooperation of the Station Manager will be a good test of possible elimination techniques.

*Guidelines for current management of "Swans Lagoon"BULS project site.*

8.1 Remove stock and shut the gate (site already fenced) – April 1998.

8.2 Spray well adapted non-release legumes with herbicides, preferably pre-flowering. Mix of dicamba - "Banvel 200" (at 1 ml/L) and metsulfuron methyl - "Ally", "Brush-off" (at 1.5g/20 L, with wetting agent) Total chemical cost $12.50/ha) – April 1998.

8.3 Burn site summer 1998/99 after first storms to kill some adult plants, soften seed, increase germination and make site more accessible to spraying. (Cost of fire breaks, equipment and team?)

8.4 Oversow site with 5 kg/ha of Bowen pertusa seed after burn, site already invaded with Bowen bluegrass. (Cost at $15/kg for 6 ha = $450).

8.5 Spray legumes with above herbicides in early wet season – 1998/99.

8.6 Apply urea at 100 kg/ha to whole site (6 ha x 100 kg = 0.6 tonne = $ 250, plus appln costs). Apply another 100 kg/ha urea to individual plots of *A. brasiliana* 93592 and 92519, *Chamaecrista rotundifolia* 86172, 93094 and Wynn and *C. pilosa* 57503 ((5 x 0.1 ha x 2 reps) = 1 ha) – after early storms.

8.7 If accessible, check site in mid March 1999 and spot spray listed legumes.

8.8 Burn site early summer 1999/2000.

8.9 Spray legumes early wet season 1999/2000.

8.10 Apply urea at 100 kg/ha to site, and an extra 100 kg/ha to problem legume plots.

8.11 Review situation in early summer 2000/2001 and if legumes are still persisting continue above operations as resources permit.

8.12 Total product cost for 6 ha Year 1 = $855.00, Year 2 = $385.00.

## Discussion / comments

9.1 The size of the problem is illustrated by *A. brasiliana* being recorded in the Q PASTURES data base as being sown at 28 COPE and associated evaluation sites (not necessarily all surviving).

9.2 MLA accepted some responsibility, on ethical grounds, to contribute to the eradication of unwanted plants from those studies assisted by NAP funding. QBII and CSIRO agreed to prepare a plan and submit it to MLA for its consideration.

9.3 It was also pointed out that new quarantine regulations would impact on evaluation processes, including the need to clean up afterwards. However nobody knew just how or, indeed, what was happening about new quarantine regulations.

9.4 *"Taskforce on the promotion of the responsible use of introduced tropical pasture plants".* Dr Bob Clements, when Chief of CSIRO Tropical Crops and Pastures, was stimulated to establish the taskforce following the publication of Mark Lonsdale's paper. One of the activities of the taskforce was to commission the Chudleigh report on "Assessing the impact of introduced tropical pasture plants in northern Australia". This report has now been released to NAPPEC. The taskforce also undertook a number of other activities including developing protocols for plant introduction and evaluation.

9.5 NAPPEC now has an evaluation protocol and over the last couple of meetings it has worked towards a code of practice. MLA would probably require an agreed code of practice before it provided funding for future projects.

9.6 *Who has the right to decide what is undesirable in a plant to classify it as a weed to be eliminated?*
It is up to the Organisation introducing the plant, or the collaborating farmer, to decide.

9.7 Very few unwanted plants have been released considering the numbers that have been grown. Those unwanted plants associated with pasture activities are mostly the result of contaminated seed from overseas (particularly in the 1960's).

9.8 NAP Management were concerned to hear that DPI were recommending that *A. brasiliana* CPI 92519 be taken off the pre-release list, without formally discussing this proposal with them. Particularly in the light of substantial beef producers' funds being invested in this work. It was noted that such an outcome had been mentioned in Milestone reports, but it was generally agreed to communicate better when Organisations were withdrawing potential new plants from pre-release, that MLA had supported financially in the development phase.

## Sown Pasture Review
## General discussion

1. NAP Management has accepted work plans for 1998/99 as detailed in the revised papers.

2. Many issues specific to the various projects have been already covered in the discussions following each paper. The issues outlined below were brought up during the general discussion.

3. CSIRO resources in permanent sown pasture work and in the genetic resource group are declining substantially.

4. Concern was also expressed by QBII about the decline in personnel and resources being provided by their organisations for future pastures species development.

5. QBII now lacks traditional extension base for assisting with pasture development and adoption. It will have to rely on present available staff. A number of initiatives are being considered, including release after sales packages; the use PIRDS/PDS/Demo sites and producer monitoring network process.

6. An ACIAR/CSIRO-QBII project is being developed for southern Africa, which includes development of extension/development methods involving producers.

7. NAP already provides funding for study tours and Producer Demonstration sites, and is interested in establishing pasture development producer groups that are managed by producers. The success of the producer monitoring project has provided us with encouragement to pursue this course.

8. The activities and relevance of the Queensland Herbage Plant Liaison Committee was discussed at some length. There is a need for a system which is more representative and is closer to the main stakeholders.

9. The role of Plant Breeders Rights (PBR) was discussed. In future selected lines from collections may not be approved for PBR. There will be a need to develop a new system for cultivar release.

10. NAP Management expressed concerns at the problem of some cultivars being developed, but the companies concerned are then not actively promoting them. Organisations cannot expect MLA to provide $ for R&D if, at the end of the project, there is not a lot of activity in promoting, producing and selling seed.

11. There is presently no formal follow up by institutions/agencies on the progress of cultivars after they are released to the grazing industries. Some form of monitoring cultivars would seem to be desirable to highlight progress and identify deficiencies and problems.

12. All participants at the meeting welcomed the opportunity of meeting together and participating in the review process.

# Part 4. 1998 ANNUAL PEER REVIEW OF LEGUME DOMINANCE AND SOIL ACIDIFICATION PROJECTS

## Background

With the increasing use of *Stylosanthes* spp. in northern Australia (c. 1.2 m ha) and the accompanying management practices, such as the use of fertilisers and supplements, Brahman cattle and increasing stocking rates, the problems of the instability and decline in condition of the native pastures, legume dominance and soil acidification, have emerged as important issues for the beef industry of northern Australia.

In 1996 a review of these issues was commissioned by the Meat Research Corporation. This 'Review of stability and productivity of native pastures oversown with tropical legumes' was conducted by Dr John G. McIvor of CSIRO Tropical Agriculture, Dr Andrew D. Noble of CSIRO Land and Water and Dr David M. Orr of the Queensland Department of Primary Industries and has been published by the MRC as NAP Occasional Publication No. 1.

## Research program

Following on from this report, a major research and extension program has been established, with CSIRO Land and Water and the Queensland Department of Primary Industries, to address problems of the instability and decline of native pastures associated with legume dominance and increasing soil acidification. This work is jointly funded by the MLA and the Land and Water Resources Research and Development Corporation, under the MLA'S North Australia Program. A Producer Panel is associated with this work and meets annually to review progress .

The five projects in this NAP program are -

- Soil acidification research in the semi-arid tropics. Final Report. Meat Research Corporation Project CS.277. MRC, Sydney. – Andrew Noble, CSIRO Land & Water.

- Workshop on the management of native pastures oversown with *Stylosanthes* spp. (NAP3.216) – Barry Walker and Judy Lambert, Meat Research Corporation, Sydney. (This workshop developed Project NAP3.220).

- Sustainability of *Stylosanthes* based pasture systems in northern Australia: Managing soil acidity (NAP3.218) – Andrew Noble, CSIRO Land & Water.

- Management of native pastures oversown with stylos (NAP3.221) – Deryk Cooksley, Queensland Department of Primary Industries.

- Communication of stylo management practices (NAP3.220) – Col Middleton, Queensland Department of Primary Industries.

In addition, ACIAR is provided funding for the following project, which was also considered at the review meeting –

- Potential constraints to the sustainability of legume based pasture systems in northern Australia and Thailand – Andrew Noble

A one day review meeting was held at the QDPI, Mareeba on Tuesday 21 July and involved the presentation and discussion of current project reports in the morning and a visit in the afternoon to a grazing experiment at Dimbulah, about 50 km west of Mareeba, which is examining strategies to manage legume dominance.

Publications from these projects are listed in Appendices III and IV. The program for the meeting and the list of participants are detailed in Appendix VI.

## Sustainability of *Stylosanthes* based pasture systems in northern Australia: Managing soil acidity

**MRC Project number:** NAP3.218
**Project duration:** 01/07/97 to 30/06/2001
**Principal Investigator:** Dr Andrew Noble
CSIRO Land and Water
Davies Laboratory
PMB, PO Aitkenvale
Townsville, Qld, 4814
Ph: (07) 4753 8555/Fax (07) 4753 8600
E-mail Andrew.Noble@tvl.clw.csiro.au

### Project objectives:

1. Establish permanent monitoring sites throughout northern Australia to assess long-term soil fertility and moisture trends under *Stylosanthes* and native pasture systems. Insight into the impact of these grazing systems on the soil resource base will assist in the development of sustainable beef production strategies.

2. Develop a soil acidity risk assessment map for the Dalrymple Shire at a level that will assist resource managers in identifying areas most vulnerable to accelerated acidification. In addition, a simple field based tool-kit will be developed to assess soils for their sensitivity to accelerated soil acidification.

3. Evaluate the impact of different *Stylosanthes* management strategies implemented at Springmount, Mareeba, on the rate of acidification. This will facilitate the development of management strategies to minimise *Stylosanthes* dominance in improved pastures.

4. Conduct greenhouse and laboratory studies to ascertain the tolerance of grass and *Stylosanthes* species to acid soil infertility and assess the impact of ash produced after burning as an acid soil ameliorant.

5. Quantify the mineral nitrogen dynamics under a *Stylosanthes* dominant pasture in order to assess the contribution of nitrate leaching to acidification. Using published data attempt to establish a total nitrogen budget for pastures with and without *Stylosanthes*.

6. Develop a comprehensive communication plan in conjunction with QDPI which will facilitate awareness amongst producers of the possible negative impacts of *Stylosanthes* dominant pastures on the soil resource base and to suggest management strategies to minimise these negative impacts.

### Project summary:

Land degradation issues are assuming greater importance in northern Australian beef grazing systems. In this respect, the aims of this project are to evaluate the long-term impact of accelerated acidification due to the introduction of *Stylosanthes* based pasture systems on mechanisms associated with this problem and the development of strategies to minimise this risk.

Whilst the project is still in its infancy there are a number of activities that have been initiated over the last 12 months. Several permanent monitoring sites have been established and at two of these sites soil moisture and rainfall monitoring equipment have been installed. Analysis of soil samples has been completed on some of these sites.

At one of the permanent monitoring sites (Thalanga) root profile distribution patterns were mapped for a native pasture and *Stylosanthes* dominant systems. Distinct differences in root distribution under the two systems were observed with *Stylosanthes* roots being more prolific at depth when compared to the native pasture. It is suggested that these differences in

rooting patterns may in part account for the higher tree mortality observed on the *Stylosanthes* site.

Another activity includes the validation of a pedotransfer function to predict the pH buffering capacity of soils and its subsequent use in the development of a soil acidification risk map for the Dalrymple Shire. A significant outcome from this mapping exercise is that large areas of the Shire, are potentially predisposed to rapid acidification if *Stylosanthes* dominance does occur. A field tool kit for the determination of potential risk of acidification is proposed which is based on a measurement of soil pH and texture. The estimated time to reach a soil pH of 5.0 can then be read off from a table. Details of the structure and rationale behind the tool kit are presented as an attachment.

A rapid screening technique based on root elongation has been validated and tested on a range of *Stylosanthes* accessions. Preliminary results indicate that the accessions tested are highly intolerant of acid soil infertility and it is speculated that continued soil acidification will result in poor legume seedling recruitment with a corresponding decline in vegetation cover. Continued screening of *Stylosanthes* and grass species are currently being undertaken.

Considerable effort has gone into communicating results and making producers aware of potential problems associated with legume dominance. This has been facilitated through field days, research articles, popular articles and video features. This has been achieved through collaboration with Col Middleton, QDPI (Project NAP3.22.).

## Results and achievements in addressing agreed objectives

**Objective 1**

Progress has been made in the establishment of permanent monitoring sites. With the prolonged wet season and associated logistical problems only 2 of the 4 permanent soil moisture and rainfall monitoring sites have been established. During the dry season continued establishment of monitoring sites will be undertaken. The 2 sites established are at Lansdown and Thalanga. Soil samples and site characterisation has been completed at both sites and the regular downloading of dataloggers has been routinely undertaken on a 3 monthly basis. At the Thalanga site, neutron moisture tubes have also been inserted in the native pasture and *Stylosanthes* dominant pasture to monitor water uptake from depths down to 2 m. In addition to the soil moisture monitoring activities on this site, an estimation of the root distribution characteristics of the two production systems was undertaken using the methodology of Nicoullaud *et al.* (1994). Whilst comprehensive analysis of the data is still being undertaken, there is clear evidence of difference in the rooting patterns between the two production systems (Figure 1). The root distribution under *Stylosanthes* appears to be deeper and more extensive than under the native pasture. The greater root proliferation observed under *Stylosanthes* may account for the significantly higher tree mortality observed on this site through competition for water.

**Objective 2**

The development of an acidity risk map for the Dalrymple Shire has progressed with the validation of a pedotransfer function and the production of a risk map for the Shire. The validation of the pedotransfer function was undertaken using archival soil samples collected from the Shire that are in storage at CSIRO Land and Water, Townsville. Thirty one surface soils were selected based on their dominance within the Shire and subjected to laboratory determinations of pH buffer capacity using a methodology previously outlined by Noble *et al.* (1997). A highly significant linear regression was observed between measured and predicted pH buffering with no significant deviation from the 1:1 line (Figure 2). For each of the soil associations within the Dalrymple Land Resource data base, a pH buffer capacity was assigned based on mean characteristics for that association. A map of Shire was produced indicating the potential risk of acidification based on the number of years required to reach a base pH of 5.5 in water and a net annual input of 3.5 kmol $H^+$/ha.yr (Figure 3). The map excludes areas with mean annual rainfall of less than 500 mm as these areas are deemed to be unsuitable for Stylos production. In the initial development of this map it was proposed that soil P could be used as one of the variables in the overall structure of the risk map. However, on statistical evaluation of the data set within a soil association the variability was too high for P to be a meaningful predictor. Consequently, the risk map is based on rainfall and pH buffering capacity.

An attempt has been made in developing a field based tool kit for the assessment of acidity risk. This tool kit is based on the measurement of soil pH using a field electronic pH meter and the determination of field based texture. Using a table system, the number of years that it would take for the soil pH to drop to a value of pH 5.0 in water is estimated. A complete discussion and outline of the method and rationale is presented in Attachment I.

**Objective 3.**
Soil sampling of the Springmount site at Mareeba is to be undertaken in August 1998 for the assessment of the impact of various *Stylosanthes* management systems on rates of soil acidification.

**Objective 4.**
The development of a rapid technique to assess the sensitivity of *Stylosanthes* and grass species to soil acidification has been undertaken. This involves evaluating root elongation over a 7 day period for seedlings grown in an acid soil that that has been ameliorated with $Ca(OH)_2$. In the development of this rapid bioassay technique the wheat varieties Egret and Carazinho where used model as plants since these varieties have been screened for their tolerance and sensitivity to acid soil infertility. The soil used in this study has a pH 4.62 and an acid saturation of 66%. The effects of remediation of acidity are clearly shown with respect to Egret whilst in the case of Carazinho there was no significant response to lime application (Figure 4a). From these results it has been concluded that the soil used in this screening process is adequately acid to illicit a response. Continued screening of *Stylosanthes* varieties is currently being undertaken, the results of which are presented in Figure 4. It is clearly evident that all of the *Stylosanthes* varieties tested to date have shown significant responsiveness of lime additions. In addition, root elongation in the unamended treatments is extremely poor suggesting that the species tested are highly sensitive to acidity. It is probable that under severe acidification there will be a decline in annual recruit. This could significantly impact on productivity. Similar bioassay tests have been attempted using different grass species. However, to date there has been problems associated with germination of seed. This matter is currently being investigated. A pot trial to assess the growth and productivity of selected grass and *Stylosanthes* varieties will be established this winter.

**Objective 5.**
In an effort to understand the nitrogen dynamics under a *Stylosanthes* dominant and sown pasture (*Urochloa mosambicenis*) pasture, a series of Teflon soil solution sampling cups was installed at a site at Landsdown. Eight samplers were installed on each site at 2 depth intervals namely 25 and 60 cm. These samplers when placed under vacuum extract the soil solution when conditions permit and allow one to determine the composition of the solution. Samplers were installed in January 1998 and soil solutions extracted on the 3/02/98, 13/03/98 and 20/05/98. Samples are currently being analysed for mineral nitrogen. Leaf litter traps have been installed on each of the sites to determine the amount of leaf senescence that does occur over the dry season and the nitrogen content of this material.

**Objective 6.**
Over the past 12 months significant progress has been made in the area of communicating the problems associated with accelerated soil acidification under *Stylosanthes* dominant pastures. This activity is associated with Project NAP3.22 "Communication of stylo management practices" coordinated by Col Middleton of QDPI. Over the reporting period field days on the properties Thalanga and Strathbogie were attended and presentations made on the potential problems associated with legume dominant pasture systems with respect to soil acidification and land degradation. In addition, presentations to research scientist visiting Davies Laboratory from India, China and Thailand have been made on the subject of accelerated soil acidification under legume based pasture systems. In cooperation with DPI and other CSIRO Divisions articles on 'Managing Stylo Pastures for Sustainable Production' and 'Soil Acidification: A Potential Threat to Legume Based Pasture Systems' have been produced for graziers and extension officers respectively. As a means of outlining the

problem of acidification to graziers at field days a poster has been produced in collaboration with Col Middleton. A video feature on stylos was produced for the program Cross Country and an article on the problem of *Stylosanthes* dominance appeared in the Spring issue of NAP News 1997. Research articles have been written for Australian Journal of Experimental Agriculture and the National Soil Acidity Meetings. A complete list of articles is attached below.

## Plans for the coming year

The establishment of further permanent monitoring sites and the installation of a further 2 soil moisture monitoring sites will be undertaken over the next 12 months. Continued monitoring of soil solution nitrate and nitrogen flux will be undertaken on the Lansdown site. It is anticipated that greenhouse studies on the productivity of selected legume and grass species will be completed by the end of 1998.

## Discussion/Comments

1. *Water use under Stylosanthes dominant pastures was higher than that under a Urochloa or native pasture systems. Could this be due to greater rainfall loss through surface runoff and therefore less infiltration?*

Preliminary results from infiltration studies undertaken at Thalanga by Christian Roth using a rainfall simulator, clearly show that infiltration rates are considerable higher under the *Stylosanthes* dominant pasture when compared to native pastures. The increased infiltration rates may in part be explained through the lower moisture content of the soil under the legume dominant system which would result in the development of surface cracks thereby facilitating preferential pathways whereby rainfall could enter the soil.

2. *Could the higher moisture consumptive patterns observed under Stylosanthes dominant pastures contribute to the decline in the grass component rather than soil acidification per se?*

This is a plausible explanation for the sites that have been monitored in northern Australia. In this respect the pH of the soils have not dropped to a level where one would expect to observe reductions in plant performance due to soil acidification. The significant tree mortality observed under *Stylosanthes* at Thalanga would suggest that the legume is extremely competitive with respect to its ability to extract stored soil moisture.

3. *Would soil acidification be more rapid on light textured soils when compared to duplex soils?*

Intuitively, one would suggest this to be the case. Results to date have indicated soil acidification is rapid on soils that have a low buffering capacity. If the dominant mechanisms associated with soil acidification are nitrate leaching and excess cation then duplex soils would acidify at a slower rate than uniform light textured soils. This is due to greater stored alkalinity in the B horizon of these soils which would buffer any changes in soil pH. Work undertaken on duplex soils in southern Australia have indicated that certain tree species may have the ability to mobilise stored alkalinity, transfer it to the soil surface through litter fall which will result in the neutralisation of surface acidity that has developed due to a legume based pasture system. This type of 'biological nutrient pumping' by trees should be viewed as a potential means of remediating soil acidification in these northern pasture systems.

4. *Would the selection of grass species tolerant to acidification be a possible way around the problem of soil acidification?*

The growing of grass species that are tolerant to acid soils should not be viewed as a means of solving the problem. The growing of tolerant species should be viewed as a tool in the remediation process.

5. *Would significant acidification due to Stylosanthes dominant pastures be a problem on Woodhouse Station?*

It is unlikely to be a major problem in the short term if the production of hay is not a major enterprise. Results for Thailand and northern Australia suggest that rates of acidification are significant higher where the entire crop is removed from the paddock. In addition, the soils that dominate the area are duplex and invariably sodic. This would mean that there is significant stored alkalinity in the profile that would buffer shifts in soil pH.

6. *Is there a critical soil pH where there would be a dramatic reduction in the survival of grass/Stylosanthes species and is there any evidence to suggest that this value has been reached?*

From the preliminary screen results there appears to be a strong responsiveness in root elongation to increases in soils pH. In this respect it is plausible that as the pH of the soil drops to a critical level, possibly pH 4.2 or lower in $CaCl_2$, seeding recruitment may decrease due to the inability of the species to establish a significant root system. This would be critical in the semi-arid tropics. There is no evidence to suggest that soils in northern Australia have reached this level. However, in Northeast Thailand it has been observed that in certain paddocks persistence, recruitment and establishment of *Stylosanthes* has been extremely poor. On these soils we have measured soil pH values of below 4.0.

7. *Increases in soil pH have been observed under Wynn Cassia dominated pasture production systems in central Queensland.*

To date we have not evaluated this species for its potential impact on the soil. However, significant decreases in soil pH have been observed under long-term Leucaena based pasture systems. It would be important to quantify these increases and also assess other legume species such as Calliandra for its impact on the soil resource.

8. *Water use under Stylosanthes dominant pastures was higher than that under a Urochloa or native pasture systems. Could this be due to greater rainfall loss through surface runoff and therefore less infiltration?*

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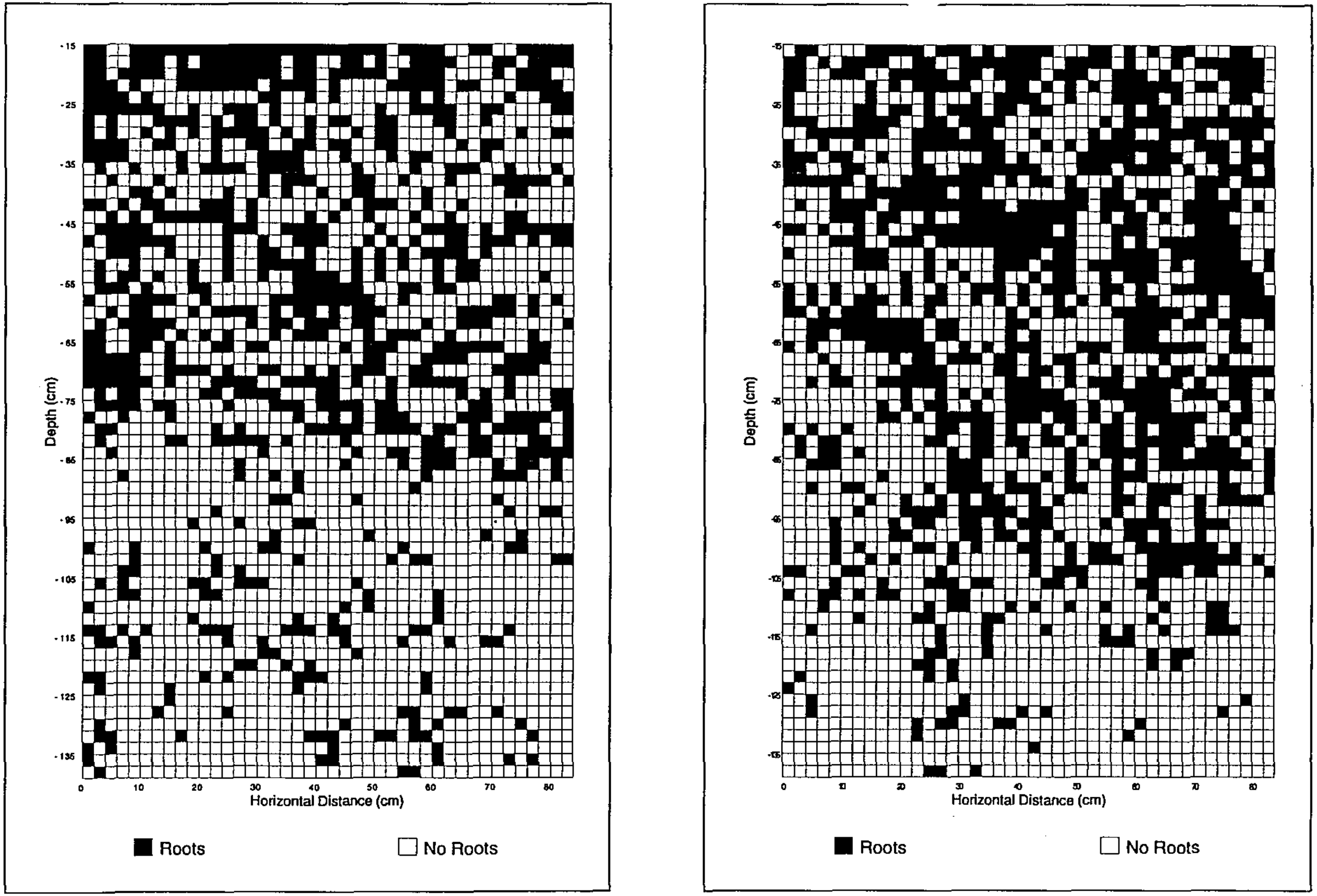
Noble, A. D., Cannon, M. and Muller, D. 1997. Evidence of accelerated soil acidification under *Stylosanthes*-dominated pastures. *Australian Journal of Soil Research* **35**:1309-1322




(a) (b)

Figure 1. Root profile distributions for (a) native grass lands and (b) *Stylosanthes* dominant pasture at Thalanga on a yellow brown earth with significant soft plinthic to indurate layers at depth.

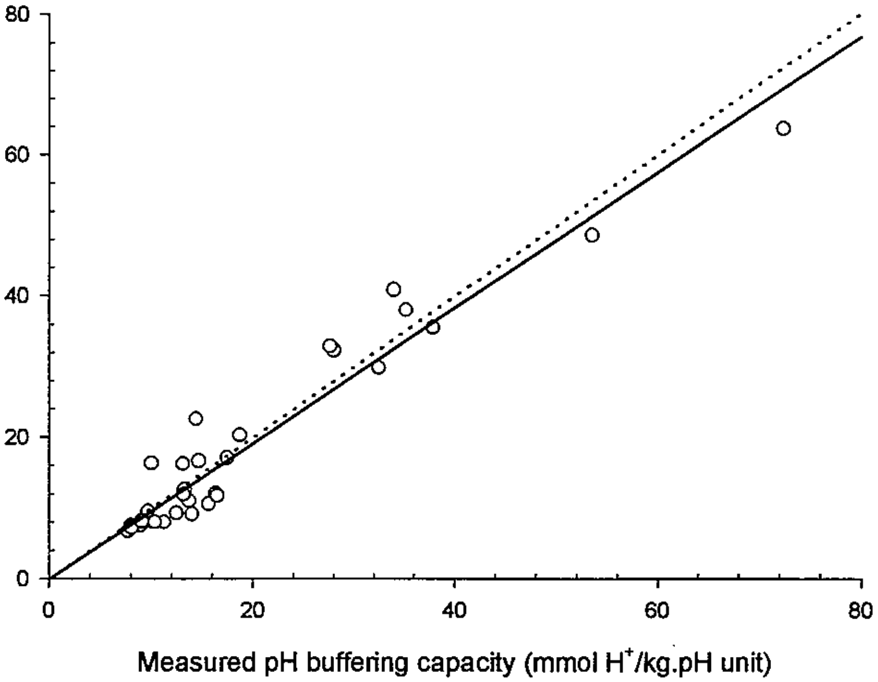



Figure 2. Validation of predicted pH buffering capacity against measured values for 31 surface soil samples from the Dalrymple Shire. The dotted line represents the 1:1 relationship between the two parameters. Equation for the solid line forcing the intercept through zero is: $y = 0.960(\pm 0.028)x$; $r^2 = 0.928$; n =31.

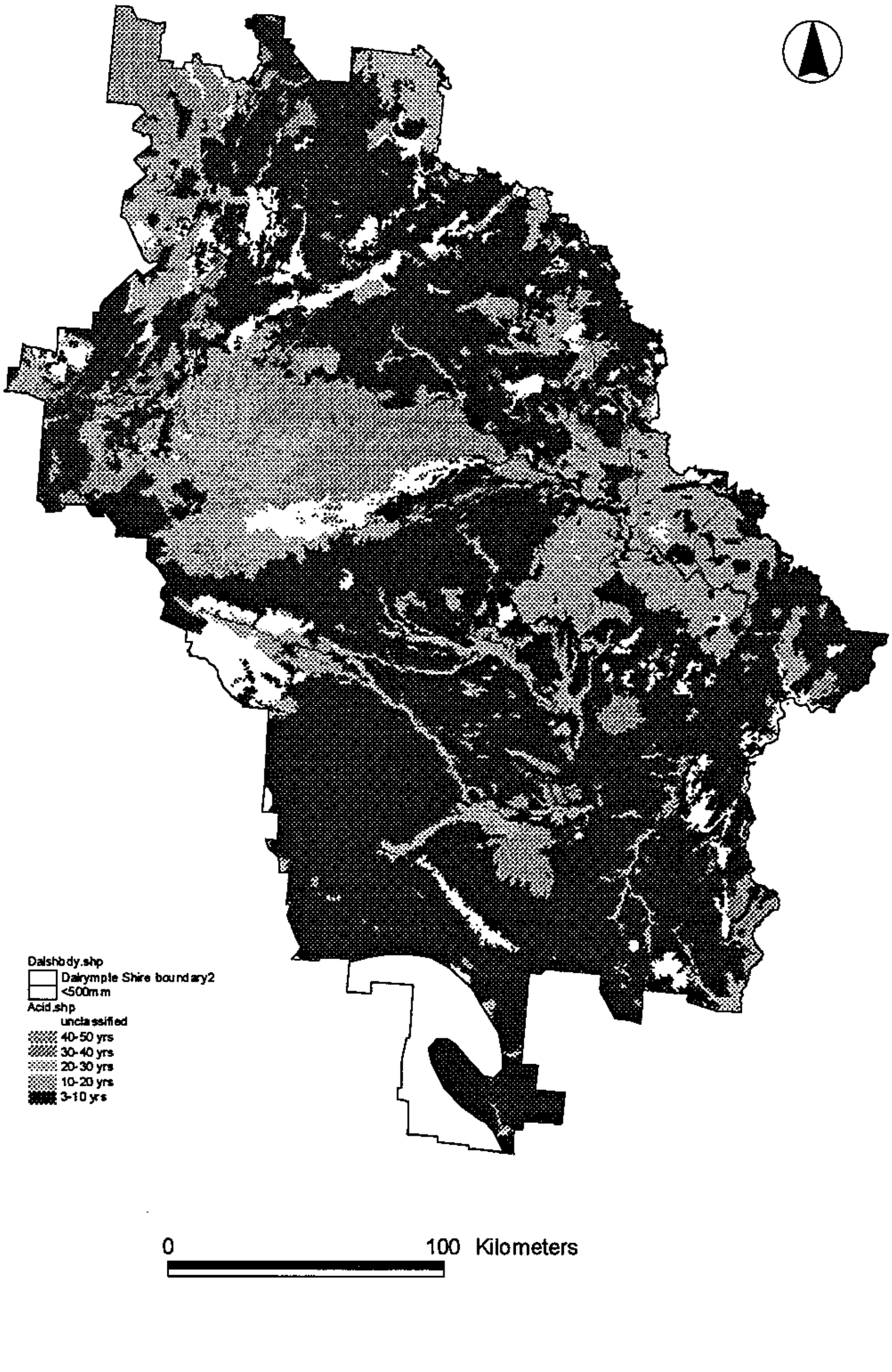



Figure 3. Acidification risk map for the Dalrymple Shire based on the time required for the soil pH to decline to 5.5.

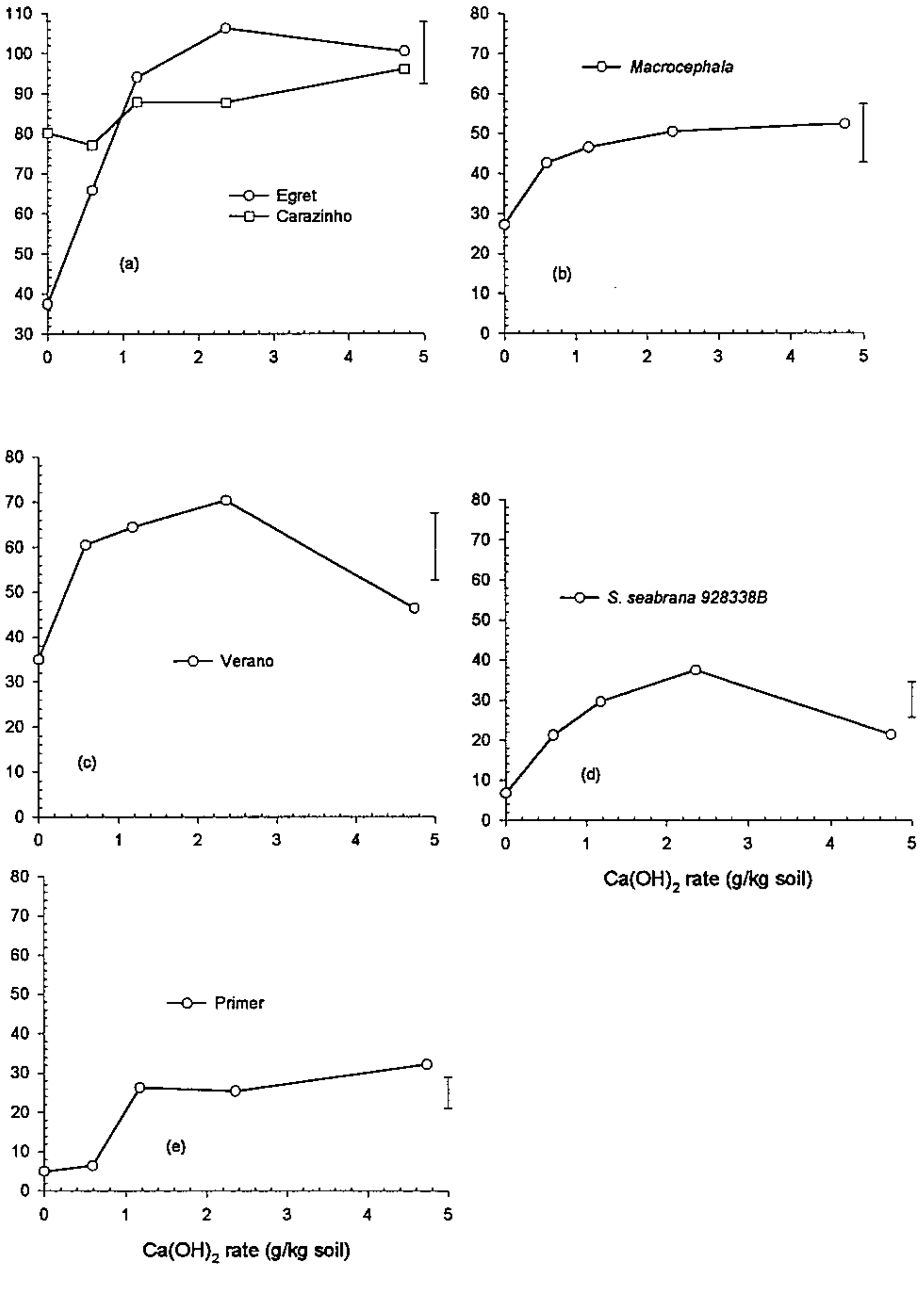



Figure 4. Root elongation in the presence of lime in (a) the wheat varieties Egret and Carazinho, and *Stylosanthes* varieties/species (b) *S. macrocephela*, (c) Verano, (d) *S. seabrana* 92838B and (e) Primer. Vertical bars represent the LSD between treatments at P<0.05.

# Attachment 1

## Draft of a field based test to estimate pH buffer capacity and acidity risk.

The test is designed for use by either graziers or extension personnel and focuses on the establishment of a risk index which is a measure of the number of years for the soil to reach a base pH of 5.0 in water. There are two stages in the process, namely collection of soil samples and preparation, measurement of pH, an estimation of the texture characteristics of the soil and finally, using pH and texture, an assessment of acidification risk.

*Collection and preparation of soil samples:*

1. Take a clean bucket into the paddock and collect surface soil samples (0-15 cm) using a soil auger or spade.
2. Collect samples randomly from a minimum of 5 locations in the paddock that exhibit uniform soil characteristics and place them in the bucket.
3. Spread the soil in a thin layer on a clean plastic sheet taking care to break up clods. Allow the soils to air dried, which may take several days.
4. Mix the soil thoroughly once it is dry making sure there are no clods.

*Measuring the soil pH:*

If you cannot borrow a pH meter you might consider purchasing one. There are a number of hand held pH meters that are on the market, which cost approximately $100. Check with the retailer before purchasing. It must be remembered that these are electronic pieces of equipment and must be handled, operated and stored with care. Note the pH meter requires calibration before use.

*Measuring pH*

1. For each of your surface soil samples weigh out 100g of soil into a clean 600 ml glass jar with lid.
2. Measure out 500 ml of <u>rainwater</u> or <u>distilled</u> water to give a 1:5 soil solution ratio. Place the lid on top of the jar and shake gently for 1 minute and then allow to stand for 2 hours.
3. After this time lapse, measure the pH of the soil suspension with a calibrated pH meter. Stir the suspension with the meter for a while and then wait 20-30 seconds for the meter reading to stabilise and record this value. Wash the glass bulb of the meter with rainwater or distilled water before and after each measurement.
4. Note this reading is referred to the pH in water. Sometimes pH is measured in a solution of calcium chloride. This lowers the reading by between 0.5 and 1.2 of a pH unit.

*Estimating field soil texture*

Soils mostly consist of particles of different size. The main classes being clay (<0.002 mm), silt (0.002 - 0.5 mm) and sand (0.5 - 2 mm). The word texture is used to indicate the relative amounts of these various sized units. An estimate of the field texture of a soil can be ascertained by the behaviour of a small handful of soil when moistened and kneaded into a ball and then pressed out between thumb and forefinger.

The following method can be used:

- Take a sample of soil sufficient to fit comfortably into the palm of the hand.
- Moisten the soil with water, a little at a time, and knead until the ball of soil, so formed, just fails to stick to the fingers.
- Add more soil or water to attain this condition. This approximates the field moisture capacity of the soil.
- Continue kneading and moistening until there is no apparent change in the soil ball. The soil ball, or *bolus*, is now ready for moulding.
- Field texture grades may be defined by the by the behaviour of the moist bolus as set out in Table 1.

| Field Texture Grade | Behaviour of moist bolus | Approximate clay content (%) |
|---|---|---|
| Sand | Little or no coherence; cannot be moulded; single grains adhere to fingers. | Less than 10 |
| Loamy sand | Slight coherence; a 'sausage' can just be formed when the bolus is rolled between hand palms | 10-15 |
| Sandy loam | Slight coherence; a 'sausage' will form which will bend slightly before cracking | 15-20 |
| Sandy clay loam | Soil contains sufficient clay to be distinctly sticky when moist; the 'sausage' will bend readily before cracking; sand fraction is still obvious. | 20-30 |
| Sandy clay | The soil contains enough clay to allow the 'sausage' to be nearly bent in a circle. | 30-55 |
| Clay | The 'sausage' can be bent into a full circle. | Greater than 55 |

Using the soil pH that has been measured and the approximate field texture, an estimate of the number of years that it would take for the soil to drop to pH 5.0 in water is given in Table 2. Note it is assumed in the calculation of this time period that the annual input of acid is 2.5 kmol $H^{+}$/ha/yr (mean acid input of *Stylosanthes* dominant pastures), the soil bulk density is 1500 kg/$m^3$ and the soil depth is 15 cm.

Table 2. Estimates of the number of years for the soil to fall to a pH of 5.00.

| Soil $pH_w$ | Field texture class | | | | | |
|---|---|---|---|---|---|---|
| | Sand | Loamy sand | Sandy loam | Sandy clay loam | Sandy clay | Clay |
| 5.5 | 3.7 | 4.6 | 5.4 | 7.6 | 13.7 | 15.2 |
| 5.6 | 4.5 | 5.5 | 6.5 | 9.1 | 16.5 | 18.3 |
| 5.7 | 5.3 | 6.5 | 7.6 | 10.7 | 19.2 | 21.3 |
| 5.8 | 6.0 | 7.4 | 8.6 | 12.2 | 21.9 | 24.4 |
| 5.9 | 6.7 | 8.3 | 9.7 | 13.7 | 24.7 | 27.4 |
| 6.0 | 7.5 | 9.2 | 10.8 | 15.2 | 27.5 | 30.5 |
| 6.1 | 8.2 | 10.1 | 11.9 | 16.7 | 30.2 | 33.5 |
| 6.2 | 8.9 | 11.1 | 13.0 | 18.2 | 32.9 | 36.6 |
| 6.3 | 9.7 | 11.9 | 14.1 | 19.8 | 35.7 | 39.6 |
| 6.4 | 10.5 | 12.9 | 15.1 | 21.3 | 38.5 | 42.6 |
| 6.5 | 11.2 | 13.8 | 16.3 | 22.8 | 41.2 | 45.7 |
| 6.6 | 11.9 | 14.7 | 17.3 | 24.4 | 43.9 | 48.8 |
| 6.7 | 12.7 | 15.7 | 18.4 | 25.9 | 46.7 | 51.8 |
| 6.8 | 13.5 | 16.6 | 19.5 | 27.4 | 49.5 | 54.9 |
| 6.9 | 14.2 | 17.5 | 20.6 | 28.9 | 52.2 | 57.9 |
| 7.0 | 14.9 | 18.4 | 21.7 | 30.5 | 55.0 | 60.9 |
| 7.1 | 15.7 | 19.3 | 22.8 | 32.0 | 57.7 | 64.0 |
| 7.2 | 16.4 | 20.3 | 23.9 | 33.5 | 60.5 | 67.1 |
| 7.3 | 17.2 | 21.1 | 24.9 | 35.0 | 63.2 | 70.1 |
| 7.4 | 17.9 | 22.1 | 26.0 | 36.6 | 66.0 | 73.2 |
| 7.5 | 18.7 | 23.0 | 27.1 | 38.1 | 68.7 | 76.2 |

*Rationale behind the development of a field based test to assess risk of accelerated acidification on a paddock scale.*

The previously discussed draft field based method for assessing risk (ie. number of years for the pH to fall to 5.0) is based on the determination of the field texture to which a pH buffer capacity is assigned. The assigned pH buffering capacity associated with each of the field texture classes was established using the Dalrymple Shire Land Resource data set. For each of the surface soils within a field texture class (based on laboratory determination of particle size distribution) the pH buffering capacity was calculated using the following equation:

$$pHBC = 6.28 - 0.11\ clay\% + 3.71\ OC\% - 0.16\ silt\% + 0.03 silt\% * clay\% \quad (1)$$

where pHBC has the units mmol $H^+$/kg.pH unit and OC is the organic carbon content of the soil. The pH buffering capacity for each of the texture classes was then subjected to statistical analysis, the results of which are presented in Table 3.

Table 3. Basic statistical analysis of pH buffer capacity for each of the field based texture classes for surface soil samples from the Dalrymple Shire Land Resource data base.

| Parameter | | | Texture class | | | |
|---|---|---|---|---|---|---|
| | Sand | Loamy sand | Sandy loam | Sandy clay loam | Sandy clay | Clay |
| | pH buffer capacity | | | | | |
| Mean | 8.31 | 10.25 | 12.06 | 16.93 | 30.55 | 33.88 |
| Standard error | 0.17 | 0.38 | 0.62 | 1.57 | 1.79 | 2.97 |
| Median | 8.11 | 9.75 | 11.25 | 15.33 | 29.59 | 31.48 |
| Standard deviation | 1.37 | 2.26 | 3.13 | 7.03 | 9.85 | 8.90 |
| Minium | 6.37 | 7.39 | 8.08 | 7.94 | 9.65 | 25.44 |
| Maximum | 13.61 | 16.61 | 20.03 | 39.31 | 49.38 | 53.95 |
| Number of samples | 60 | 35 | 25 | 20 | 30 | 9 |

It will be noted from Table 3 that range of pH buffering capacities values becomes larger as the clay content increases. This is due in part to greater range in clay contents assigned to each class as one moves from a sand clay loam to a clay (Table 1).

Using the mean values for pH buffering capacity for each of the field texture classes the amount of time taken for the pH to fall to 5.0 is calculated using the following equation:

$$T = [(pH_i - 5.0) \times pHBC \times BD \times V]/NAAR \quad (2)$$

where T is time in years; $pH_i$ is the measured soil pH; pHBC is mean pH buffering capacity of the field texture class (kmol $H^+$/kg. PH unit); BD is soil bulk density (1500 kg/$m^3$); V is volume of soil in depth of 0.15 m; and NAAR is nett acid addition rate (kmol $H^+$/ha. year) which is assumed to be 2.5 kmol $H^+$/ha. year.

# Field based assessment of soil acidification under *Stylosanthes* based production systems in Northeast Thailand
## (ACIAR Project No. LWR1/96/196)
by

A.D. Noble, S. Ruaysoongnern and B. Palmer

## Progress Report
## June 1998

### Background
A major constraint to animal production in northern Australia and Northeast Thailand is an inadequate supply of high quality feed throughout the year. Low quality pastures during the cool/dry season severely restrict animal performance. In order to rectify this shortcoming the inclusion of the shrub legume (*Stylosanthes scabra*; *S. hamata*) has been shown to be an ideal low cost method of improving the quality and dietary value of these pastures (Miller *et al.*, 1988, 1991). In this respect the introduction of these shrub legumes has had a significant impact on the profitability of the beef industry in north Australia. However, increasing use of *Stylosanthes spp.* in northern Australia (c. 1.2 million ha) and Northeast Thailand (c. 10 000 ha) with accompanying management practices, such as fertilisers and supplements, improved cattle breeds and increased stocking rates has not been without associated problems with respect to land degradation (McIvor *et al.*, 1996).

Surveys of long-term grazing trials with *Stylosanthes* in northern Australia have shown that significant acidification has occurred under *Stylosanthes* dominant pastures when compare to native grass systems (Noble *et al.*, 1997). In an extension of this work, a survey of several long-term *Stylosanthes* seed production systems was undertaken in Northeast Thailand to ascertain whether the same trends observed in northern Australia were occurring elsewhere where *Stylosanthes* has been introduced.

### Methods and materials
A preliminary evaluation of acidification under *Stylosanthes* based pasture systems was undertaken by Dr Sawaeng Ruaysoongnern in order to ascertain whether accelerated acidification had occurred under *Stylosanthes* production systems and to identify sites for more intensive sampling. In the preliminary assessment, paired sites were selected and a single set of samples were collected to 100 cm at 10 cm intervals. Electrical conductivity, and pH in a 1:5 soil solution ratio was measured in both water and 0.01 *M* $CaCl_2$. From this initial broad based approach, five potential sites were selected to go forward into a more intensive sampling exercise undertaken in March 1998 (Table 1).

Table 1. Soil $pH_s$ values measured on selected sites in a preliminary investigation into soil acidification under *Stylosanthes* based pasture systems in Northeast Thailand.

| Depth (cm) | Nampong T3/1 | | Nampong T3/2 | | Satuk T2 | | Satuk T6 | | Korat T7 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Control | Stylo | Control | Stylo | Control | Stylo | Control | Stylo | Control | Stylo |
| 0 - 10 | 5.57 | 4.03 | 4.03 | 4.15 | 4.54 | 3.74 | 3.70 | 3.74 | 3.80 | 3.93 |
| 10 - 20 | 5.22 | 3.81 | 3.85 | 3.93 | 4.01 | 3.58 | 4.64 | 3.48 | 3.90 | 3.84 |
| 20 - 30 | 4.45 | 3.84 | 3.85 | 3.99 | 3.70 | 3.54 | 4.61 | 3.46 | 4.27 | 3.84 |
| 30 - 40 | 4.24 | 3.77 | 3.91 | 4.03 | 3.72 | 3.45 | 4.19 | 3.49 | 4.07 | 3.87 |
| 40 - 50 | 4.19 | 3.71 | 3.88 | 4.04 | 3.53 | 3.44 | 5.57 | 3.57 | 3.85 | 3.80 |
| 50 - 60 | 3.98 | 3.73 | 3.89 | 3.76 | 3.55 | 3.54 | 5.06 | 3.59 | 3.76 | 3.75 |
| 60 - 70 | 3.93 | 3.78 | 4.04 | 3.76 | 3.56 | 3.52 | 5.54 | 3.56 | 3.94 | 3.72 |
| 70 - 80 | 3.80 | 3.85 | 3.92 | 3.72 | 3.68 | 3.54 | 5.11 | 3.79 | 4.42 | 3.78 |
| 80 - 90 | 3.73 | 3.88 | 4.03 | 3.71 | 3.68 | 3.56 | 4.33 | 3.76 | 5.70 | 3.82 |
| 90 - 100 | 3.73 | 3.86 | 3.93 | 3.73 | 3.68 | 3.57 | 3.74 | 3.72 | 6.19 | 3.89 |
| **Mean** | **4.28** | **3.85** | **3.93** | **3.88** | **3.76** | **3.54** | **4.65** | **3.61** | **4.39** | **3.82** |

The 5 sites selected to go forward to a more intensive assessment were all seed production systems situated in Northeast Thailand (Table 2). This type of production system represent the most extreme case of *Stylosanthes* dominance and therefore the most susceptible to accelerated acidification. In order to assess changes in soil pH, a paired area approach was used to estimate the effect of *Stylosanthes* pasture on rates of soil acidification. The selection of sites was based on the following criteria: (1) the existence of a grass/crop dominated production system in close proximity to a *Stylosanthes* the seed production area of known history; (2) a well defined boundary (ie road or bund) separating the two production areas; (3) the same soil type in both areas; and (4) little topographical difference (ie slope) between the two areas. Samples were taken at five points in each area along a transect at right angles to the boundary separating the two areas. Sampling points were 2.5 m apart and at each point an auger hole was dug with samples being taken at 10 cm depth intervals to a depth 100 cm.

Table 2. Selected soil properties and details of sites used in comprehensive sampling undertaken in March 1998.

| Site No | Location | Local soil series | USDA classification | Age of plots | Acidification zone (cm) | Net acidification rate (kmol $H^+$/ha.year) |
|---|---|---|---|---|---|---|
| 1 | Nontun 48Q 0256913 UTM 1807082 | | | (10) | 20 | 1.90 |
| 2. | Chodyai 48Q 025 3597 UTM 180 2824 | | | 9 | 100 | 4.03 |
| 3. | M3 48Q03240 95 UTM 1785137 | | | 10 | 80 | 1.15 |
| 4. | Khon Kaen University | | | | | |
| 5. | Sakon | | | | | |

Samples were air dried and sieved to pass a 2 mm mesh before pH was measured in both water ($pH_w$) and 0.01 *M* $CaCl_2$ ($pH_s$) using 1:5 soil:solution. The $pH_s$ measurements are presented in preference $pH_w$ because dilute salt solution assists in reducing seasonal effects due to variations in soil solution salt concentrations.

An estimation of the pH buffering capacity ($pH_{BC}$), for 3 of the sites was made on composite samples from each depth interval for both the *Stylosanthes* and control areas. The methodology used differed from that previously used by Noble *et al.* (1997) since this method required an incubation period of 7 days. In this study buffering curves for each of the depth intervals and sites were produced using the methodology of Bruce *et al.* (1985) which is very similar to that of Aitken and Moody (1994) used previously. In this case the incubation period was only 22 hr. A modification to the Bruce *et al.*, (1985) was introduced in that 0.25 mL chloroform was added to the solutions to prevent microbial activity since in an earlier study in evaluating the method it was found that the final pH after 22 hr was significantly lower where chloroform was omitted (data not presented). The entire data set used to construct buffer curves for the samples from Thailand were analysed at the Townsville laboratory.

*Estimation of net acid addition rate*

The net acid addition rate (NAAR, kmol $H^+$/ha.yr) to the *Stylosanthes* based pasture area was calculated relative to the adjacent control area at each site for each depth interval using the following equation:

$$NAAR = [(pH_C - pH_S) \times pH_{BC} \times BD \times V]/T \quad (1)$$

where the subscript C and S refer to the control and *Stylosanthes* areas respectively; $pH_{BC}$ is the mean pH buffering capacity (kmol $H^{+}$/kg soil. pH unit) of the control and *Stylosanthes* areas; BD is soil bulk density (kg/$m^{3}$); V is the soil volume in the depth interval under consideration ($m^{3}$/ha); and T is time (years) since the establishment of the *Stylosanthes* pasture. The net acid addition due to the introduction of *Stylosanthes* was estimated from the sum of all depth intervals where there was a difference in $pH_s$ between the two sites.

*Statistical analysis*

In order to avoid auto-correlation with depth in the profile, statistical analysis was carried out for each site x depth combination, thereby testing for any effect due to the contrast between the *Stylosanthes* and control areas for that particular depth interval. The statistical package Genstat5 was used in all analyses.

## Results

The $pH_s$ results from the preliminary assessment of sites are presented in Table 1. Whilst a rigorous statistical assessment of changes in pH due to acid addition is not possible due to the lack of replication, the data clearly shows that the mean profile $pH_s$ under the *Stylosanthes* based production systems was lower than that of the control. A distinct characteristic of sites sampled in this preliminary survey was the very low pH values recorded throughout the entire sampling depth.

The location, soil classification, annual rainfall and site history for the 5 sites included in the comprehensive assessment are presented in Table 2. The soils were of a sandy to sandy loam texture and were dominated by fine sands and silt with only a slight increase in clay content with depth. These soils are massive when dry with extremely high bulk densities. The pH values under the *Stylosanthes* dominant production systems were significantly ($P<0.05$) more acid than under the adjacent control area in all 5 sites presented in Figure 1. The extent of acidification ranged from significant measurable changes in pH that were confined to the top 20 cm (site 3) to what may be termed severe subsurface acidification extending to over 90 cm (Figure 1). It is of note that the $pH_s$ were extreme and would indicate severe acidification. Under these conditions one would expect the exchange complex to be dominated by $Al^{3+}$ with very low levels of base saturation.

The pH buffering capacities for selected sites (sites 1, 2 and 3) were extremely low throughout the entire soil profile (Table 3). This is in part due to the low clay content and organic carbon. An estimation of the NAAR was undertaken assuming an average bulk density of the soil of 1.5 g/$cm^{3}$ and the length of time under *Stylosanthes* as outlined in Table 2. The acidification rates ranged from 1.15 (site 3) to 4.03 (site 2) kmol $H^{+}$/ha.year (Table 2).

Table 3. Soil pH buffer capacities as determined on bulked samples from the control treatments.

| Depth (cm) | Site<br>1 | 2<br>(mmol $H^{+}$/kg.pH unit) | |
|---|---|---|---|
| 0-10 | 4.88 | 5.44 | 5.26 |
| 10-20 | 6.15 | 4.43 | 6.12 |
| 20-30 | 3.00 | 5.08 | 5.90 |
| 30-40 | 2.91 | 6.28 | 6.24 |
| 40-50 | 2.91 | 8.63 | 6.09 |
| 50-60 | 2.73 | 21.00 | 8.42 |
| 60-70 | 2.84 | 12.94 | 6.63 |
| 70-80 | 3.85 | 13.74 | 6.23 |
| 80-90 | 4.33 | 12.80 | 7.47 |
| 90-100 | 4.55 | 11.79 | 7.05 |

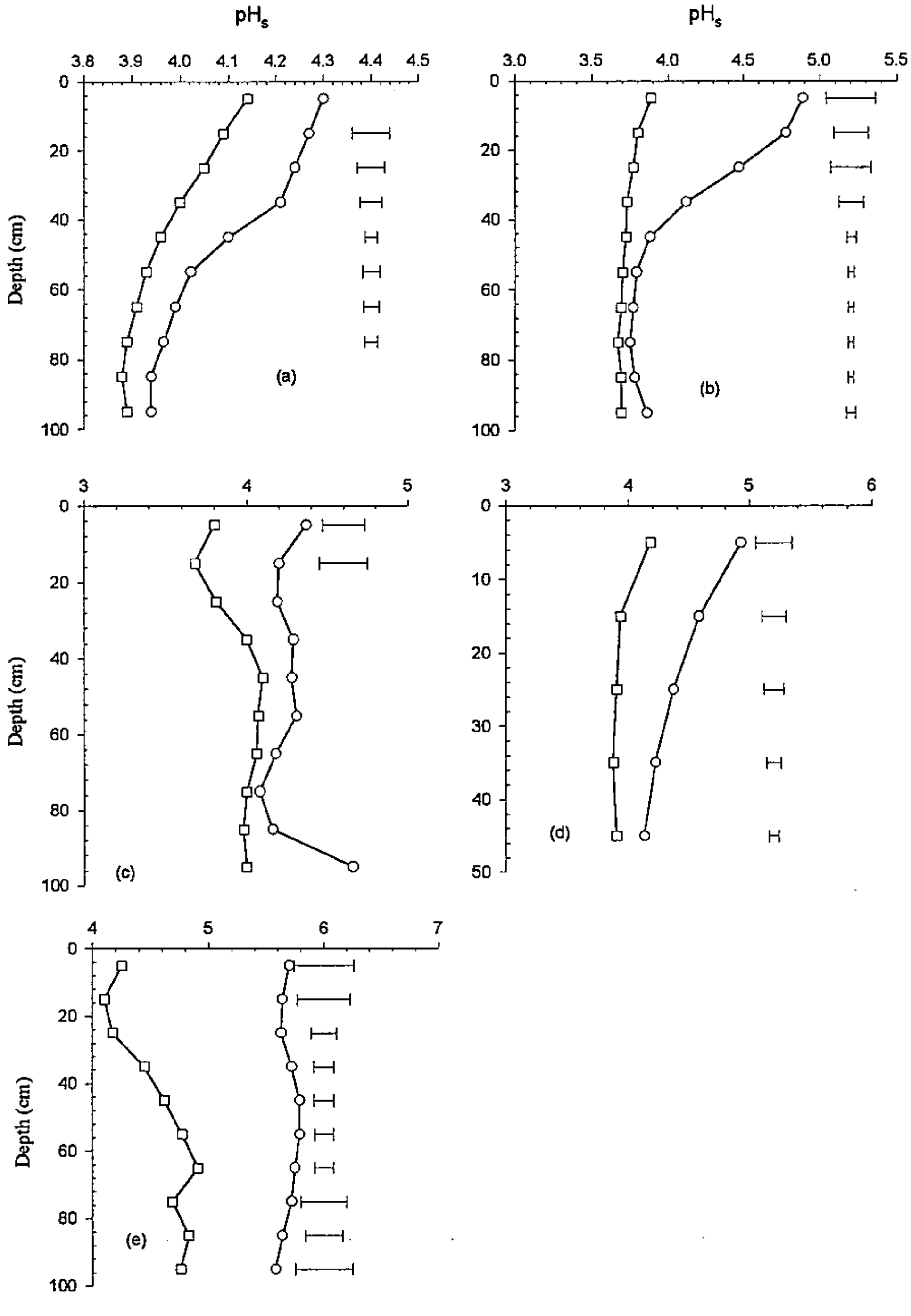



Figure 1. Soil pH$_s$ (0.01 *M* $CaCl_2$) profiles for sites sampled during survey of Northeast Thailand *Stylosanthes* production systems. (a) M3, (b) Chodyai, (c) Notun and (d) Khon Kaen University, (e) Sakon. *Styolsanthes* ( ) production systems and a reference site (O). Horizontal bars represent the LSD ($p<0.05$) for that specific depth interval.

## Discussion

*Acidification rate*

The results from this study clearly demonstrate that with the introduction of a *Stylosanthes* production system there has been significant measurable declines in soil pH over a relatively short period of time and confirms previously reported observation for extensive legume based pasture systems in northern Australia (Noble *et al.*, 1997). Whilst soil acidification rates can be estimated as absolute changes or relative to some control soil, the former is often used due to the lack of comprehensive data sets. Using the first method, acid addition rates are calculated from analyses of soils before and after a period of acidification. This requires comparable measurements usually separated by many years. However, relative rates of acidification can be derived from survey data (e.g. fence-line contrasts of developed and undeveloped sites) such as in this study and are more often reported, because of the paucity of suitable data from long-term studies. Because it is likely that acidification occurs in the controls but at a slower rate than on the *Stylosanthes* sites, it can be argued that the rates of acidification presented in Table 2 are conservative. Previous studies by Noble *et al.*, (1997) have shown this to be the case for northern Australian sites surveyed. In addition, the values for pH buffering capacity could be questioned since the methods available do not properly estimate the slow reactions due to the dissolution of aluminium and silica (Ridley *et al.*, 1990a). In previous studies this aspect has not been taken into consideration (Ridley *et al.*, 1990a; Dolling and Porter, 1994; Dolling, 1995). If these slow reactions are indeed significant, actual pH buffering capacity values would be higher than shown in Table 3 and consequently the calculated rates of acidification conservative. In deed, the dissolution of solid phase Al and Fe have been reported on these soils (Brinkman and Dieleman, 1977), thereby acting as a potential sink for protons.

When estimating the pH buffering capacity of a soil it is assumed that there is a linear relationship between pH and acid added. This relationship is only true in the pH range 4.5 to 6.0 and where the neutralisation of exchangeable Al is of minor importance. However, under the prevailing circumstance this may not be the case. A plot of acid/base addition versus pH is given in Figure 2 for selected depth intervals for the Chodyai site (site 2). It is evident from the shape of the curves that as the pH drops below 4 linearity decreases. This would result in an under estimation of the acid addition if a linear relationship was assumed. In the current study we have assumed linearity and consequently the estimation of net acid addition should be treated with caution.

Previous studies of acidification under legume based pastures in temperate Australia have found that the $pH_{BC}$ is raised following the introduction of a legume component in the sward (Ridley *et al.*, 1990a; Dolling and Porter, 1994). However, this has been shown to be not the case in *Stylosanthes* based pasture systems of northern Australia where there has been no significant changes in soil organic carbon after the introduction of *Stylosanthes* (Noble *et al.*, 1997). This is probably a direct result of temperature and rainfall which are conducive to increased mineralisation. In Northeast Thailand where periodic cultivation is undertaken and where the entire crop is removed, the probability of organic carbon increasing under *Stylosanthes* is extremely low.

Net acidification rates under *Stylosanthes* based pasture production systems in Northeast Thailand are similar to those reported for the semi-arid tropics of northern Australia by Noble *et al.* (1997) and by Moody and Aitken (1997) for pastures in the humid tropics. Noble *et al.* (1997) reported rates of 0.2 to 10.6 kmol $H^+$/ha.year for northern Australian production systems, with the extreme rate being measured on an irrigated commercial seed production system. Moody and Aitken (1997) reported rates of between 1.0 to 11.0 kmol $H^+$/ha. year for production systems ranging from grazed grass/legume pastures through to fertilised hay production systems. Similarly, Ridley *et al.* (1990) working in temperate Australia reported acidification rates of 2 kmol $H^+$/ha. year under grazed annual grass/legume pastures and 1.36 kmol $H^+$/ha. year under comparable pastures based on the perennial grass phalaris instead of annuals. In the current study the acidification rates are comparable to those reported by Noble *et al.* (1997).

Control soil Cy site

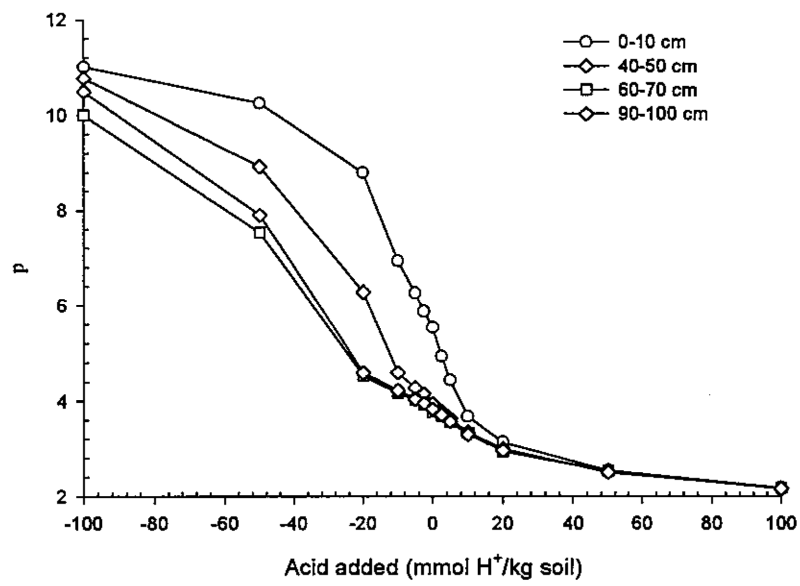



Figure 2. pH buffer curves for the Chodyai site (site 7) for selected depth intervals.

*Acidification processes and agricultural systems*

The rate of acidification following the introduction of *Stylosanthes* can be assumed to be a function of (i) soil (ii) climate and (iii) the population density of *Stylosanthes*. The systems that were sampled in this study were predominantly seed production systems and would therefore represent an extreme situation with respect to plant population density. These production systems are characterised by the entire removal of the crop to some location in the field where threshing of the seed is undertaken and subsequent burning of the trash. The removal of all above ground biomass at harvest would represent a net export of alkalinity from the site. In this respect the ash alkalinity of a number *Stylosanthes* accessions have been determined (see section below) and found to range from 81.1 to 130.4 $cmol_c\ kg^{-1}$ which is equivalent to 40.6 to 65.2 kg $CaCO_3$ per tonne of *Stylosanthes* dry matter. This would represent a significant addition to the proton pool over time. In contrast to these monoculture systems Noble *et al.* (1997) have reported that on soil with a high inherent buffering capacity and an equitable distribution of legume and grass in the pasture, no significant acidification has occurred over a 20 year period.

In evaluating the various components that contribute to net acidification, it is difficult in the current study to directly apportion absolute values to the various components due to a lack of records or measurements. However, it is pertinent to discuss the potential contributors to this process. Net acidification due to product export, namely the harvesting of the crop for seed, may be largest contributor to acidification. Depending on the size of the crop harvested and the ash alkalinity of the material one would assume that the net contribution due to product removal could be substantial. Using the previously quoted ranges of ash alkalinity as measured on a set of samples from Lansdown, northern Australia, a mean value of 91.5 $cmol_c\ H^+/kg$ on dry matter basis could be expected for the varieties grown in Northeast Thailand. This would effective equates to 0.91 kmol $H^+$/ha.year per ton of material removed. With the entire removal of the crop, the opportunity for nitrogen mineralisation of plant material is minimised therefore the potential for nitrate leaching and its associated acidification is reduced. Whilst no attempt was made to evaluate the mineral nitrogen status of the soils sampled there is evidence from northern Australia where there has been significantly elevated nitrate levels in a profile dominated by *Stylosanthes* in comparison to an adjacent *Urochloa mosambicensis* (Sabi grass) dominated pasture (Noble *et al.*, 1997). In these northern Australian pasture systems there is evidence to suggest that nitrate leaching may be the dominant mechanism of acid input since the quantity of acid added in product export (beef cattle) is negligible. In these extensive beef systems it is speculated that with the onset of the first rains significant mineralisation of organic nitrogen could occur and in the absence of an actively growing pasture sward leaching of nitrate could follow. Similar effects could be expected under the monoculture production systems of Northeast Thailand.

*Minimising the risk of acidification*

The extent of acidification over a relative short period of time should be of concern on these light textured soils. These soil have an inherently low buffering capacity and are therefore predisposed to rapid acidification. From a practical perspective the remediation of acidity using conventional surface applications of lime over extensive areas of northern Australia and parts of Northeast Thailand may be both ineffectual, due to the extremely slow vertical movement of surface applied lime (Coventry, 1992), and uneconomic. In addition, the problem of over liming resulting in potential micronutrient deficiencies is a distinct possibility on these light textured soils. Consequently, management strategies to minimise the impact of these production systems need to formulated. Within the extensive grazing systems of northern Australia a series of strategies that focus on reducing *Stylosanthes* dominance in the sward and promoting a more balanced grass/legume population is being promoted. These strategies include:

1. In situations where legume dominance has occurred, the use of fire in the early spring followed by reduced grazing pressure will promote the growth of perennial grass species such as *Heteropogen contortus* in the pasture thereby reducing legume dominance. Since *Stylosanthes* is relatively intolerant of fire this strategy will result in re-establishment by seed of the grass species and allow a competitive advantage for the regeneration of the grass component.
2. Grazing management which favours seed production by perennial grasses during the summer through spelling and reduced grazing pressure. In addition, minimising the spread of legume seed by grazing animals.
3. The establishment of pasture species that are tolerant of grazing pressure would reduce the risk of legume dominance occurring in a sward. Species such as *Urochloa mosambicensis* and *Bothriochloa pertusa* have been identified as possible species that may fill this niche (McIvor *et al.*, 1996). In addition, these species which have a vigorous growth habit and therefore a high demand for nitrogen, have the ability to capture nitrate before it is leached. This would significantly reduce the risk of nitrate leaching and associated acidification.
4. In legume dominant swards the addition of phosphorus may assist in maintaining perennial grasses in the pasture. Conversely, the planting of *Stylosanthes* could be confined to soils that have a high inherent phosphorus status so that grasses can better compete with the legume.
5. Given that the management of oversown pastures can be extremely difficult it is suggested that planting small areas to legume and managing these areas intensively may reduce the risk of widespread accelerated acidification. Typically these areas would be confined to soils having a high pH buffering capacity or to areas with an inherently high P status.

Whilst these options may not be relevant under current production systems in Thailand, they do offer an insight into potential ways of managing the problem.

The positive impacts of legume introduction on the soil resource base may be evident in the increase in the inherent fertility of the soil through the fixation of nitrogen and its subsequent transfer to the soil (this may need to be substantiated). The results of this study clearly show that the impact of *Stylosanthes* introduction on accelerated soil acidification is more pronounced on soils having a low buffering capacity. If this acid is not neutralised, ultimately the pH falls to a level where the soil resource is degraded and becomes less productive. Key management strategies that promote the maintenance of an equitable grass/legume composition will slow down the rate of acidification by capturing greater amounts nitrogen. However, these changes which may have negative impacts on production in the long-term have to be viewed in the context of the short to medium term benefits of legume establishment in native pastures.

## Discussion/Comment

Issues concerning this paper were discussed with those from the previous project (NAP3.218) and are detailed on pages 63-75 of this report.

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# Management Of Native Pastures Oversown With Stylo

**MRC Project:** NAP3.221
**Project Duration:** 1/7/93-30/6/2001

**Principal Investigators:**

Mr. Deryk Cooksley
Department of Primary Industries
PO Box 1054 Mareeba Q 4880
Phone: 07 4092 8555 Fax: 07 4092 3593
E-mail: cooksld@dpi.qld.gov.au

Dr. Mick Quirk
Department of Primary Industries
PO Box 976 Charters Towers Q 4820
Phone:07 4787 2155 Fax:07 4787 4998
E-mail: quirkm@dpi.qld.gov.au

## Project Objectives:

Identify and communicate practical methods of maintaining a balance of grass and legume in oversown native pastures by:
(1) testing management options (fire, grazing) for maintaining native perennial grasses in pastures oversown with *Stylosanthes* species;
(2) developing methods for introducing and managing exotic grasses into stylo-dominant pastures;
(3) assessing the economic benefits of different management systems;
(4) communicating and promoting management practices that encourage stability and productivity of oversown pastures

## Summary:

To help identify effective management options for managing the grass-legume balance in stylo-based pastures, a field experiment was established near Dimbulah during 1993-94 using an existing stylo-dominant pasture (Seca and Verano). Combinations of various stocking rates, wet-season spelling, fire and seeding with exotic grasses, are being evaluated. In addition, commercial stylo-based pastures in the Einasleigh and Burdekin regions are being monitored to document the extent of stylo dominance and the success of introduced grasses.

The experimental site was heavily stylo-dominant (>90% of pasture as stylo) and was initially very resistant to change regardless of management. However, a combination of fire and spelling is now producing a significant recovery in native grasses, as a consequence of less competition from stylo plants and greater generation of new grass seedlings. Opportunities to effectively burn these pastures have been few, due to lack of fine fuel. However, even patchy fires have reduced the amount of Seca, in favour of grass.

Sowing exotic grasses into cultivated portions of each paddock was successful, after the second attempt, and these grasses (predominantly Sabi grass) now contribute up to 50% of pasture in the sown portions. Fire and light grazing pressure have favoured the sown grasses over stylo.

Commercial stands of stylo that were sown during the 1980's now contain up to 90% Seca, so will be resistant to attempts to increase the grass component. Stylo pastures sown during the 1990's were slow to establish, due to poor seasons, but now contain up to 30% legume. Where grass seed (usually sabi grass) has been included in the seed mix, it has usually taken 5 years or more to produce a significant sown grass component in the stand.

## Background

There is concern over the long-term stability of native pastures oversown with stylo, due mainly to observations of stylo dominating pastures to the exclusion of perennial native grasses. This in turn increases the risk of weed invasion, accelerated erosion, increased variability in animal production, and soil acidification.

Native perennial grasses are displaced by stylo because of (1) increased grazing pressure on grasses and (2) competition from stylo plants. Varying the overall grazing pressure and wet-season spelling are two options for favouring native grasses. Fire kills at least some stylo plants and intermittent burning therefore offers a potentially potent way of managing the balance of native grass and stylo. An alternative strategy is to sow seed of introduced grass species that may compete and persist better under current management.

A field experiment was set up to compare the relative effectiveness of combinations of these options for restoring and maintaining the grass component in an existing stylo-dominant pasture. We are also monitoring the composition and vigour of a wide sample of commercial stylo pastures to document the extent of stylo dominance and the success of introduced grasses.

## Methodology

The field experiment commenced in 1993 on Mr Neil Davis's property on Eureka Creek, west of Dimbulah. The 15-ha area is part of a paddock that was sown to Seca and Verano in 1982. By 1993, the pasture was dominated by the stylos with little grass cover remaining. Different combinations of grazing pressure, spelling during the early wet, fire, and sowing with introduced grass, have been implemented to form a suite of treatment plots with 2 reps of each (see Table 1).

**Table 1.** Grazing, fire, and sowing treatments at the experimental site.

| Treatment number | Grazing pressure (stocking rate) | Fire | Early wet spell[2] | Exotic grasses[1] |
|---|---|---|---|---|
| 1 | low (5.25 ha/hd) | yes | no | 10% of area |
| 2 | low | no | yes | 10% of area |
| 3 | medium (3.5 ha/hd) | no | no | 10% of area |
| 4 | medium | no | yes | 10% of area |
| 5 | medium | yes | no | 10% of area |
| 6 | medium | yes | yes | 10% of area |
| 7 | high (1.75 ha/hd) | no | yes | 10% of area |

[1] mix of Indian couch (*Bothriochloa pertusa*), buffel (*Cenchrus ciliaris*), and Sabi grass (*Urochloa mosambicensis*)
[2] spelling from the break in the wet until the black speargrass plants commence flowering

## Results

*Rainfall*

Wet season rainfall at the experimental site for 1997-98 was above average, for the first time since the trial began (Table 1).

**Table 2.** Seasonal rainfall by year at the experimental site

| | 1993/94 | 1994/95 | 1995/96 | 1996/97 | 1997/98 | Long-term average |
|---|---|---|---|---|---|---|
| Wet season | 330 | 551 | 552 | 529 | 781 | 723 |
| Dry season | 5 | 62 | 141 | 70 | | 73 |

*Maintaining perennial native grasses in stylo pastures*
(These results pertain to the area of each paddock not sown with grasses)
The experimental site had very little native perennial grass remaining when the experiment commenced, so our results relate more to the restoration of native grasses rather than to maintaining an already healthy contribution of grasses. Standing crop (SC, the amount of standing pasture) in all pastures contained about 90% stylo at the start of the experiment (1993-94 growing season), with Verano contributing most to SC (50-60%, see Fig. 1).

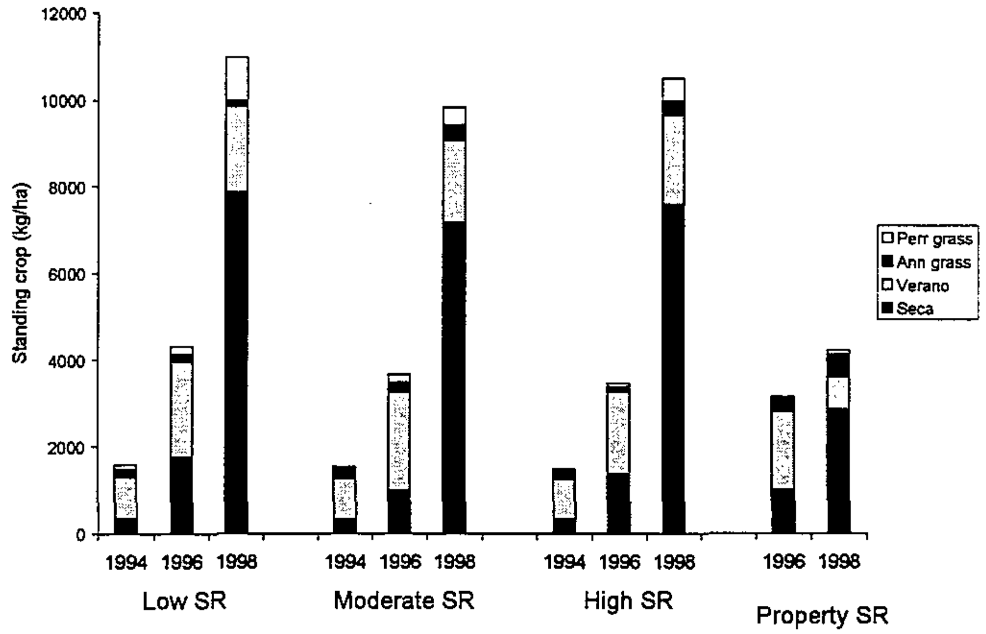


**Fig. 1.** Changes in standing crop and composition between 1994 and 1998 for pastures grazed at either low, moderate, high, or "property" stocking rates.

Stocking rate has had little effect on the grass-stylo balance in these pastures (Fig.1). Total standing crop has steadily increased at all stocking rates, with a small boost to native grasses under the lightest stocking pressure. Interestingly, even the highest stocking rate is clearly much lighter than the grazing pressure outside the trial area under normal commercial management (Fig. 1).

Fire and spelling have been the keys to initiating changes to the grass-stylo balance in this experiment. Only patchy, infrequent fires have been possible due to lack of fine fuel, but this has still been sufficient to increase the amount of perennial grass in the pasture to 18% of SC, compared to only 7% in the absence of fire (Fig. 2). While this is only a small absolute increase, the amount of grass has likely reached the critical mass required to accelerate the rate of recovery. Spelling has had little effect on the relative standing crop of grass and stylo. However, the data on frequency of perennial grasses (a measure of abundance and distribution through the paddock) more clearly shows the effect of fire and spelling on the population of grass plants. For example, frequency data for black speargrass (Heteropogon contortus) show a large benefit from a combination of fire and spelling (Fig. 3). Fire has also changed the structure of the pasture sward, with less "woody" stylo thickets and more patchiness in pasture composition.

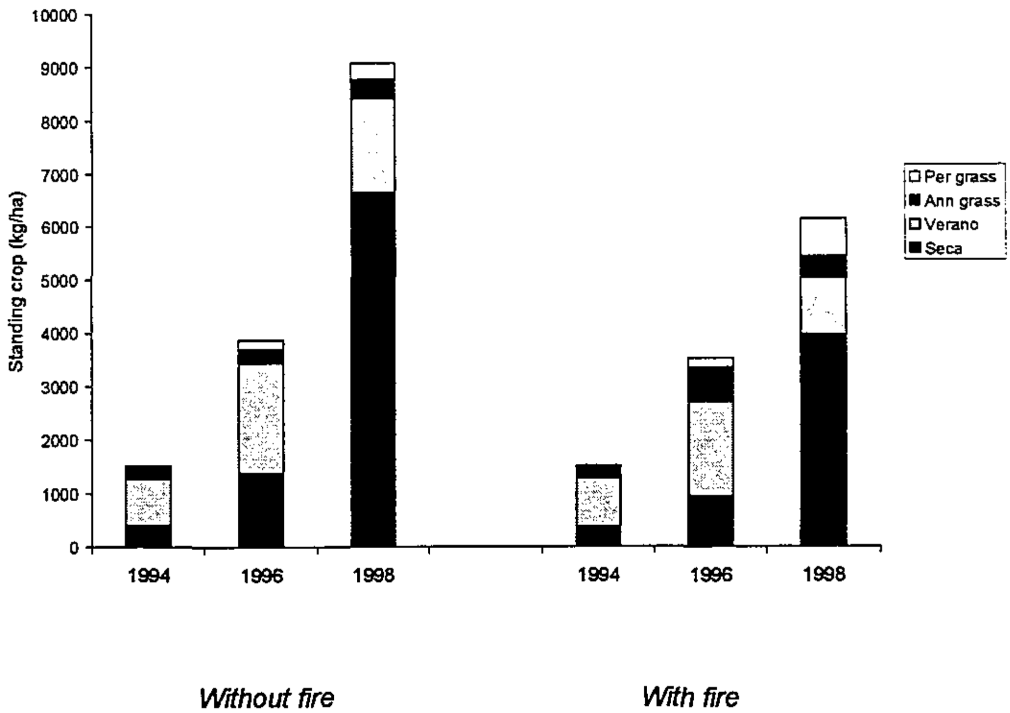


**Fig. 2.** Effect of fire on the standing crop and composition of pastures between 1994 and 1998

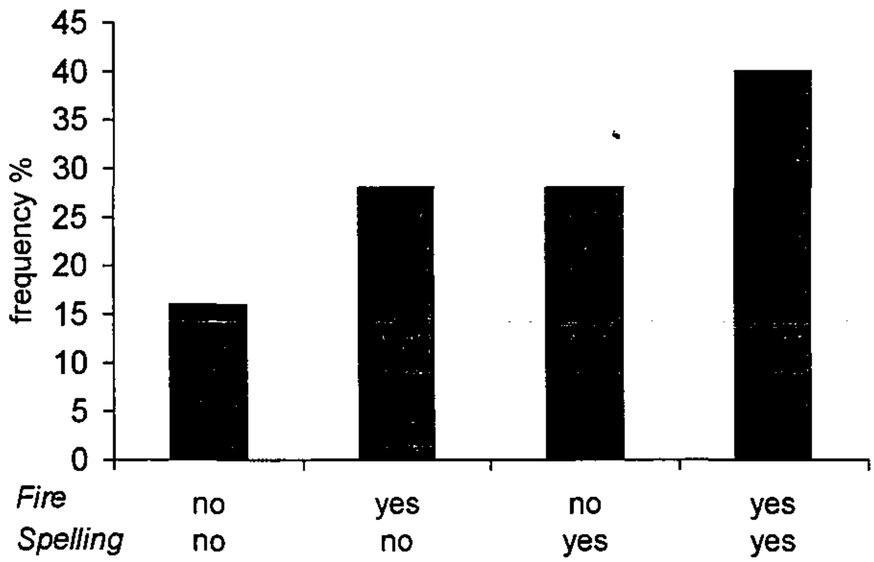


**Fig. 3.** Effect of fire and spelling on frequency of black speargrass in April 1998 (averaged over all stocking rates).

*Establishing sown grass into stylo-dominant pastures*
(These results pertain only to the sown portion of each paddock)
Establishment was satisfactory for all 3 grass species (after a second sowing), but Sabi quickly became the dominant sown grass, contributing up to 40% of SC by the end of the 94-95 season. As expected the pre-sowing cultivation reduced stylo yield and density dramatically but Verano recovered quickly such that it was the dominant pasture species (43-70% of SC) in the cultivated portion of paddocks by the end of the 1994-95 season (Fig. 4). Seca, by comparison, contributed less than 2-4% of SC at this time. Interestingly, Seca has regained its dominance in the sown area of each paddock, but the over-all balance of Seca, Verano and sown grasses varies depending on management.

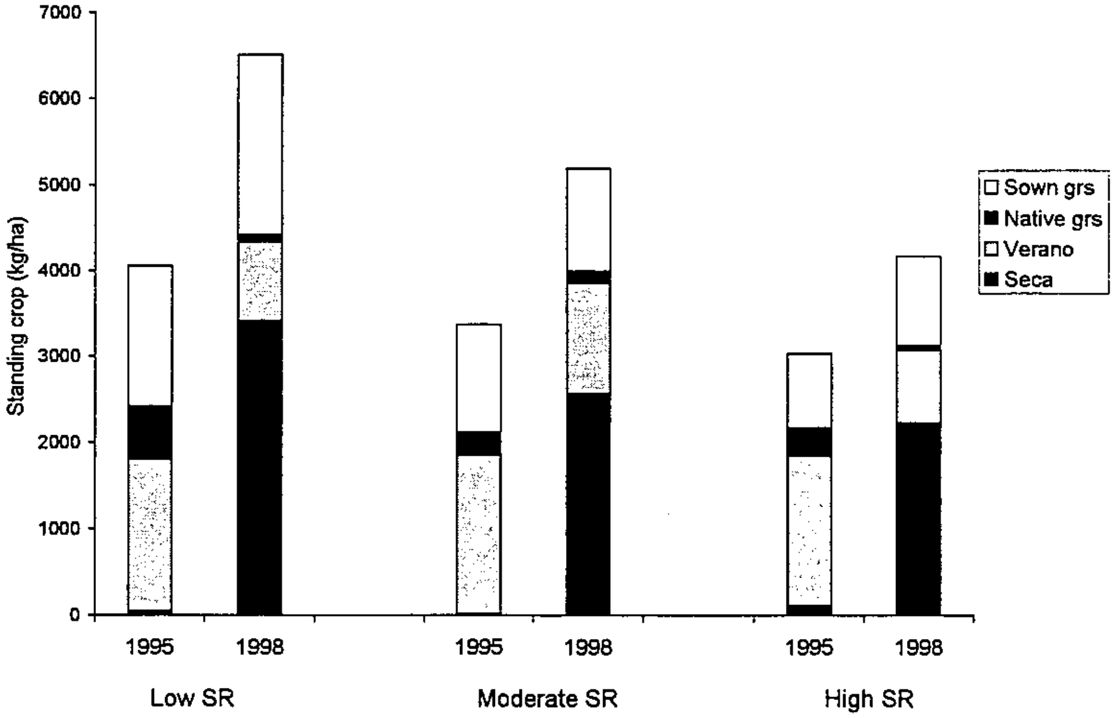


**Fig. 4.** The effect of stocking rate on the balance of grass and stylo in the sown portion of each paddock

Stocking rate affected total standing crop, but has had little effect on the balance of grass and stylo (Fig. 4). Light stocking has only given the sown grasses a slight advantage over stylo, compared to heavier stocking rates, and has not retarded the resurgence of Seca. All combinations of spelling and fire are being tested under the moderate stocking rate, so comparison of the current compositions of these paddocks (Fig. 5) shows the potential for fire and/or spelling to influence the balance of sown grass and stylo. In the absence of either fire or spelling, stylo dominates the sown areas (>70% of SC). In contrast, a combination of fire and spelling has produced a 50:50 balance of grass and stylo (Fig. 5).

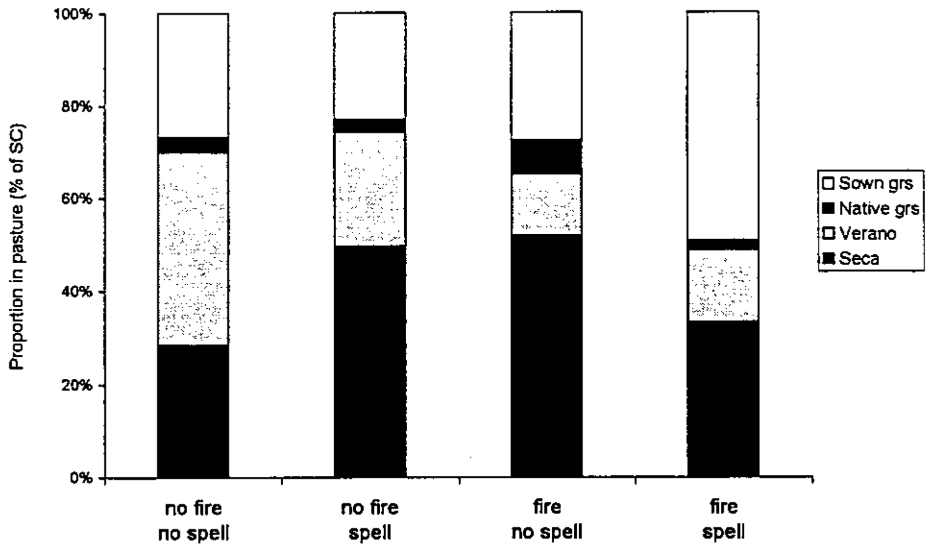


Fig. 5. The effect of fire and/or spelling on the current balance (% of SC) of grass and stylo in the sown portions of paddocks grazed at a moderate stocking rate.

*Grass-stylo balance in commercial stands*

The balance of grass and stylo in 18 commercial pastures, located in the Mareeba, Georgetown, and Charters Towers areas, was measured in 1995 and again this year. There is a mix of recently-sown and older sites, and most sowings had included some grass seed. In 1995, the younger pastures (sown 1991-93) had little legume and were generally dominated by native pasture. This year, most of these pastures have 10% to 30% legume but the content of sown grass varies from 5% to 85%. Older pastures (sown 1983-89) were stylo dominant (50 to 70% of SC) in 1995. Stylo has continued to build up at these sites, with standing crop at some sites of 6000-9000 kg/ha, 80 to 90% of this being stylo.

## Conclusions:

- Once pasture becomes heavily stylo dominant, it is resistant to simple management options such as spelling and fire. Such options should be applied before stylo exceeds 60% or so of the pasture.
- Simply adjusting stocking rate is not likely to greatly influence the grass-stylo balance. Fire, combined with wet-season spelling, is required to give a competitive edge to grasses.
- Exotic grasses such as Sabi grass may be more competitive with stylo than native grasses, but reliable establishment is problematic.
- Existing commercial stylo pastures should plan to use fire and spelling to manage a healthy mix of stylo and grass. New sowings should include seed of colonising grass species.

## Communication Activities

- Twelve producers attended a field day on productivity and management of stylo at "Thalanga", west of Charters Towers, on 20th November 1997.
- The importance of maintaining a healthy mix of grass and stylo was one of the issues covered in several pasture management workshops held in the Charters Towers district.
- A short article reporting the major findings of the project is being prepared for distribution to regional newspapers and newsletters

### Planned activities

- Complete and circulate the media article, and prepare a technical note for inclusion in NAP News and the newsletters of the Tropical Grasslands and Aust. Rangelands Societies.
- Hold a field day at the experimental site in April 1999.
- Prepare a paper on stylo-grass management for the International Rangelands Congress in Townsville, July 1999.
- Lobby for, and assist with, the integration of project findings into all pasture extension material and modules (eg FutureProfit).

## Discussion/Comments

1. *Do wet sites or dry sites favour stylo over grass ?*
   This has not yet been resolved in the experiment. Probably because we have so far had a series of dry years.

2. *Fire and spelling result in increased frequency of perennial grasses. When is the time of spelling relative to fire?*
   Note that, in the field experiment, the spelling period occurs after fire, but the spelling also increases the fuel load for following season.

3. *What/how is pasture yield measured?*
   Using the BOTANAL methodolgy, pasture yield and composition are measured at end of growing season, so it is actually presentation or residual yield not total growth that is measured. There was then a lot of discussion on the usefulness of these measurements and the need to get a measurement of actual total growth.

4. *Is there selective use of grass early in season; if so, could be underestimating actual grass contribution?*
   There is a lot of evidence that grasses are favoured in early wet, which would mean that grass yields are underestimated, but the frequency measurements should not be as sensitive to selective grazing. It would be fairly simple to check the degree of selective grazing with the delta carbon technique eg. C4 grasses versus C3 legumes

5. Rodney Barrett mentioned a spelling system that utilises stylo-dominant paddocks after grass-dominant paddocks, thereby conserving fuel, and using grass when it is of higher quality.

6. *Is there any animal production data from the trial? What are implications of lower versus higher contents of stylo for short-term animal gain?*
   There is no animal production data from this trial. There is not much evidence around to relate stylo content to animal production, but animal production probably peaks out after 50% stylo content. Also, in large paddocks there is variable stylo growth and selective grazing, which will cause variation in stylo contribution across the landscape

7. *Where is there evidence for 50% stylo for maximum animal weight gain?*
   There is some limited evidence in the literature, but it is mainly anecdotal.

8. Woodhouse Station experience is that the potential advantage of stylo dominance to animal production varies with the type of year. In drier years, probably an advantage to having very high contents of stylo.

9. Woodhouse Station wants more grass and less "big bushes" of stylo, to avoid plants dying out, and also want more grass for burning of rubber vine. They use short-term heavy stocking to knock Seca down, followed by spelling.

10. The assessment of commercial sowings of introduced grasses on beef properties was not covered in the presentation. It is too early to get meaningful results. However, the monitoring of commercial sowings on up to 20 properties is an important aspect of this work and should continue for many years following the completion of the NAP project.

**11. Comments by Joe Miller**

**Achievements:**

i. Burning and spelling promote increase in perennial grasses, both native and exotic. Mild fires and summer spelling each have similar effect alone and their effect in combination is additive. The three stocking rates used had no effect but all rates were fairly lenient and differential effects might be expected if there had been a greater range in stocking rates.

ii. Nothing new has been attempted with respect to establishing exotic grass. Cultivation was reasonably effective, as expected. Spread of exotic grass from the sown blocks was not reported, so the differential effect of burning or grazing management is unknown. With respect to maintaining exotic grass, comments under 1 apply.

iii. Economic benefits cannot be estimated from this work, since animal production was not measured.
iv. Communication and promotion has been minimal, there being few results worth comment before 1998.

**Recommendations:**

i. Measure frequencies after 1998-99 wet season to check that the apparent effects of management are not due only to specific year effects. Then terminate field experiment. Some PDS-type work might be worthwhile to demonstrate these management options on a commercial scale, particularly where hotter fires would be possible.
ii. Some work is needed somewhere on establishing exotic grasses in oversown pastures. Age of pasture, soil fertility, degree of disturbance are possible factors. Might be best done opportunistically with commercial developments.
iii. Some desk exercises should be done on possible economics of reducing stocking rate, spelling and burning.

# Communication of Stylo Management Practices

**Project No:** NAP3.220 (PROMIS 2323)
**Duration:** 01/10/1997 to 01/04/2001

**Principal investigator:** Col Middleton, DPI, Qld Beef Industry Institute
Tropical Beef Centre, PO Box 5545,
M/C Rockhampton, Queensland 4702.
Phone: 07 4923 8100, Fax: 07 4923 8222
E-mail: middlec@dpi.qld.gov.au

**Region coordinators -** Joe Rolfe, DPI, Charters Towers
Phone: 07 4787 2155, Fax: 07 4787 4998
E-mail: rolfej@dpi.qld.gov.au
Roger Cheffins, DPI, Bundaberg
Phone: 07 4153 7825, Fax: 07 4787 4998
E-mail: cheffir@dpi.qld.gov.au

## Objectives:

By June 2001 ensure that the majority of producers with stylo-based pasture are made aware of management strategies and practices that can reduce the incidence of acidification and erosion so as to improve long term production and sustainability.

## Summary:

A project aimed at minimising the potentially bad effects of legume (stylo) dominance on soils was commenced in the latter part of 1997. The project was designed in response to a recognition by scientists and graziers that situations existed where stylo could dominate native grass and that this legume dominance could lead to increased soil acidification and soil erosion. In August 1997 an industry workshop identified management guidelines and mechanisms for their promotion.

The identified management guidelines to reduce the risk of legume dominance included: identification and mapping of 'at risk' environments; strategic control of grazing pressure; summer spelling to promote grass seed production; periodic summer burning to reduce stylo and promote grass; use of 'grazing resilient' grasses to compete with stylo; use of fertiliser to promote grass in specific situations; particular strategies for legume seed and hay crops; the use of GRASS CHECK to monitor pasture changes.

To date a Technical Note on soil acidification has been prepared (Andrew Noble - CSIRO) and distributed to Technical Field Staff. The guidelines have been prepared. Awareness articles were published in the NAP and Tropical Grassland Society Newsletters, Cross Country TV, ABC Country Hour, local ABC Breakfast Session (twice) and Landcare Newsletter (Marlborough). Stylo Management has featured in two major Field Days (North Qld) and two Landcare Field Walks (Central Qld). A 3-fold colour brochure is under preparation for mail-out at the beginning of 1998/99 summer season. The mail-address database has been prepared. Similarly the material will be available in electronic form ( DPI Notes, Farm Fax, Prime News CD ROM and DPI Web Site) by Spring 1998.

## PROGRESS REPORT 1997-98

### 1) Problem definition:

Pasture scientists and producers have been aware for some time that stylo could dominate native grass pastures in some situations. While high legume content improved animal performance there was a potential problem with soil exposure to erosion where grass cover declined to a low level. A MRC commissioned review (McIvor, Noble and Orr (1998)) of the stability of native pasture oversown with legume highlighted the problem of legume dominance and the associated risks. Noble *et al* (1997) emphasised problems with stylo dominance when they showed that unused nitrogen 'fixed' by stylo dominant pasture caused significant soil acidification when leached down the soil profile.

Industry workshops were convened by MRC in Novenber 1996 and June 1997 to review the situation. The 1997 workshop brought together pasture specialists in research and extension together with the practical use and management of stylo-based pasture provided by graziers. The workshop outcomes were:

- stylo-based pasture had a highly beneficial economic effect on beef production
- there was emerging evidence that stylo dominance at the expense of native grass could expose the soil to degradation in particular situations
- there already was a body of knowledge and practical experience available on management practices that would assist in maintaining grass/legume balance in pasture
- in the interest of the long-term production and stability of stylo-based native pasture 'best practice' management guidelines should be widely promoted by a wide range of extension methods.

**2) Defining the objectives and methodology**

The objective as defined at the workshop was: *by June 2001 ensure that the majority of producers with stylo-based pasture are made aware of management strategies and practices that can reduce the incidence of acidification and erosion so as to improve long term production and sustainability.*

It was agreed that the collective experience of the workshop group would be used to identify and contribute to the preparation of appropriate management strategies and their communication to clients.

The workshop group identified a wide range of extension/promotion activities to assist in achieving the objective. These included the use of all media (written, radio, TV, video, electronic) as well as field days, meetings, conferences etc.

The project will be evaluated for achievement of objectives in the final year.

**3) 1997-98 achievements in relation to objectives/milestones**

In broad terms the contracted milestone in the 1998/99 year of the project was to ***'prepare a Technical Note on soil acidification and management guidelines for distribution in various forms including a colour brochure and Farm Notes.....by December 1997'.*** The Project Proposal detailed the use of all media types as in indicated in 2).

The achievements to date have been:

**(i) Preparation of management guidelines** (copy attached).

The workshop group combined to help prepare and edit management strategies for stylo based pasture. These included 500-800 word information sheets on each of the following topics:

a) ***Stylo dominance - a need for management.*** This introductory note outlines the history of stylo and highlights its significance to the Queensland beef industry. With close to 1M ha sown it can have a big effect on animal performance in terms of weight gain, age of turnoff and improved breeding. This sheet also warns readers that stylo can dominate in certain circumstances and that this can lead to undesirable effects on pasture, soil, animal production and ultimately landscape sustainability.

*b)* ***Stylo dominance - areas at risk.*** The Second Guideline identifies the areas and conditions under which stylo dominance is most likely to occur. The most 'at risk' areas are light textured, infertile soil and where summer grazing pressure is excessive. This situation gives a competitive advantage to stylo over native grass. It is important to recognise and map these areas so that appropriate management systems can be incorporated in the whole property management plan.

*c)* ***Grazing management to prevent stylo dominance.*** Grazing management, the Third Guideline, identifies grazing pressure as a major factor that can influence grass/legume balance. It explains the powerful effect that continual heavy selective grazing in summer has on grass seeding and its subsequent regeneration and survival. The role of strategic summer spelling is promoted.

*d)* ***Using fire to manage stylo dominance.*** The Fourth Guideline re-introduces readers to the role that periodic burning can have in native pasture containing stylo. In addition to the traditional reasons for graziers to burn native pasture, it can be used effectively in reducing the stylo population and promoting native grass. Burning needs to be implemented while there is still grass fuel available in the paddock.

*e)* ***A role for sown grasses.*** In areas where stylo dominance is considered likely or where dominance has already occurred then the inclusion of a sown grass more competitive than the native grasses may be a viable proposition. In the Fifth Guideline a number of grasses have been identified for different environments, the stoloniferous ones being important (*Bothriochloa, Urochloa, Digitaria, Brachiaria*). A region list is provided together with suggestions on how and when to incorporate them.

*f)* ***Managing seed and hay crops.*** Legume seed and hay crops present special problems as the pure stand of 'N' fixing legume, where most material is removed from the paddock, predisposes to rapid soil acidification. The use of fertiliser and lime may be necessary. Other strategies that include rotational land use with grass crops and pasture to 'soak' up fixed nitrogen are discussed.

g) ***The role for fertiliser.*** A draft of this module will be presented at the review meeting for comment.

**(ii) Preparation of colour brochure.**

This has not yet been completed. The text material, colour photos and general style have been decided. The delay has been due to a backlog of jobs at the Toowoomba Office where it is being prepared. This milestone was re-negotiated with Barry Walker so that its printing and mail-out would occur at the beginning of next growing season. A database of mail-out addresses has been prepared. This includes all graziers with over 250 ha of land, >500 mm annual rainfall and north of 26$^{o}$ latitude.

**(iii) Promotion of management guidelines.**

Significant progress has been achieved. The following activities have been conducted.

*a)* ***Preparation and distribution of a Technical Note on Soil Acidification by legumes.*** The purpose was to inform Technical Staff of recent scientific developments. This was prepared by Andrew Noble (CSIRO Land and Water). About 70 copies were distributed by the Project Leader in October 1997.

b) ***Awareness articles on stylo dominance problems*** **(see Publications).** The first client announcement of potential problems with stylo dominance and the project aims to counter these was via articles in NAP News and the Tropical Grassland Societies Newsletter T G S News and Views (October and December 1997).

*c)* ***Radio.*** One ABC Country Hour interview and two Breakfast Session interviews dealing with stylo management were conducted by the Project Leader in October and November 1997.

*d)* ***TV and Video.*** A segment on stylo dominance, soil acidification and management options was aired in late October 1997. Copies of this are held at major Information Centres.

*e)* ***Field Days.*** Two major Field Days have been held in north Queensland where the ramifications of stylo dominance have been presented. A Field Day at "Thalanga", Charters Towers, was hosted by the proactive Dalrymple Landcare Committee with financial support from DPI and MRC. Presentations and discussions involved graziers, DPI, CSIRO and the Seed Industry and covered the full range of benefits and problems associated with stylo sown in native pasture. Practical demonstrations of grass planting were also carried out. An excellent booklet was compiled (Rolfe and Dahl,1997) for distribution which contained all the presentations plus the project Management Guidelines.

A second Field Day (March 1998) hosted by MRC and the Tropical Grassland Society at "Strathbogie", Gumlu where the owner, Jim Bloomfield, was presented with the MRC-TGS Pasture Award. Over 80 people attended. Andrew Noble facilitated a session on stylo and soil acidification. A poster on stylo dominance was on display and the Management Guidelines were distributed.

*f)* ***Landcare Field Walks.*** Col Middleton and David Orr were involved in Field Walks with both the Marlborough and Ulam/Raglan Landcare Groups in October and November 1997. The former was held at a PDS site that addresses some of the management principles highlighted in our Guidelines.

*g)* ***Technical papers, conferences etc.*** A poster paper by Raymond Jones and Andrew Noble on the potential of soil acidification by leucaena was presented at an International Leucaena Workshop in Hanoi in February 1998. David Orr (Orr *et al* 1997) presented a Poster Paper highlighting management needs of Seca stylo pasture to the Australian Rangelands Society Conference (Gatton) in Dec 1997. Andrew Noble and Col Middleton prepared and presented Posters and Poster Papers at the National Soil Acidification Conference at Coolum last week. These highlighted the problem of legume dominance and demonstrated the cooperative effort between graziers, scientist and extension workers, agri-business and funders in promoting sustainable management practices.

*h)* ***Other promotion.*** The Guidelines were made available to FARMLINE for its Fact Sheets. Marlborough Landcare featured stylo management in one issue late 1997. Harry Bishop had an article on the need for grass maintenance in stylo pasture in The Queensland Farmer, October 1997.

**4) Plans for 1998-99**

In the 9 months since the project commenced the major objective has concentrated on preparation of stylo-based pasture management guidelines combined with an awareness program aimed at all sections of the industry from pasture scientists and technicians to the grazier. The second year will concentrate on extending the guidelines to all graziers within stylo growing areas of northern Australia using a variety of methods. The main thrust of the program will commence in the spring. Activities planned include:

- In cooperation with Andrew Noble attend the International Soil Acidification Conference at the Sunshine Coast in July 1998 and present two Poster Papers outlining the problem and our method of managing potential problems caused by pasture legumes.
- Present 1997/98 Progress Report for Peer Group review in July 1998 and incorporate accepted changes.
- Complete the Colour Brochure with management guidelines and have this mailed out to all graziers in the stylo growing areas in the early spring of 1998. Additional copies (number depending on cost) will be made available to MRC, Information Centres, seed outlets etc.
- Get the prepared guidelines onto DPI Notes (by August 1998) CD ROM and the DPI Home Page (by Dec 1998)
- Make the Guidelines available to appropriate Government and Industry Agencies and Agri-business outlets for use by Dec 1998.
- Proactively promote through retail outlets, the booklet on *Stylo for better beef* as this booklet contains most of the management guidelines in question.
- Continue to promote the value of GRASS CHECK in all published material.
- Hold at least one major Field Day on stylo management in each of the Burnett, Central and Northern areas of Queensland during the 1998/99 growing season.

The Workshop Group will continue to be involved in the preparation of all management guidelines.

**5) Linkages to other projects**

Several other MRC funded projects have significant direct relevance to this project. Close contact is maintained with the relevant Project Leaders so that any valuable management guidelines that emerge can be incorporated in the management promotion guidelines. Linked projects include:

(i) *Sustainability of stylo-based pasture systems in northern Australia: Managing soil acidity* (Andrew Noble - CSIRO)

(ii) *Effect of stocking rate, legumes, supplements and fire on animal production and stability of native pasture* (Bill Burrows - DPI) that researches grazing pressure and fire effects on soil/pasture/animal in native pasture with/without stylo.

(iii) *Management of native pasture oversown with stylo* (Deryk Cooksley - DPI) that researches some management practices (fire, summer spelling, sowing grasses, and grazing pressure) aimed at maintaining grass/legume balance in stylo based pasture.

(iv) *Producer Demonstration Sites* (Col Middleton - DPI). Sites at Mackay/Proserpine (Harry Bishop) and Marlborough (David Orr) that demonstrate pasture management practices in stylo based pasture.

## Discussion/Comments

1. As a result of the first stylo/soil acidification awareness material being distributed, there has been no adverse reaction from "greenies", producers, etc. A responsible view and outcome has been achieved.

2. *Has there been sufficient emphasis on management?* We need to exploit (highlight, promote) the management techniques of successful producers.

3. *Could a management package be linked to seed sales?* Yes, legume management information to manage stylo dominance could be dispensed at seed sale outlets; but this could scare producers away from planting Seca.

4. *What is the DPI's experiences with the extension value of various communication methods - information notes, videos etc?* Acidification should not be over emphasised in extension messages, but the messages must sufficiently strong to get producer's attention. There is an "element" out there that may take this acidification information and use it against the industry. If it is sold too hard there may be a backlash.

5. Evaluation of communication methods; must be a progressive evaluation; Eric Anderson offered to facilitate the use of QBII's new Marketing Officer.

6. If too much stylo is detrimental to your pastures but improves liveweight gains, what is the right balance? (See the discussion at the end of Project NAP3.221 on page 31.

7. So far, acidification is only a potential problem; many stylo users are aware of this potential problem; use existing, established producer networks to promote management skills.

8. Producers do know about acidification; the basics, not perhaps the details.

9. The avoidance of legume dominance should be part of the whole grazing management promotion.

10. Could over-kill the message; it's only applicable to producers.

11. There are lots of groups accessing information on pasture management. The acidification story should be just one part of the whole management story - it's just one aspect of pasture management.

12. It's a long term problem, not a short term problem; like green house gasses; we must be committed to tackle long term problems.

13. Happy with the positive, pro-active attitude to this problem. Now need a revised communication plan for the second year of the project.

14 The communication plan outlined by Col Middleton seemed pretty comprehensive. Some opportunistic field days on commercial sites could fit well with pasture management forums under Future Profit, Beefplan, Landcare etc. groups. The Technical Notes on managing stylo pastures are very wordy and not very convincing. They need more diagrams, drawings etc.

## Legume dominance and soil acidification review: General discussion

1. NAP Management has accepted work plans for 1998/99 as detailed in the revised papers. There are a good collection of projects which are working well together and are dealing with the important issues

2. Many issues specific to the various projects have been already covered in the discussions following each paper. The issues outlined below were brought up during the general discussion.

3. It was planned to have an independent review of the projects and the meeting, but the invited reviewer had to withdraw at the last moment and there was insufficient time to arrange for another person to conduct the review.

4. There have been three consultative meetings so far, and the strong involvement of producer in this work from the onset has been a good thing. This consultation process is a good example of how R&D management should function and the benefits of involving producers from the outset.

5. Communication issues concerning legume dominance and soil acidification have been handled responsibly and well by the project personnel.

6. A bonus for this work is that a set of robust management recommendations are available. These will be refined in light of further findings from the on-going trials.

7. There is a need to review the communication plan and be more pro-active in promoting management recommendations.

8. A great deal of the discussion centred around the definition of the terms pasture utilisation and dry matter on offer. It was agreed that for the next meeting there would be clearer definitions and explanation of these terms.

9. A second major issue was the relationship of stocking rate to animal production per head and per hectare, particularly over the medium and long term and the cost benefits from different grazing strategies and various pasture legume contents. These issues should also be explored in more detail at the next meeting.

10. More attention should be placed on collating and reviewing commercial management experience.

11. The inclusion of a field visit in the program was warmly welcomed and should continue to be a part of future annual review meetings. A visit to a commercial property next year was supported.

12. Individual comments by producers at the meeting, as well as subsequent correspondence showed strong support for the work being undertaken and welcomed the opportunity for producers to meet with project personnel each year.

# APPENDIX I

## NAP projects on sown pasture development, management and utilisation

### Completed projects

Middleton, C.H. (1989). Developmental pasture agronomy in Queensland. Final Report. Meat Research Corporation Project DAQ.M015. MRC, Sydney.

Pratchett, D. (1990). Optimising cattle growth on leucaena in northern Western Australia. Final Report. Meat Research Corporation Project DAW NAP P21. MRC, Sydney.

Hopkinson, J.M. (1990). Tropical pasture seed production 1986-1990. Final Report. Meat Research Corporation Project DAQ.NAP. P2. MRC, Sydney.

Middleton, C.H. (1991). Developmental pasture agronomy – Stylo development, Central Queensland sites - The Springs, Wycheproof and Melmoth. Final Report. Meat Research Corporation Project DAQ.M015. MRC, Sydney.

Gutteridge, R.C. and Shelton, H.M. (1991). Evaluation of *Sesbania sesban* – A new forage shrub species for tropical and subtropical Australia. Final Report. Meat Research Corporation Project UQ NAP P.23. MRC, Sydney.

Brandon, N.J. (1991). Establishment requirements of leucaena. Final Report. Meat Research Corporation Project UQ/DAQ.NAP. P22. MRC, Sydney.

Cameron, D.F. (1991). Control of anthracnose disease of Stylosanthes scabra by breeding for resistance and by use of genotype mixtures. Final Report. Meat Research Corporation, Project CS73. MRC, Sydney.

Middleton, C.H. (1991). Developmental pasture agronomy – Stylo development, Central Queensland sites - The Springs, Wycheproof and Melmoth. Final Report. Meat Research Corporation Project DAQ.M015. MRC, Sydney.

Partridge, I.J. (1991). Development of band-sowing in commercial pastures in the inland Burnett. Final Report. Meat Research Corporation Project DAQ. MO 16, MRC, Sydney.

Cook, S.J. (1992). Development of low cost equipment and technology for establishing improved species in existing pastures. Final Report. Meat Research Corporation Project CS.NAP.P12. MRC, Sydney.

Edye, L.A. (1992). Evaluation of *Stylosanthes hamata* lines. Final Report. Meat Research Corporation Project CS.NAP.P14. MRC, Sydney.

Miller, C.P., Coates, D.B., Gilbert, M.A., Hendricksen, R.E. McLean, R.W. and Kerridge, P.C. (1992) Mineral nutrition of legume-based cattle production systems in northern Australia. Final Report. Meat Research Corporation Project CS.NAP.P19. MRC, Sydney.

Kerridge, P.C.(1992) Characterisation of the nutrient requirements of new tropical pasture legumes. Final Report. Meat Research Corporation Project CS.027. MRC, Sydney.

Jones, R.M. (1993). Beef production from Cassia/buffel grass pastures in sub tropical Queensland . Final Report. Meat Research Corporation Project CS.P.011. MRC, Sydney.

Ahern, C.R., Shields, P.G., Enderlin, N.G. and Baker, D.E. (1994) Soil fertility of central and north-east Queensland grazing lands. *Information Series QI94065. Department of Primary Industries, Queensland.* Final Report. Meat Research Corporation Project DAQ.075. MRC, Sydney.

Edye, L.A. (1994) The development of *Stylosanthes hamata* and *S. scabra* cultivars for sub-tropical environments in south east Queensland. Final Report. Meat Research Corporation Project CS.079. MRC, Sydney.

Hacker, J.B. and Minson, D.J. (1994) new forage pearl millets for northern Australian graziers. Final Report. Meat Research Corporation Project CS.126. MRC, Sydney.

Rickert, K. (1996). FEEDMAN – a pasture and crop decision-support system. Final Report. Meat Research Corporation Project UQ.038. MRC, Sydney.

McIntyre, S. (1996). Sustainable and profitable native grass-legume pastures for southern spear grass lands. Final Report. Meat Research Corporation Project CS. 80/CS.195. MRC, Sydney.

McIvor, J.G., Noble A.D. and Orr, D.M. (1996). Stability and productivity of native pastures oversown with tropical legumes. A report for the Meat Research Corporation's North Australia Program (NAP3.203). MRC, Sydney.

Middleton, C.H., Smith, P., Tyler, R., Knights, P. and Chamberlain, J. (1996a). Producer Demonstration Site Final Report 1986-1996 - Parts 1 & 2. Project Summary (60 pages) plus Appendix and Attachments.

Middleton, C.H., Smith, P., Tyler, R., Knights, P. and Chamberlain, J. (1996b). Producer Demonstration Site Final Report 1986-1996 – Part 3. Compendium of Site Final Reports 1986-1996 (420 pages).

Irwin, J.A.G. and V.M. Brake, V.M. (1997). Slow-rusting and rust resistance forage oat development for subtropical Australia. Final Report. Meat Research Corporation Project DAQ.063. MRC, Sydney.

Miller, C.P., Coates, D.B., Ternouth, J.H. and White, S.J. (1997). Phosphorus management for breeding cattle in northern Australia. Final Report. Meat Research Corporation Project DAQ.093. MRC, Sydney.

McLennan, S.R. (1997). Developing profitable strategies for increasing growth rates of cattle grazing tropical pastures. Final Report. Meat Research Corporation Project DAQ.100. MRC, Sydney.

Noble, A.D. (1997). Soil acidification research in the semi-arid tropics. Final Report. Meat Research Corporation Project CS.277. MRC, Sydney.

Pengelly, B.C. and Staples, I.B. (1997). Development of new legumes and grasses for the cattle industry of northern Australia. Final Report. Meat Research Corporation Projects CS054.185 and DAQ053/081. MRC, Sydney.

Jones, R.J. (1998). Persistant perennial grasses for tropical pastures. Final Report. Meat Research Corporation Project CS.152. MRC, Sydney.

Edye, L.A. (1998). New tropical stylo cultivars from the 1986 *S. hamata* – *S. scabra* collection. Final Report. Meat Research Corporation Project CS.153. MRC, Sydney.

Staples, I.B. and Middleton, C.H. (1998). Evaluation of grasses for heavy grazing (continuation of evaluation of grass sites from project CS.185/DAQ.081. Final Report to Meat & Livestock Australia, Sydney.

## Interim Reports

Middleton, C.H. (1994). NAP Producer Demonstration Site Annual Report 1992-93. 306 pages.

Middleton, C.H. (1995). NAP Producer Demonstration Site Annual Report 1993-94. 314 pages.

Middleton, C.H. (1996). NAP Producer Demonstration Site Annual Report 1994-95. 207 pages.

Middleton, C.H. (1997). NAP Producer Demonstration Site Annual Report 1995-96. 272 pages.

Middleton, C.H. (1998). NAP Producer Demonstration Site Annual Report 1996-98. 179 pages.

Burrows, W.H. (1996) Effects of stocking rate, legume augmentation, supplements and fire on animal production and stability of native pastures. Interim Final Report. Meat Research Corporation Project DAQ.080/NAP3.207. MRC, Sydney.

Bishop, H.G. (1996). Back up legumes for stylos. Interim Final Report. Meat Research Corporation Project DAQ.083. MRC, Sydney.

Clem, R.L. and Jones, R.M. (1996). Legumes for clay soils. Interim Final Report. Meat Research Corporation Project DAQ.086. MRC, Sydney.

Palmer, B. (1996). The evaluation of selected shrub legumes under grazing cattle. Interim Final Report. Meat Research Corporation Project CS.187. MRC, Sydney.

## Continuing Projects

Clem, R.L. et al. - *Stylosanthes sp aff scabra* – On property grazing demonstrations (Project DAQ.111.).

Bishop, H.G. - Back up legumes for stylos (DAQ.083)

Clem, R.L. and Jones, R.L. - Legumes for clay soils (NAP3.103)

Palmer, B. - The evaluation of selected shrub legumes under grazing cattle (CS.187)

Date, D.A. - Alternative delivery systems for the inoculation of new strains of stylo (CS.273)

Hopkinson, J.M. - The reversion problem in shrubby stylo seed production

Noble, A.D. - Soil acidification research in the semi arid tropics (NAP3.218)

Cooksley, D. and Quirk, M.F. - Management of native pastures oversown with stylos (NAP3.224)

Middleton, C.H. - Communication of stylo management practices (NAP3.220)

# APPENDIX II

## List of NAP workshops and conferences supported by MRC funding

**Phosphorus and beef production in northern Australia** (1988) Proceedings of an AMLRC workshop held in Townsville in June 1988, edited by Peter C. Kerridge. Papers published in *Tropical Grasslands* **24**, 129-255.

**Sown pastures for the seasonally dry tropics** (1989) Proceedings of a workshop held on the Atherton Tablelands in June 1989. Edited by Ian J. Partridge and C.P. (Joe) Miller. *Queensland Department of Primary Industries Conference and Workshop Series QC91002.*

**Sown pastures for the brigalow lands.** (1991) Proceedings of a workshop held on Bribie Island, southern Queensland in 1991. Edited by Ian J. Partridge, Bill (W.H.) Burrows and Errol J. Weston. *Queensland Department of Primary Industries Conference and Workshop Series QC94005.*

**Shrub legume workshop (1991).** Proceedings of a workshop held at CSIRO Division of Tropical Crops and Pastures, St Lucia. Collated by Brian Palmer. CSIRO Brisbane.76 pages.

**Nitrogen-fertilised pastures for beef production in Queensland** (1991) Proceedings of a workshop held at the Gympie Forestry training Centre from 30 April to 1 May 1991. Edited by Mike Gilbert and Beth Woods.

**Tropical pasture establishment** (1992) Proceedings of a workshop held at Brian Pastures Research Station, Gayndah, in June 1992. Convenor – David Gramshaw. Papers published in *Tropical Grasslands* **27**, 257-419.

**State and transition models for rangelands** (1993) Proceedings of a workshop held at the Forestry Training Centre, Gympie, Queensland, September 13-14, 1993. Edited by John Taylor, Neil MacLeod and Andrew Ash. *Tropical Grasslands* 24, 193-283.

**Beef production from ponded pastures** (1993) Proceedings of a workshop held in Yeppoon, Queensland, April 1993. Edited by Pam A. Pittaway, John H. Wildin and Cam McDonald. *Tropical Grassland Society of Australia Occasional Publication No.7*

**Integrated management for sustainable forage-based livestock systems in the tropics** (1995) The manual was prepared for a short training course on tropical forage resources and livestock production held at Atherton, North Queensland, in June 1995. Edited by David Gramshaw. *Tropical Grassland Society of Australia Occasional Publication No.6.*

**International research and development on *Stylosanthes*** (1996). Proceedings of a workshop held at the CSIRO Davies Laboratory, Townsville, Queensland in April 1996. Papers published in *Tropical Grasslands,* **31**, 385-526.

The MRC provided funding support for a number of national and international conferences, viz –

- 17th International Grassland Congress Palmerston North, New Zealand and Rockhampton, Australia, February 1993.
- 5th Tropical Pasture Conference, Atherton, Queensland, June 1995.
- 8th Biennial Conference of the Australian Rangeland Society, Katherine, Northern Territory, July 1994.
- 9th Biennial Conference of the Australian Rangeland Society, Port Augusta, South Australia, September 1996.
- 10th Biennial Conference of the Australian Rangeland Society, Gatton College, Queensland, December 1997.

# APPENDIX III

## Scientific and technical publications relating to MRC NAP sown pasture projects, activities and workshops from 1986 onwards

Ahern, C.R., Shields, P.G., Enderlin, N.G. and Baker, D.E.. (1994). Soil fertility of central and north-east Queensland grazing lands. *Information Series QI94065. Department of Primary Industries, Queensland.* Final Report. Meat Research Corporation Project DAQ.075. MRC, Sydney.

Ahern, C.R., Shields, P.G. and Baker, D.E. (1995). Mean bicarbonate phosphorus of Central and North-east Queensland. 1:1 000 000 colour map, Queensland Department of Primary Industries, Reference No 94-NEG-1-P3034.

Ahern, C.R., Shields, P.G. and Myers, J.K. (1995). Grazing land types and landscape units of Central and North-east Queensland. 1:1 000 000 colour map, Queensland Department of Primary Industries, Reference No 94-NEG-1-P3007.

Ahern, C.R., Weinand-Craske, M.M.G. and Baker, D.E. (1995a). Mean exchangeable potassium of surface soils in of Central and North-east Queensland. 1:1 000 000 colour map, Queensland Department of Primary Industries, Reference No 94-NEG-1-P3035.

Ahern, C.R., Weinand-Craske, M.M.G. and Baker, D.E. (1995b). Phosphorus mapping in N.E. Queensland grazing lands. First National Soil Phosphate Conference, November 1995. Wagga Wagga, NSW. Australian Society of Soil Science Incorporated.

Anderson, E.R., Back, P.V., Rutherford, M.T., Conway, M.J. and Myles, D.J. (1993). Dynamics of *Stylosanthes scabra* in a tropical savanna woodland in eastern Australia after treatment with tebuthuiron. *Proc. XVIIth International Grassland Congress, Rockhampton.* Dunmore Press, New Zealand. pp. 1927 - 1928.

Anon. (1994) Desmanthus: a promising legume for clay soils, QDPI, CSIRO and Wrightsons' Seeds.

Anon. (1996) Milgarra Butterfly Pea, fact sheet on *Clitoria ternatea* QDPI and Progressive Seeds.

Anon. (1996). Caatinga stylo *Stylosanthes* – 'Primar' and 'Unica'. *Plant Varieties Journal,* **9**: 19-20.

Anon. (1997). International research and development on *Stylosanthes*. Proceedings of a workshop held at the CSIRO Davies Laboratory, Townsville, Queensland in April 1996. Papers published in *Tropical Grasslands* **31**, 385-526.

Anon. (1998). Description of oat cv. Gwydir (Application No: 97/276). *Plant Varieties Journal,* **11**: 29-31.

Banisch, G.A., Date, R.A., Brandon, N.J. and Pittaway, P. (1998). Growth responses of *Desmanthus virgatus* to inoculation with *Rhizobium* strain CB3126. I. A pot trial from 8 clay soils from central and southern Queensland, *Tropical Grasslands,* **32:** 13-19.

Becerra Stiefel, A.C., Date, R.A. and Brandon, N.J. (1998). Survival of rhizobia on seed of *Desmanthus virgatus* stored at different temperatures, *Tropical Grasslands,* **32:** 28-33.

Bielig, Leone M. (1997). Chromosome numbers in the forage legume genus *Aeschynomene* L. Sabrao-Journal **29**(1):33-39.

Bielig, L.M. and Jones, R.J. (1993). Chromosone numbers of *Bothriochloa pertusa* (L). A. Camus. *In*: SOCGI Plant Chromosome number reports XI. *Journal of Cytology and Genetics,* **28:** 189-90.

Bishop, H.G. (1994). Finding backup legumes for stylos. Australian Rangeland Society 8th Biennial Conference, working papers p 175-176, Katherine, NT, June 21-23, 1994.

Bishop, H.G. (1999). Backup legumes for stylos. Proceedings QBII sown pasture R, D & E Workshop, Marburg 5-7 October 1998. (In press).

Bishop, H.G., Bushell, J.J. and Hilder, T.B. (1996). Back-up legumes for stylos. Proceedings Fifth Tropical Pasture Conference, Atherton, Queensland, June 1995. In *Tropical Grasslands*, **30**:153.

Bishop, H.G., Cook, B.G., English, B.H., Bushell, J.J. and Hilder, T.B (1997). More *Aeschynomene* pasture legumes for the Tropics and Sub-tropics. Proceedings of XVIII International Grassland Congress, Volume 1, p 1-1, Canada, June 1997.

Bishop, H.G., Cook, B.G., Hopkinson, J.M. and Hilder, T.B. (1995). *Aeschynomene americana* L. American jointvetch cv Lee. *Australian Journal of Experimental Agriculture*, **35**: 122-123.

Bishop, H.G. and Hilder, T.B. (1993) The *Aeschynomene* genus as a source of pasture legumes for tropical and sub-tropical Australia. *Proceedings XVII International Grasslands Congress*, Rockhampton. Dunmore Press, New Zealand 2153 – 2154.

Bishop, H.G., Hilder, T.B. and Bushell, J.J. (1997). Pasture yield and animal performance from *Aeschynomene americana* cultivars Glenn and Lee. Proceedings of XVIII International Grassland Congress, Vol 1 Canada, June 1997.

Bishop, H.G., Pengelly, B.C. and Ludke, D.H. (1988). Classification and description of a collection of the legume genus *Aeschynomene*. *Tropical Grasslands*, **22**: 160-175.

Bishop, H. G. , Shaw, K. A. Middleton, C. H. and Cook, B. G. (1996) Interim final report on project DAQ 083, Backup Legumes for Stylo. A report to Meat Research Corporation, October 1996.

Blumenthal, M.J., O'Rourke, P.K., Hilder, T.B. and Williams, R.J. (1989). Classification of the Australian collection of the legume *Macrotyloma*. *Australian Journal of Agricultural Research*, **40**: 591-604.

Blumenthall, M.J. and Staples, I.B. (1993). Origin, evaluation and use of *Macrotyloma* as forage - a review. *Tropical Grasslands*, **27** (1): 16-29.

Brake, V.M. and Irwin, J.A.G. (1992). Partial resistance of oats *to Puccinia coronata f.sp. avenae*. *Australian Journal of Agricultural Research*. **43**: 1217-1227.Brandon, N.J. (1991). Establishment requirements of leucaena. Final Report. Meat Research Corporation Project UQ/DAQ.NAP. P22. MRC, Sydney.

Brandon, N.J. and Dalzell, S.A. (1996). *Macroptilium bracteatum*: a promising legume for leys. *Proceedings of the Eighth Australian Agronomy Conference*, p 625.

Brandon, N.J. and Date, R.A. (1998). Nutrient limitations of clay soils for *Desmanthus virgatus*. I. What is the cause of chlorosis in field-grown desmanthus on a black earth soils, *Tropical Grasslands*, **31**: 1-5.

Brandon, N.J., Date, R.A., Clem, R.L., Roberston, B.A. and Graham, T.W.G. (1998). Growth responses of *Desmanthus virgatus* to inoculation with *Rhizobium* strain CB3126. II. A field trial at 4 sites in south-east Queensland, *Tropical Grasslands*, **30**: 20-27.

Brandon, N.J., Date, R.A., Jones, R.M., Clem, R.L., Bahnisch, G.A., Spies, P.R. and Becerra Steifel, A.C. (1997). Rhizobial and nutritional responses of *Desmanthus virgatus* on clay soils of Queensland, Australia. *Proceedings of XVIII International Grassland Congress*. Canada.

Brandon, N.J. and Jones, R.M. (1998). The effect of sowing depth and duration of watering on emergence of tropical legumes in clay soil in growth cabinets, *Tropical Grasslands*, **32**: 81-88.

Bray, R.A. (1988). Variation in the resistance of Leucaena species and varieties to the leucaena psyllid. Final Report. Meat Research Corporation Project CS.NAP.P13. MRC, Sydney.

Burrows, D.M. and Porter, F.J. (1993). Regeneration and survival of *Desmanthus virgatus* 78382 in grazed and ungrazed pastures, *Tropical Grasslands*, **27**: 100-107.

Burrows, W.H. (1990). Prospects for increased production in the north-east Australian beef industry through pasture development and management. *Agri. Sci.* **3**: 19-24.

Burrows, W.H. (1996) Effects of stocking rate, legume augmentation, supplements and fire on animal production and stability of native pastures. Interim Final Report. Meat Research Corporation Project DAQ.080/NAP3.207. MRC, Sydney.

Burrows, W.H., French, A.V. and Robbins, G.B. (1994). Managing sown pastures In: *Sown pastures for the brigalow lands.* (eds. I.J. Partridge, W.H. Burrows, E.J. Weston). (QDPI: Brisbane). 39-42.

Burrows, W.H., McKeague, E.J., Newman, S., Silbence, M.N. and Vercoe, J.E. (1996). Innovation and responsiveness will be the hallmarks of the tropical beef industry. *Pro. Aust. Soc. Anim. Prod.* **21**: 48-54.

Burrows, W.H. and Vercoe, J.E. (1995). Sustainability of stocking and grazing in northern Australia. *Focus,* **88**: 8-12.

Cameron, D.F. (1991). Control of anthracnose disease of *Stylosanthes scabra* by breeding for resistance and by use of genotype mixtures. Final Report. Meat Research Corporation, Project CS73. MRC, Sydney.

Cameron, D.F., Chakraborty, S., Davis, R.D., Edye, L.A., Irwin, J.A.G., Manners, J.M. and Staples, I.B. (1989). A multi-disciplinary approach to anthracnose diseases of *Stylosanthes* in Australia. *Proceedings XVII International Grasslands Congress*, Rockhampton. Dunmore Press, New Zealand. 2153 – 2154.

Cameron, D.F., Chakraborty, S., Manners, J. and Edye, L.A. (1996). Protecting stylo from anthracnose. *Tropical Grasslands*, **30**: 130.

Cameron, D.F., Miller, C.P., Edye, L.A. and Miles, J.W. (1993). Advances in Research and Development with Stylosanthes and other Tropical Pasture Legumes. *Proceedings XVII International Grasslands Congress.* Rockhampton. Dunmore Press, New Zealand. 2109-2114.

Cameron, D.F. and Staples, I.B. (1992). Development of new legumes and grasses for the cattle industry of northern Australia. Final Report. Meat Research Corporation, Projects CS054 and DAQ053. MRC, Sydney.

Cameron, D.G., Jones, R.M., Wilson, G.P.M., Bishop, H.G., Cook, B.G., Lee, G.R. and Lowe, K.F. (1989). Legumes for heavy grazing in coastal subtropical Australia. *Tropical Grasslands,* **23**: 153-161.

Cavaye, J.M., Graham, T.W.G. and Robbins, G.B. (1989). Sown grass productivity: run down but not out. *Queensland Agricultural Journal*, **115**: 281-283.

Chakraborty, S., Cameron, D.F., Irwin, J.A.G. and Edye, L.A. (1989). Quantitatively expressed resistance to anthracnose *(Colletotrichum gloeosporioides)* in *Stylosanthes scabra. Plant Pathology,* **37**: 529-537.

Clark, R.A. (1995). Beef industry constraints and opportunities. *In:* Integrated management for sustainable forage-based livestock systems in the tropics. Ed, D. Gramshaw. Tropical Grassland Society of Australia. Occasional Publication No. 6.

Clem, R.L. (1997). A new stylo for beef producers, *Beef Talk,* Volume 1997, QDPI.

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# APPENDIX IV

## Reports of producer sown pasture case studies

### 1. Brigalow management

<u>**Sown pastures for the brigalow lands. (1994).**</u> Proceedings of a workshop held on Bribie Island, southern Queensland in 1991. Edited by Ian J. Partridge, Bill (W.H.) Burrows and Errol J. Weston. *Queensland Department of Primary Industries Conference and Workshop Series QC94005.*

Archer, David and Carol (1994). Commercial development of 'Kyewong', Dysart, Northern brigalow region. 69-71.

Ford, Roy and family (1994). Commercial development of 'Forest Home', Capella. Northern brigalow region. 72-74.

Delforce, Rex and Marilyn (1994). Commercial development on 'Billabong', Arcadia Valley. Central brigalow region. 75-76.

Sparke, R.L. and E.E. (1994). Commercial development of 'Wirranda', Moura. Central brigalow region. 77-79..

Clark, Adam (1994). Commercial development on 'Bimbadeen', Taroom. Central brigalow region. 80.

Cameroon, Brian (1994). Commercial development on 'Howqua', The Gums, Tara Shire. Southern brigalow region. 81-82.

Green, Ralph (1994). Commercial development on 'Coonardoo', Roma. Southern brigalow region. 82-83.

### 2. Sown pastures for the seasonally dry tropics

<u>**Sown pastures for the seasonally dry tropics (1991).**</u> Proceedings of a workshop held on the Atherton Tablelands in June 1989. Edited by Ian J. Partridge and C.P. (Joe) Miller. *Queensland Department of Primary Industries Conference and Workshop Series QC91002.*

**Zone A: Northern high rainfall (more than 1200 mm)**
Wincen, Bob (1991) Commercial development on 'Sudley', via Weipa. 37-41.

**Zone B: Reliable moderate rainfall (800-1200 mm)**
Arnold, Gordon (1991). Commercial development on 'Wrotham Park', via Chillagoe (1963-1988). 44-48.
Hart, Ted (1991). Commercial development on 'Hodgson River' via Katherine. 48-52.

**Zone C: Unreliable marginal rainfall (600-800 mm)**
Barrett, Rodney (1991). Commercial development on 'Salisbury Plains', Bowen. 54-58.
Rebgetz, Ian (1991). Commercial development on 'Thalanga', Balfes Creek via Charters Towers. 59-60.

**Zone D: Moderate rainfall (600-1200), Central Queensland**
Chapman, Bruce (1991) Commercial development on 'Rowanlea', Calliope. 62-69.
Bethel, Geoff (1991) Commercial development on 'Willinga', via Nebo. 69-74.

**Zone E: High rainfall (more than 1200 mm), east coast**
McLean, Roy (1991) Commercial development on 'Kuttabul', via Mackay. 75-79.

### 3. *Stylosanthes* management

<u>**International research and development on *Stylosanthes* (1997).**</u> Proceedings of a workshop held at the CSIRO Davies Laboratory, Townsville, Queensland in April 1996. Papers published in *Tropical Grasslands* **31**, 385-526.

Chapman, Tom (1997). Grazier experience with Stylosanthes technology. I. The use and significance of *Stylosanthes* on Wycherproof. *Tropical Grasslands* , **31,** 515-518.

Barrett, Rodney (1997). Grazier experience with Stylosanthes technology. II. More than a way of life. *Tropical Grasslands* , **31**, 519-521.

Arnold, Gordon (1997). Grazier experience with Stylosanthes technology. III. Wrotham Park, 1963-1988. *Tropical Grasslands* , **31**, 522-526.

## 4. Ponded pastures for beef production

**Beef production from ponded pastures (1995).** Proceedings of a workshop held in Yeppoon, Queensland, April 1993. Edited by Pam A. Pittaway, John H. Wildin and Cam McDonald. Tropical Grassland Society of Australia Occasional Publication No.7

Lyons, J. (1995), Developing ponded pastures at 'Wambiana', Charters Towers. 10-12.

Bahnisch, R. (1995). The role of ponded pastures in drought mitigation at 'Ayrshire Park', Avon Downs. 13-14.

Geddes, B. (1995). Ponded pastures at 'Doonside', Milman. 30-32.

Smith, E.G. (1995). Ponded pastures at 'Strathmuir', Marlborough. 33.

Hall, M. and B. (1995). Ponded pastures on 'Laurel Hills', Clermont. 34-35.

## 5. Producer demonstration sites

Since 1987 there have been almost 300 producer demonstration sites established across northern Australia. Of this total about 35% have dealt with sown and native pasture management and production issues. Details are provided in the publications by Middleton *et al.* listed in Appendix III.

## 6. Study tours and conference reports

Report on a Leucaena study tour by north Queensland beef producers to Central Queensland in March 1998. Tour organisation and report by Greg Brown, Jim Kernot, John Chamberlain and George Lambert.

## 7. MRC/Tropical Grasslands Pasture Award

Since 1994, the MRC's North Australia Program has sponsored annually the MRC/TGS award to a commercial operator for outstanding contributions to the use and development of tropical pastures. The award is assessed using the following criteria –

- Is the development innovative.
- How does it fit the farming/grazing system.
- Does it involve a whole farm approach.
- Can it be applied to a wider rural community.
- Has the farmer/grazier promoted the development.

The Award is made on a rotational basis within the Northern, Central and Southern regions of northern Australia. The following have received the award to date.

- 1994 – Mr Grant Morris, 'Hazelmere', Cooktown (Northern Region).
- 1995 – Mr Rob Anderson, Maneroo', Moree (Southern Region).
- 1996 – Mr Nev Mills, 'Melrose', Mornish via Rockhampton (Central Region).
- 1997 – Mr Jim Blomfield, 'Strathbogie", Binbee via Bowen (Northern Region).
- 1998 – Mr David Illing, 'Hillview', Pittsworth (Southern Region).

These awards and the field days have stimulated a great deal of interest and debate in the respective regions. Details of these awards are provided in the *Tropical Grasslands Journal.*