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Prepared by: R. L. Clem
QLD DPI, Brian pastures Research Station
R.M.Jones
CSIR ropical A riculture

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Legumes for Clay Soils

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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: M J Conway, C R Esdale, T B Hilder, Kay Taylor, and T J Hall

Project Objectives:

By June 1998,

1. to develop and provide interim guidelines that will allow producers to successfully establish and manage *Desmanthus virgatus* and *Stylosanthes seabrana* pastures.

2. to quantify the liveweight gain from established *Desmanthus virgatus* demonstration areas.

3. to demonstrate the cost effectiveness of planting *Desmanthus virgatus* and *Stylosanthes seabrana* in a beef grazing enterprise.

4. to have sown 10,000 ha of *Desmanthus virgatus* in Queensland.

5. to 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 trails 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 LIVEWEIGHT 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 (5th year) and Bauhinia Downs 3 t/ha (3rd 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 long-term survival may be at risk.

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

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.

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 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.
   - 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).

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Discussion/Comments

1. These 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. (Ross Brunckhorst)

   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. (Bob Clem, Bruce Pengelly, John Hopkinson)

3. Is the experience of high seedling numbers but low soil seed banks in Caatinga stylo widespread and is it recognised by the seed industry? (Barry Walker)

   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)

4. 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. (Barry Walker)

   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. (Bob Clem, Bruce Cook, John Hopkinson)

5. Bruce Pengelly was asked by the chairman to outline the ley legume project.

This project funded by GRDC 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.

6. Is the impact of legume likely to be through gain/head or gain/ha. If gain/ha then quantity of feed is critical. (David S)

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. (Bob Clem, Col Middleton, Dick Jones)