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Sustaining productive pastures in the tropics
7. Tree and shrub legumes in improved pastures

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Abstract

Among tropical legumes, the tree species, *Leucaena leucocephala*, has demonstrated a high potential for increasing liveweight gain. Expansion of its use is limited by damage from the psyllid (*Heteropsylla cubana*) and the slow rate of establishment of leucaena seedlings in some environments. These problems with *L. leucocephala* have given impetus to the search for alternative varieties and species of tree legumes with similar features. These features include longevity and versatility of management once established, high animal production potential, tolerance of a wide range of climatic and edaphic environments, and potential for use in a range of agroforestry applications because of their deep rooted habit. The shading effect of tree canopies can have a positive effect on understorey grass yield and quality due to improved nutrient cycling.

There is potential for selection of higher yield, improved psyllid and cool temperature tolerance within the *Leucaena* genus. Other promising genera of tree legumes include *Calliandra*, *Gliricidia*, *Albizia* and *Sesbania*. However, there are problems of lower nutritive value and acceptance in some of these genera and further evaluation is required. Also it is not known how well these other tree legumes can tolerate direct grazing.

The future acceptance of tree legumes by graziers will depend on the improved availability of suitable germplasm, a practical knowledge of their establishment and management requirements, and a clear demonstration of their potential economic benefits.

Resumen

Entre la leguminosas tropicales, la especie arbórea, Leucaena leucocephala, *han mostrado un mayor potencial para incrementar la ganancia de peso vivo que cualquiera de las especies de leguminosas herbáceas actualmente utilizadas. El daño que le ocasiona el psyllid (*Heteropsylla cubana*) y la lenta tasa de establecimiento de las plántulas de leucaena en algunos medios ambientes, han limitado la extensión de su uso. Estos problemas observados con* L. leucocephala *han impulsado la búsqueda de variedades y especies de leguminosas arbóreas con rasgos similares. Tales rasgos incluyen longevidad y versatilidad en su manejo una vez que se encuentra establecida, un potencial elevado de producción animal, tolerancia a un amplio rango de tipos de clima y suelos, y su uso potencial en un rango de aplicaciones forestales debido a su hábito de enraizamiento profundo. La sombra de las copas de los árboles puede tener un efecto positivo en el rendimiento y calidad de la gramínea que se desarrolla por debajo debido a un mejoramiento en el ciclo de nutrientes.*

Entre el género Leucaena *se tiene un potencial de selección de especies con mayor rendimiento y una mejor tolerancia al psyllid y las bajas temperaturas. Otros géneros prometedores de leguminosas arbóreas incluyen* Calliandra, Gliricidia, Albizia *y* Sesbania. *Sin embargo, hay algunos problemas con varios de esos géneros relacionados con su bajo valor nutritivo y su aceptación, por lo que se requiere evaluaciones adicionales. No se conoce tampoco que tan bien aquellas otras especies de leguminosas arbóreas pueden tolerar el pastoreo directo.*

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La futura aceptación de las leguminosas arbóreas por los ganaderos dependerá de la disponibilidad del germoplasma adecuado, de un conocimiento práctico acerca de su establecimiento y sus requerimientos de manejo, así como una demostración clara de sus beneficios económicos potenciales.

Introduction: why use tree legumes?

The present interest of Australian agriculturalists in the use of tree legumes in pastures is a natural extension of our belief in the sustaining role of nitrogen fixing legumes in pastures and cropping systems (Shelton 1990).

Historically, the use of tree legumes in pastures in tropical and subtropical Australia has been confined to the lopping of native species for drought feeding of livestock. Many species have value in this role (Wildin 1990) although the best known is mulga (*Acacia aneura*), a species which occupies large areas of the arid zone of the Australian continent. With the notable exception of the exotic species *Leucaena leucocephala*, few tree legumes have been deliberately sown for use in animal production systems in Australia. Even so, with leucaena, development has been slow, and significant commercial development did not commence until 1980 (Wildin 1981). There is now an estimated 16,000 ha of leucaena in Central Queensland. The more widespread use of this highly nutritious plant is currently restricted by the challenge of the leucaena psyllid (*Heteropsylla cubana*) and continuing uncertainty with established (Lesleighter and Shelton 1986).

There are many reasons for the current interest in the use of tree legumes in pastures. Trees such as leucaena are an alternative to herbaceous legume species, due to their high productivity and persistence, flexibility of management in mixed pastures and ability to retain or produce green leaf in times of low soil moisture and low temperature. The deep-rooted character of most tree legumes offers scope for exploitation and use of moisture and nutrients from deep in the soil profile (Caldwell and Richards 1989), and for stabilization of landscapes against erosion and salting.

Some of these issues are discussed and some avenues for future research and development are proposed.

Availability of suitable germplasm

Since the success of leucaena in the early 1980s and the advent of the leucaena psyllid there is a need to find alternative tree legume species for a wider range of environments. A broader base of genetic material is required for the many pastoral environments currently in use. Brewbaker (1986) reported more than 200 species of tree legumes but indicated that only 25 of these are widely used for fodder and are known to fix N. Wildin (1990) listed a significant number of species with fodder value, however, some of these are of low nutritional quality and we have confined this paper mainly to the species shown in

Table 1. Environmental tolerances of some fodder tree legumes

	Climatic tolerances				Edaphic tolerances				
Species	Rainfall (mm)	Drought	Cool temp	Frost	Low fertility	Water logging	Acidity	Alkalinity	Salinity
1.[1] *Acacia aneura*	200-500	VG[2]	G	G	G		G		
2. *Acacia villosa*	600-3000	G	M	P	G	G	G		
3. *Albizia chinensis*	600-3000	G	M	M	G	P	G	G	
4. *Abizia lebbeck*	600-2500	G	M	M			G	G	G
5. *Codariocalyx gyroides*		P	P			G			
6. *Calliandra calothyrsus*	700-4000	P	M	P	G	P	G		
7. *Chamaecytisus palmensis*	350-1600		G	G	M	P	M	G	
8. *Desmanthus virgatus*	>700	VG	M	M	P		M	G	
9. *Flemingia macrophylla*	1100-3000	G	M		G	G	VG		
10. *Gliricida sepium*	900-3500	P	P	VP	G	M	G	G	M
11. *Leucaena leucocephala*	650-3000	G	M	P	P	P	M	G	
12. *Sesbania grandiflora*	>800	G	VP	VP		VG		G	G
13. *Sesbania sesban*	>1500	P	G	P	M	VG	M	G	G

[1]Reference 1. Turnbull 1990; 2.&3. R.C. Gutteridge, pers. comm.; 4. Prinsen 1986; 5. Jones 1984, Skerman 1977; 6. Lowry 1988; 7. Davies 1987; 8. Skerman 1977, pers. comm.; 9. Budelman 1989; 10. Glover 1984; 11. Jones *et al.* 1982; 12.&13. Evans 1986; Hansen and Munns 1985.

[2] VP = very poor; P = poor; M = medium; G = good; VG = very good

Table 1. Most of these species have membranous bipinnate leaves and not the sclerophyllous leaves found in most Australian *Acacia* species which are fibrous and of lower nutritive value.

It is possible that the combination of attributes found in *L. leucocephala* may be unique and without parallel in other species. If this is the case, improved genotypes of leucaena will need to be selected from existing germplasm collections or bred from within this genus. The extensive CSIRO collection of c.700 accessions of *Leucaena* (including c.500 *L. leucocephala*) provides a major resource.

Leucaena species

In Australia, there are currently 3 commercial cultivars of *L. leucocephala*, namely cvv. Cunningham, Peru and K8, although multisite agronomic trials have demonstrated the superiority of several other accessions of *L. leucocephala* over cv. Cunningham. These include CPI 58396 and CPI 61227 (Bray *et al.* 1988) and CPI 85176 and CPI 90814 (B. Palmer, R. Bray and Tatang Ibrahim, unpublished data). In addition, the F1 offspring of *L. leucocephala* x *L. pulverulenta* crosses and the Hawaiian cultivar K8 were superior in production of edible forage in comparison with cv. Cunningham (Bray *et al.* 1988) (Table 2).

However, all of these varieties are susceptible to psyllid damage and whilst there is some scope for biological control from the beetle *Curinius coeruleus* and the parasitic wasp *Psyllaephagus* nr. *rotundiformus* (Anon. 1990) the identification of genotypic resistance is a highly desirable solution. Overseas, *L. leucocephala* K636 shows promise both for its tolerance of psyllid attack and its performance when psyllids are absent. The species *L. diversifolia* and *L. pallida* are generally psyllid resistant and productive, but less digestible alternatives, to leucaena (R. Bray, B. Palmer and Tatang Ibrahim, unpublished data) although there is considerable variation among accessions. *L. diversifolia* CPI 46568 has a high level of psyllid resistance, and has yielded well in trials conducted by the Nitrogen Fixing Tree Association (R. Wheeler, personal communication), but in Australia was less productive than cv. Cunningham at some sites (Table 2).

Other species

Of the other species listed in Table 1, only *Albizia chinensis*, *A. lebbeck*, *Calliandra calothyrsus*, *Gliricidia sepium*, *Sesbania sesban* and *Desmanthus virgatus* have received any attention in Australia for possible use in tropical and subtropical pastures. Of these, species evaluation of the genetic diversity is being undertaken for *D. virgatus* (CSIRO, James Cook University and Queensland Department of Primary Industries) and *S. sesban* (University of Queensland). No collection of germplasm has been made of the other species even though *A. lebbeck* is found in indigenous populations from Cape York to the Kimberleys, occurs very widely as an introduction, and there are naturalized populations of introduced material.

The Oxford Forestry Institute, has an extensive collection of *G. sepium* and has coordinated a worldwide network of evaluations which demonstrated differences in both yield and other

Table 2. Yield of edible dry matter of some *Leucaena* lines at five sites in Queensland

Line	Yield of edible dry matter				
	Brian Pastures	Samford	Lansdown A	Lansdown B	Kairi
			(g/plant)		
L. Leucocephala					
cv. Cunningham	475	1113	1149	1175	1575
cv. Peru	350	764	850	712	1474
CPI 58396	689	900	1412	1449	2400
CPI 61227	664	899	1187	1202	2187
cv. K8	600	876	1300	1325	2212
L. diversifolia					
CPI 46568	363	1451	374	563	1563
F1 crosses of *L. leucocephala* x *L. pulverulenta*					
Mean of 3 hybrids	525	1263	1921	1830	2813

plant characters. They are currently assembling a collection of *C. calothyrsus*.

Agronomic characteristics

Climatic and edaphic tolerance

Climatic tolerance. All the species listed in Table 1, except *Chamaecytisus palmensis*, are tropical or subtropical in origin and therefore have little or no frost tolerance although tall mature trees may avoid light frosts which occur close to the ground. Only tagasaste (*C. palmensis*), and *A. aneura* have moderate frost tolerance while *Albizia chinensis*, *A. lebbeck*, *C. calothyrsus*, *L. diversifolia* and *S. sesban* are noted for their cool season growth; *S. sesban* has outstanding cool season growth compared to the other species (Figure 1) although it is not tolerant of frost.

Identification of new germplasm which has both cold and light frost tolerance should receive priority in research programs especially within the higher nutritive value species such as *L. leucocephala*. The presently used cultivars provide little cool season growth and shed their leaves, even after light frosts (Isarasenee *et al.* 1984). Other species such as *G. sepium*, and *Tipuana tipu* are deciduous in the cool season of subtropical Queensland (Gutteridge 1990; Whiteman *et al.* 1986) while *A. lebbeck* is deciduous in the dry season over its entire range of adaptation.

The generally accepted rainfall tolerances of tree legumes indicate that many species are adapted to a wide range of rainfall environments, although not arid environments, and this is one of their advantages. The accepted rainfall range of *L. leucocephala* (750-3000 mm) is wide although yields are generally much reduced at rainfall levels < 1500 mm (Brewbaker *et al.* 1985). However, it is very drought tolerant even during establishment.

Edaphic tolerance. Highest productivity of leucaena is obtained on fertile soils (Cooksley *et al.* 1988). However, one of the advantages of leucaena is that it will persist on less fertile soils without regular fertilizer application. Tree legumes exhibit a wide variety of other tolerances of soil conditions (Table 1). *Calliandra calothyrsus, Flemingia macrophylla* and *G. sepium* are reported to be tolerant of very acidic soils (Palmer *et al.* 1990, Glover 1984, Budelman, 1989) and leucaena is recognized as being more

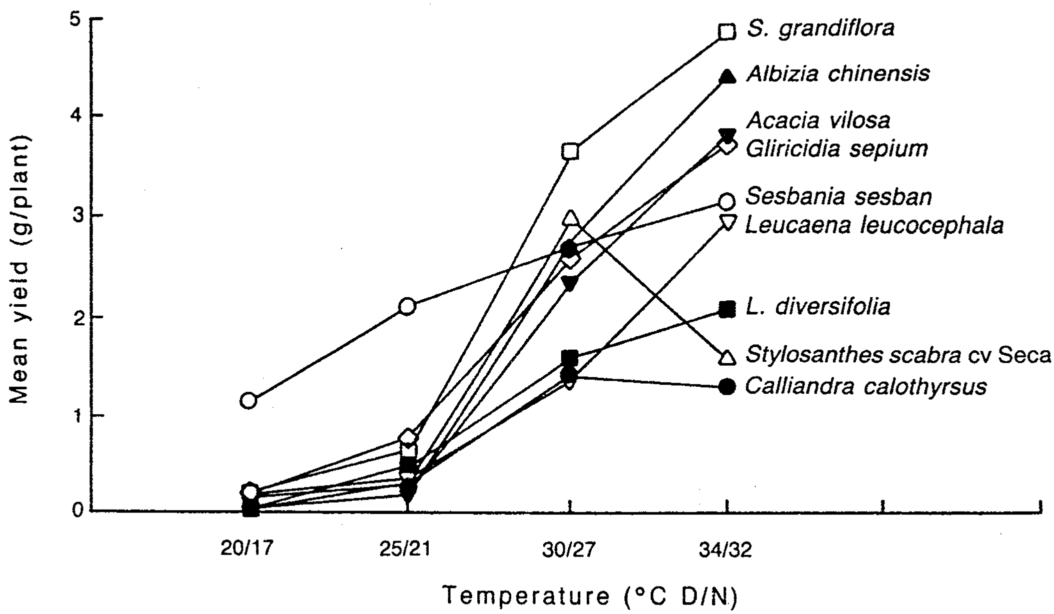

Figure 1. The response of nine tree legume species to variation in day/night temperature in a controlled environment glasshouse (S. Swasdiphanich, unpublished data).

tolerant of soil acidity than originally thought (Ruaysoongnern 1990). Many species are adapted to alkalinity while *Sesbania* species and *A. lebbeck* are well adapted to saline soils (Table 1). Tree species also vary in their tolerance of water-logging with *S. sesban* demonstrating excellent tolerance and *A. chinensis* being quite intolerant (Table 3).

Table 3. Water logging tolerance of eight leguminous shrubs and trees

Waterlogging tolerance group	Species	Reduction in yield as moisture increased from 90 to 140% field capacity (% reduction)
Excellent tolerance	*S. sesban*	1
Good tolerance	*A. villosa*	14
Moderate tolerance	*S. grandiflora*	25
	A. americana	29
	G. sepium	31
Moderate intolerance	*L. leucocephala*	47
	C. calothyrsus	47
Intolerant	*A. chinensis*	75

Source: M.C. Galang, R.C. Gutteridge and H.M. Shelton, unpublished data

Establishment

Many tree legume species exhibit slow early seedling growth even though mature growth may be vigorous. An exception is *S. sesban* (Figure 2). During establishment, plants are susceptible to competition from weeds (Maasdorp and Gutteridge 1986) and predation by wildlife and this has often resulted in an extended period of establishment and sometimes establishment failures (Lesleighter and Shelton 1986). For this reason, well-prepared seedbeds and clear cultivation during the year of establishment are recommended for leucaena and a number of herbicides are now available for pre and post-emergence control of weeds (Brewbaker *et al.* 1985). Full cultivation may also promote conservation of moisture. (Pratchett and Triglone 1990).

Recent work has demonstrated the importance of microbial symbiotic associations with the roots of tree legumes. The new *Rhizobium* strain *(TAL 1145)* is more effective than previous strains for nodulation and N fixation of leucaena (Halliday and Somasegaran 1983) and work is underway to identify the most effective strains for *S. sesban*

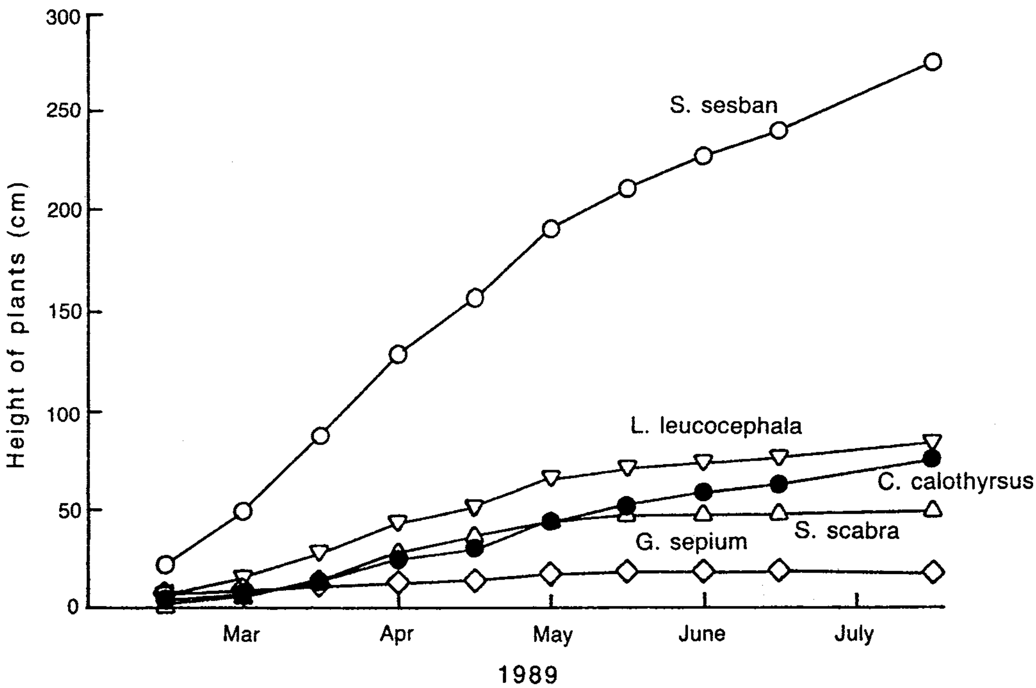

Figure 2. Seedling growth rates of five tree legume species at Redland Bay in Southeast Queensland (S. Swasdiphanich, unpublished data).

(M. Masafu, unpublished data). In controlled environment studies, vesicular arbuscular mycorrhizal (VAM) associations with roots of tree legumes were demonstrated to be an important factor in the growth, nodulation and phosphorus nutrition of leucaena (Ruaysoongnern 1990) and for the growth of *C. calothyrsus* (B. Palmer, unpublished data). Field testing of these microbial symbioses is needed.

Much less work has been done on the nutrient requirements of tree legumes compared to herbaceous legumes. The most detailed study with leucaena is that of Ruaysoongnern *et al.* (1989) who reported the critical concentrations and external rates of application required by seedlings for a range of nutrients. These and other data on the concentration of nutrients in plant tissue may be used as indicators of sufficiency of supply (Table 4). Similar data for other species are not available.

Table 4. Concentration of various nutrients in the young leaves of nodulated *Leucaena leucocephala*

Element	Critical conc. in young leaf of seedlings (Ruaysoongnern *et al.* 1989)	Young leaf of healthy cv. Peru trees (Jones 1979)	Mean conc. in young leaf of cv. Peru trees at several sites (Shelton, unpublished data)
N (%)	4.1	4.1	5.4
P (%)	0.25	0.21	0.32
K (%)	2.0	1.5	2.01
S (%)	0.24	0.27	0.31
Ca (%)	0.49	0.66	0.98
Mg (%)	—	0.31	0.30
Na (%)	—	0.03	0.03
Cu (ppm)	—	7	9
Zn (ppm)	—	29	29
Mn (ppm)	325	—	45
Fe (ppm)	—	—	164

Planting of leucaena by seed to form hedgerows is the most common method for broad-acre sowings in Australia. Appropriate row spacings for leucaena range from 2-10 m. Taller species such as *A. lebbeck* would most likely be planted as spaced trees (Lowry 1990). Techniques for direct drilling of seed may need to be developed to achieve wider spacing along rows. More work is also required to ascertain the effect of planting configuration for tree legumes on the competition with companion grass and on the contribution to the animal diet.

Work at the University of Queensland, has demonstrated the feasibility of establishing rows of leucaena on arable land in conjunction with summer cereal crops such as maize or sorghum (K. Jeanes, R.C. Gutteridge and H.M. Shelton, unpublished data) with minimal effect on cereal yield. This technique, which has been reported elsewhere (Savory *et al.* 1980, Gill *et al.* 1982), has the advantage that the cost of establishment and the long delay before first grazing is absorbed in the value of the cereal crop. However, the technique may not be suitable for drier regions where the level of stored moisture will be reduced by the cereal crop and the growth of leucaena plants may be limited.

Persistence

The longevity of, and therefore the persistence under grazing of leucaena is one of its great advantages. Jones and Carter (1989) report it to have a half-life of over 50 years. Less is known of the life cycle of other species especially under regular defoliation. However, species such as *S. sesban* and *C. gyroides* are known to be short-lived while some of the tree species (e.g. *S. grandiflora* and *A. lebbeck*) will not survive regular defoliation.

Influence of trees on grass growth and quality

In the seim-arid pastoral regions of northern Australia it is generally accepted that many native trees have a negative effect on pasture growth (Burrows *et al.* 1988). Many *Eucalyptus* species are generally recognized as being unsuitable for agroforestry purposes; however, recent reports from Australia and elsewhere in the world suggest that some trees, usually leguminous, may be beneficial to understorey herbage and that this effect may be species and ecosystem specific (Bille 1978, Le Houerou 1978, Pinney 1989, Raintree 1987, Lowry *et al.* 1988 and Wilson *et al.* 1990).

The enhanced grass growth observed in the shade of trees may be partly related to the recycling of nutrients, but is certainly associated with increased availability of soil N (Wilson and Wild 1990). This effect also occurs under artificial shade and appears related to increased rates of mineralization of organic N and perhaps to decomposition of litter, in "run-down" grass pastures.

A further unquantified effect of the tree canopy on understorey grass, is its influence on the length of the growing season. We have observed that growth of shaded grass has continued into dry periods well after surrounding unshaded grass has ceased growing. Trees also protect grass from the effects of frosts. Both these aspects require further study.

Another effect of shade which has been the subject of recent study is its influence on the quality of shaded grass. Variable results have been reported. Hight *et al.* (1968) and Samarakoon *et al.* (1990) showed a reduced intake by sheep of shaded compared to herbage grown under full sunlight while Norton *et al.* (1990) showed no difference. It appears that under conditions of adequate N supply, there may be no effect of shade on grass quality.

Animal production and management

The high quality and animal production potential of leucaena over a wide range of environments is now widely appreciated (Jones and Jones 1984, Davison 1987). The outstanding quality of leucaena forage can be related to a number of factors viz., excellent palatability and digestibility and therefore intake of herbage; balanced chemical composition of protein, minerals (except Na and I) and amino acids (Jones 1979); low fibre content; moderate tannin content to promote by-pass protein value; and the biological solution of the problem of toxicity of the non-protein amino acid mimosine and its degradation products 3,4 and 2,3 DHP (Jones and Lowry 1984).

Much less is known about the nutritive quality of other species of tree legumes but there is reason to doubt that alternative germplasm of equivalent quality will be found (Brewbaker 1986). The quality of most Australian native fodder trees is known to be low (Wildin 1989).

There is great variation in the quality of foliage among the exotic species. Digestibility (*in sacco* or *in vitro*) varies from very high ($> 65\%$) (*S. sesban* and *G. sepium*) to moderate (50-65%) (*A. lebbeck* and *C. gyroides*) to low (30-50%) (*A. chinensis*, *C. calothyrsus* and *L. diversifolia* (Robertson 1988, Bamualim, 1981). Crude protein values may be low ($< 20\%$) (e.g. *A. aneura* and *F. macrophylla*). The amount of protein degradation in the rumen and final delivery of bacterial and undegraded plant protein to the intestines will be affected by the amount of condensed tannin present and this aspect of the quality of tree legumes is largely unstudied. In one experiment, condensed tannin content, in the accessions tested, varied from very high in *C. calothyrsus* (11%) to none in *A. lebbeck* and *S. sesban* (Ahn *et al.* 1989). There are reports of poor acceptability of species such as *G. sepium*, *C. calothyrsus* and *S. sesban* which may be related to varietal differences, state of fed material, and feeding history of animals. The acceptance of *G. sepium* is reported to increase after wilting and this may be related to reduction in condensed tannin content with drying (Ahn *et al.* 1989). More work is also required on other anti-quality factors such as the saponins in *S. sesban*.

The supplementary feeding value for small ruminants of species such as *G. sepium* (Chadhokar 1982) and *S. sesban* (Singh *et al.* 1980) has been well established. *A. lebbeck* is notable for the variety of edible products (green leaf, fallen leaf, flower and pod). These have been evaluated with sheep as a sole diet (Lowry 1989) and shown to be good quality feed and as supplements to spear grass (Schlink *et al.* 1990). However, very little is known of the feeding value of species other than leucaena in intensive grazing systems. Preliminary results of a small grazing trial at the University of Queensland Mt Cotton farm conducted between March and October 1990 indicated that an initial period of "acclimatization" of 2-3 months was required before weaner heifers consumed *S. sesban* in a mixed *S. sesban*/signal grass (*Brachiaria decumbens*) pasture. They subsequently gained an average of 30 kg more than animals on signal grass alone. However, *S. sesban* has more brittle stems than *L. leucocephala* and there was considerable damage to trees from the grazing animals. The susceptibility of the various species to damage from grazing animals and the effect on persistence is not well understood.

It may also be possible to increase animal production indirectly by incorporation of taller tree species such as *A. lebbeck* into grass paddocks in a genuine agroforestry system. Production of fodder *may* be increased from high quality leaf and pod fall during autumn and winter, and increased yield and extended growth period of desirable grass species due to the "canopy effect" of the trees (Lowry 1989).

Further work is clearly required to elucidate the contribution of tree legumes to animal production in grazing systems and the costs versus benefits of establishment of such systems.

Environmental impact

Agroforestry uses

There is currently growing interest by landholders in the greater use of trees on farms. This has been stimulated by the wide publicity given to land degradation and soil erosion and an appreciation of the protective benefits of trees in the landscape.

Whilst practical methods and systems for the incorporation of trees onto farms still need to be developed, evidence from research shows that tree legumes planted on the contour of sloping lands can help reduce soil erosion (Metzner 1982; Piggin and Parera 1984; Panning-batan *et al.* 1989). A ten fold reduction in soil loss has been observed from a cultivated podzolic soil on a slope of 10% protected by 5m wide rows of *L. leucocephala* and *C. calothyrsus* (R.C. Gutteridge, unpublished data). Other possible uses of tree legumes are as windbreaks and shelter belts.

Weed potential

Leucaena is a declared weed in the city of Darwin, Northern Territory. It is an offence in Vanuatu to transport leucaena seed between islands. Leucaena can form thickets along creeks and can dominate natural ecosystems if no ruminant grazers are present.

Tree legumes have great potential to invade and devastate the productivity of natural grassland communities. The introduced thorny species *Acacia nilotica* on the Mitchell grasslands of Australia and *Prosopis glandulosa*, the mesquite of Southern U.S.A., are two such examples.

A consideration of weed potential must now be an integral part of current and future evaluation programs. We must carefully consider the implications of the life cycle, acceptance by livestock, and effects of livestock on seed dispersal.

Grazier acceptance

In the past, graziers and scientists have often perceived trees to have a negative impact on pasture productivity. The initial slow adoption of leucaena may have been partly related to this perception as well as to problems of poor establishment and of mimosine toxicity (Wildin 1981; Lesleighter and Shelton 1986). However, many graziers in Central Queensland now accept fodder trees as a valuable component in forage systems and believe that a greater variety of species are needed for the diversity of soils and climatic conditions experienced in northern Australia. This can be related to the continuing success of leucaena in sub-coastal Queensland and to the conclusion that, in the present economic climate, leucaena is one of the most profitable and cost-efficient forages avaialable (T. Ryan and C. Rosenberger, unpublished report; S. McGhie, personal communication).

Conclusions and priorities

There are now strong economic and environmental reasons to explore the potential of exotic fodder tree legumes further. The *Leucaena* genus, in particular, merits further study as varieties with cool season growth and psyllid resistance would extend the current environmental range of valuable species such as *L. leucocephala. A. lebbeck* appears to have some potential for extensive systems in drier areas > 600 mm.

A number of other exotic species offer potential, and their genetic diversity requires further evaluation. More information is required on their environmental adaptation and yield potential, microbial associations, establishment requirements and seed production characteristics. Current work on the effects of canopy shade or understorey grass growth and quality contributes to our understanding of agroforestry systems and should be continued.

Apart from leucaena, our knowledge of the nutritive quality, including animal acceptance and anti-quality factors, of tree legumes is poor and we know little of the animal production potential or management requirements of such species.

In the present political climate and with the current interest in land care, farmers are likely to be interested in incorporating new tree species in rural production systems once proven species and low cost methods of establishment are available.

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