Yield and quality of *Gliricidia sepium* accessions at two sites in the tropics

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Abstract

Twenty-eight accessions of gliricidia (largely from the Oxford Forestry Institute collection) were evaluated under cutting at Utchee Creek, north Queensland, and a subset of 22 also evaluated in North Sumatera, Indonesia. There were up to 3-fold differences in yield between accessions, but relative yields across harvests were fairly consistent. In Australia, the best lines were CPI 113739 and 113742 (OFI 14/84 and 17/84 respectively); in Indonesia, CPI 113739 and 113749 (OFI 14/86) were the best, particularly in dry season production. There was a range of 68–80% in *in sacco* digestibility, but dry matter digestibility was positively correlated with yield. It is thus possible to select high yielding, highly digestible accessions. There was a considerable range of mineral contents. Levels of P and Na may be insufficient for sustained high animal production. It may be possible to select accessions with favourable nutrient composition but this may necessitate some compromise in yield.

Resumen

Se evaluaron 28 accesiones de gliricidia (la mayor parte de la colección del Instituto Forestal de Oxford) bajo corte en Utchee Creek, al norte de Queensland; un sub-grupo de 22 accesiones fue también evaluado en el Norte de Sumatera, Indonesia. Se encontraron diferencias de hasta tres veces en el rendimiento entre accesiones, pero los rendimientos relativos entre cosechas fueron consistentes. Las mejores líneas en Australia fueron CPI 113739 y 113742 (OFI 14/84 y 17/84, respectivamente); las mejores líneas en Indonesia fueron 113739 y 113749 (OFI 14/86), especialmente durante la época de seca. La digestibilidad in sacco *tuvo un rango de 68–80%, sin embargo la digestibilidad de la materia seca estuvo positivamente correlacionada con el rendimiento. Por lo tanto, es posible seleccionar accesiones con alto rendimiento y alta digestibilidad. Hubo un rango considerable en el contenido de minerales. Puede ser que los niveles de P y Na no sean suficientes para mantener una producción animal alta. Podría ser posible seleccionar accesiones con una composición favorable de nutrientes, pero esto implicaría un compromiso con el rendimiento.*

Introduction

Gliricidia sepium (gliricidia) is a deep rooted perennial leguminous tree which was introduced to south-east Asia from its native central America. Although its original use was primarily for a shade plant in coffee and cocoa plantations, it is now widely used both as "living fences" and as a feed source for ruminants in cut-and-carry systems (Wiersum 1989). Gliricidia forage has a pungent smell, but is generally consumed readily by animals after an adaptation period, or after wilting. There are no reported toxic effects in ruminants, although it has been reported to contain coumarin, hydrocyanic acid and tannins (Smith and van Houtert 1987). Gliricidia has the potential to provide a high quality supplemental feed throughout the year in the tropics, both in cut-and-carry systems and under direct grazing (Falvey 1982; Chadhokar 1982).

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Until recently only a restricted range of gliricidia has been available for study, so potential forage yields are uncertain. However, recent collections from throughout its extensive distribution in Mexico and central America have been made by the Oxford Forestry Institute. This paper reports on the variation in yield and quality of a range of gliricidia accessions at 2 sites in the tropics.

Materials and methods

Sites

Experiments were established at 2 sites — at Utchee Creek (17°45'S, 146°00'E) in north Queensland (Australia), and at Sei Putih (3°30'N, 99°00'E) near Medan in North Sumatera, Indonesia. The soil at the Utchee Creek site is classified as an oxisol and is a highly weathered uniform-textured soil of basaltic origin. The soil at Sei Putih is classified as a tropudult and is in excess of 150cm deep; the soil parent material is probably an old alluvium derived from redistributed acid volcanic tuff. Both soils have a pH of about 5 in water, low exchangeable calcium (1.5meq/100g), and low aluminium saturation (10%). Both soils are well drained and are of moderate fertility, having previously been used for pasture production (Utchee Creek) and rubber production (Sei Putih). The Utchee Creek site has a long-term mean annual rainfall (MAR) of about 3500 mm with less than 20% of the annual precipitation falling between June and September. The Sei Putih site has a long-term MAR of about 1900 mm, well distributed throughout the year, although January, February, March and April are the driest months. Rainfall data for the two sites during the experimental period are shown in Figure 1.

At each site, seedlings were raised for about 8 weeks in 300 ml black plastic bags containing local soil. Twenty-eight lines (Utchee Creek) and 22 lines (Sei Putih) were planted in a randomised block design with 3 replicates on 20 December 1987 (Utchee Creek) and 17 January 1988 (Sei Putih). Rows were spaced 2 m apart, with plants 50 cm apart within the rows at both sites. Plot size was 6 plants at Utchee Creek, and 12 plants at Sei Putih. All seedlings were inoculated with the appropriate rhizobium. At planting, 20 kg/ha P as Mo superphosphate, spread in a 50 cm-wide

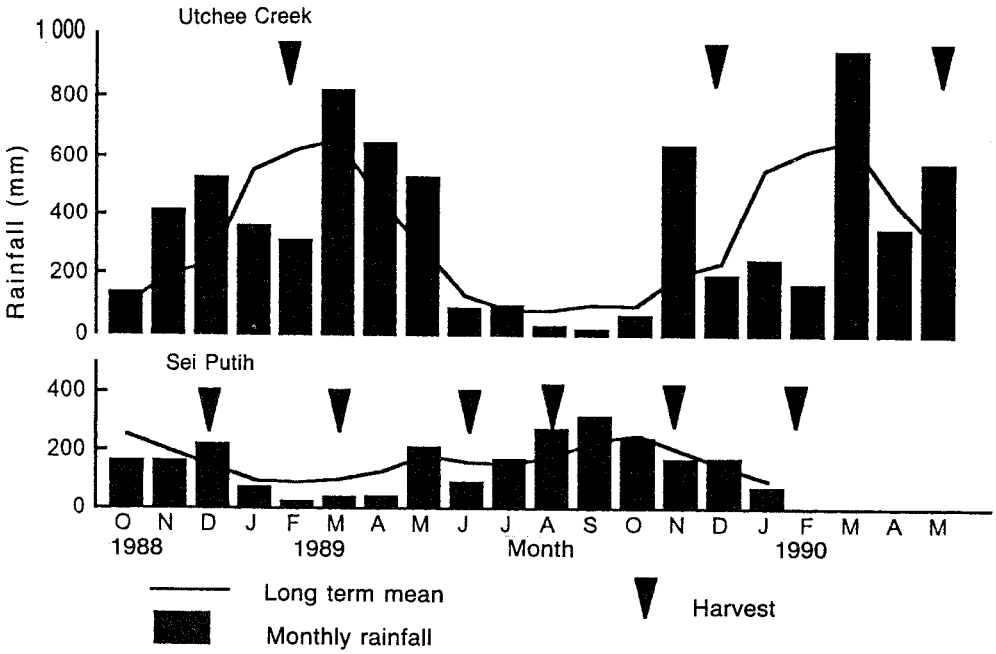

Figure 1. Monthly and long term mean rainfall at Utchee Creek (Australia) and Sei Putih (Indonesia) and harvest times.

band along the row, was applied at both sites. Apart from initial watering to ensure establishment, no irrigation was applied. Weeds were controlled by hand-chipping until the gliricidia was well established.

Gliricidia lines

Most of the entries (Table 1) were supplied by Oxford Forestry Institute as part of an international series of trials. The accessions from India and Indonesia are not native to those areas. CPI 60796 has been widely tested in a range of experiments in Australia and Indonesia (Palmer *et al.* 1990). Of the 28 accessions grown at Utchee Creek, only 22 were sown at Sei Putih, due to limited seed supplies. Accessions will be referred to throughout the paper by the last two digits of their CPI number (e.g. 39 is CPI 113739).

Site management and data collection

Utchee Creek: The experiment was subjected to a clearing cut (to 75 cm height) on September 14, 1988, and plots subsequently harvested on February 15 and December 11, 1989; and May 15, 1990. The first and third harvests represent growth in the wet season, and the second harvest growth in the dry season. At each harvest, yield samples were taken from the central 4 plants in each plot, which were cut to 75 cm. These were sub-sampled to enable the conversion of total yield to dry weight yield of edible material (leaf plus stem to 5 mm diameter), hereafter referred to as leaf yield.

Sei Putih: Following a clearing cut to 75cm on August 31, 1988, plots were harvested 6 times at approximately 3-month intervals (December 23, 1988; March 6, June 6, August 26 and November 18, 1989; and February 10, 1990). Ten plants were harvested per plot, and at each harvest, subsamples were taken to estimate leaf dry weight.

Statistical treatment of data

We do not believe that "split-plot in time" analyses of harvest x accession interactions have

Table 1. Details of the gliricidia collection.

CPI number	Other ID (OFI)	Country of origin	Altitude	Rainfall	Grown at Utchee Ck	Grown at Sei Putih
			(m)	(mm)		
113733	24/86	Colombia	20-50	950	yes	yes
113734	13/86	Panama	5-10	850	yes	yes
113735	1/86	Venezuela	520	800	yes	yes
113736	11/86	Costa Rica	20-100	1000	yes	yes
113737	12/86	Costa Rica	20-100	1000	yes	yes
113738	13/84	Guatemala	950	1060	yes	yes
113739	14/84	Guatemala	330	3500	yes	yes
113740	15/84	Guatemala	150	700	yes	yes
113741	16/84	Guatemala	450	830	yes	yes
113742	17/84	Guatemala	5	1650	yes	yes
113743	24/84	Honduras	480	1400	yes	yes
113744	25/84	Honduras	825	1100	yes	yes
113745	10/86	Honduras	450	1200	yes	yes
113746	29/84	Nicaragua	220	1200	yes	yes
113747	30/84	Nicaragua	605	800	yes	yes
113748	31/84	Nicaragua	60	1100	yes	yes
113749	14/86	Nicaragua	75	1650	yes	yes
113750	33/85	Mexico	1100	650	yes	yes
113751	34/85	Mexico	10-50	1130	yes	yes
113752	35/85	Mexico	10-30	950	yes	yes
113753	36/85	Mexico	100-150	1500	yes	no
113754	37/85	Mexico	600-700	1030	yes	no
113755	38/85	Mexico	0-30	900	yes	yes
113756	39/85	Mexico	30	1400	yes	no
113757	40/85	Mexico	30	1796	yes	no
113758	41/85	Mexico	60-100	800	yes	yes
110576		Indonesia			yes	no
60796		India			yes	no

much validity in the analysis of data from experiments involving repeated harvests of perennial plants, due to the almost certain violation of several assumptions normally implicit in analysis of variance. Consequently, simple analyses of variance were performed only on data from single harvests, and on data pooled over harvests, using the NEVA statistical package.

Measurement of nylon bag digestibility and chemical analysis

At Utchee Creek on May 24, 1989, leaf samples were collected from each line in the Oxford collection in all replicates and snap frozen in the field using solid carbon dioxide. The frozen samples were then stored at −15 °C prior to freeze drying. The dried material was cut to a maximum length of 5 mm for nylon bag digestibility studies. Samples in the nylon bags (100 x 250 mm, 44 micron pores) were incubated for 48 h in the rumen of fistulated swamp buffaloes fed *Stylosanthes hamata* chaff. After incubation the nylon bags were washed thoroughly until clean and then freeze dried. The same leaf samples were bulked and used for chemical analysis (N, P, S, Ca, Mg, Na, K).

Results and discussion

Leaf:stem ratio

Utchee Creek: No significant differences ($P > 0.05$) were detected for leaf:stem ratios of the different accessions for the three harvests (means 0.80, 1.20, and 1.16 for harvests 1, 2, and 3 respectively). Data subsequently reported in the paper are for leaf yield only.

Sei Putih: Data on stem weights are available only for the first two harvests. Although there were significant differences ($P < 0.01$) between leaf:stem ratios at both harvests, there was no consistency between the two harvests; on an individual plot basis, $r = 0.17$. Mean leaf:stem ratios were 0.95 and 1.65 for harvests 1 and 2. Data reported below are for leaf yield only.

Yield at Utchee Creek

There was a 3-fold difference between the leaf yields of the best and worst accessions (Table 2). However, as is common with yield data from small plots of shrub legumes, the CVs for individual harvests were of the order of 35–40%, and thus significant differences were difficult to establish. Performance of accessions across harvests was generally fairly consistent. However, on the basis of rankings, and particularly dry season performance, accessions 39 and 42 appear to be superior. The poorest performing entries were the "non-Oxford" lines 76 and 96, and accession 58. The yield of the best accession of approximately 10 t/ha/yr (allowing for the total period of harvests) compares favourably with yields obtained in an adjacent experiment from *Leucaena leucocephala* cv. Cunningham of 6 t/ha/yr, gliricidia CPI 110398 8 t/ha/yr, and *Calliandra calothyrsus* CPI 110395 13.5 t/ha/yr (B. Palmer, T. Ibrahim and R.A. Bray, unpublished data).

It can be seen from Figure 1 that the 2 wet seasons experienced in this experiment were drier than the long-term average. In addition, at harvest 3 (made in May) growth may have been restricted by low night temperatures. Thus potential yield may be higher than obtained in this experiment.

Yield at Sei Putih

Productivity varied greatly among the 6 harvests (Table 3), with the greatest difference between harvests 2 and 3. This difference probably reflects the limiting effect of the dry season early in 1989. Again, there was a wide range in yield among accessions, with 39 and 49 being the highest yielding accessions overall. It is interesting to note that these 2 accessions performed outstandingly well at the 2 dry season harvests (2 and 6), where their yields were 45% greater than the next most productive accession.

The relationship between performance at the two sites

By comparing rankings of total yields, it is clear that there was a general positive relationship between performance at the 2 sites (Spearman's Rank Correlation Coefficient $r_s = 0.52$, $P < 0.02$). Accession 39 ranked first at both sites, and 58 ranked last of the common set. However there were several major changes in rank across the sites, the most notable being the much better performance of 46 at Utchee Creek, compared

Table 2. Leaf yields of 28 gliricidia accessions at Utchee Creek.

CPI	Harvest 1	Rank	Harvest 2	Rank	Harvest 3	Rank	Total	Rank
	t/ha		t/ha		t/ha		t/ha	
113733	4.30	11	2.70	18	2.96	7	9.96	12
113734	2.67	25	1.62	27	1.26	26	5.55	25
113735	3.74	18	3.48	10	2.75	9	9.97	11
113736	3.60	20	2.44	20	2.42	13	8.46	19
113737	4.95	8	4.32	3	2.50	11	11.76	7
113738	6.42	1	3.82	8	3.68	2	13.91	3
113739	6.33	2	5.35	1	3.84	1	15.52	1
113740	4.10	14	2.95	16	2.70	10	9.75	14
113741	5.10	6	4.04	6	2.83	8	11.97	6
113742	5.96	3	4.77	2	3.21	5	13.93	2
113743	4.14	13	2.58	19	1.93	17	8.65	18
113744	3.75	17	3.45	12	2.18	16	9.37	16
113745	4.34	10	2.98	15	2.99	6	10.30	10
113746	4.82	9	4.10	4	3.42	3	12.35	5
113747	3.82	16	3.46	11	2.20	15	9.49	15
113748	5.84	4	3.94	7	3.26	4	13.04	4
113749	4.96	7	4.05	5	1.88	18	10.89	8
113750	3.07	24	2.02	24	1.57	23	6.66	24
113751	3.51	22	2.94	17	1.45	24	7.90	22
113752	3.55	21	2.44	21	2.36	14	8.35	20
113753	5.51	5	3.41	13	1.68	21	10.60	9
113754	3.38	23	3.10	14	2.48	12	8.95	17
113755	4.25	12	3.81	9	1.77	19	9.83	13
113756	3.69	19	2.34	23	1.73	20	7.76	23
113757	4.05	15	2.36	22	1.59	22	8.00	21
113758	2.14	28	1.85	25	0.53	28	4.52	28
110576	2.23	27	1.45	28	1.41	25	5.09	27
60796	2.66	26	1.76	26	0.75	27	5.17	26
MEAN	4.17		3.13		2.26		9.56	
LSD (P = 0.05)	1.7		2.17		1.53		4.73	

Table 3. Leaf yield (t/ha) of 22 gliricidia accessions at Sei Putih over an 18-month period.

CPI	Harvest number 1	2	3	4	5	6	Total	Rank
113733	2.12	1.21	1.99	2.47	2.11	0.99	10.88	5
113734	0.85	0.23	1.52	1.37	1.48	0.84	6.30	20
113735	1.94	1.06	2.79	2.80	1.44	1.17	11.19	3
113736	1.30	0.63	2.11	2.17	1.27	0.94	8.41	15
113737	1.20	0.49	1.82	1.75	2.00	0.51	7.77	18
113738	1.20	0.75	2.37	2.34	1.83	0.96	9.45	11
113739	1.97	1.91	2.99	2.43	2.75	1.31	13.36	1
113740	0.98	0.64	2.50	2.27	2.06	0.95	9.39	13
113741	1.39	0.97	2.83	2.40	1.66	1.02	10.28	6
113742	1.32	0.72	2.78	2.65	2.23	1.47	11.16	4
113743	1.69	0.76	2.24	2.14	2.00	1.29	10.11	8
113744	1.01	0.37	1.77	1.83	2.73	0.96	8.68	14
113745	1.87	0.83	2.49	2.25	1.88	0.93	10.25	7
113746	0.76	0.29	1.52	1.46	1.49	0.68	6.20	21
113747	1.20	0.74	2.44	2.52	1.71	0.97	9.57	10
113748	1.11	0.68	2.28	2.22	2.11	1.05	9.44	12
113749	2.53	1.53	2.63	2.73	2.10	1.65	13.17	2
113750	1.44	0.67	2.69	2.61	1.88	0.62	9.92	9
113751	1.12	0.43	1.94	1.58	1.18	0.34	6.58	19
113752	0.98	0.66	2.36	1.86	1.50	0.44	7.79	17
113755	1.07	0.57	2.28	2.07	1.51	0.41	7.90	16
113758	0.67	0.21	1.07	0.84	0.93	0.16	3.87	22
MEAN	1.35	0.74	2.25	2.12	1.81	0.89	9.17	
LSD (P = 0.05)	0.88	0.61	0.86	0.74	1.06	0.88	3.32	

to Sei Putih. Other accessions to do better at Utchee Creek were 37, 38, and 48, while 43, 49, and 50 performed markedly better at Sei Putih. These changes could have been due to the different harvesting regimes employed, or the different environments, but it seems clear that selection of the best line(s) would have been effective quite early in the program. In these trials we have seen little evidence of differences in persistence; hence evaluation for more than one year may not be warranted, and selection of the best lines in the dry season would result in the best overall selections.

We have been unable to discern a relationship between the origin of the accessions and their subsequent performance. Accession 39 came from an area with 3500 mm rainfall, but 49 from a 1650 mm zone. The latter may have been more suited to the relatively drier environment at Sei Putih.

Nylon bag digestibility and nitrogen content

Dry matter disappearance after 48 hours from the intra-ruminal nylon bags ranged from 68–80% (CV 4%, SE 1.9) (Table 4). Significant differences occurred between accessions, and there were no differences between field replicates or animals used. There was a small though positive relationship between yield and digestibility ($r = 0.47$, $P < 0.02$), and several lines showing high values for both characters could be identified. For example, line 39 ranked second in yield at this harvest, and equal second in digestibility. It would have produced the highest yield of digestible dry matter. Nitrogen content of the leaf ranged between 3.00–4.15%, again with a poor correlation with yield ($r = 0.49$, $P < 0.01$). Accession 39 again stood out for its high N content and high yield, but 96 was poor for both characters.

Mineral composition

The ranges of data from chemical analyses are summarised in Table 4, together with detailed data from 5 of the higher yielding accessions. In general, the levels are similar to those already reported (see for example Chadhokar 1982; Smith and van Houtert 1987), but we are not aware of previous documentation of nutrient contents of a range of genotypes. There was considerable variation (generally about 2-fold) for all nutrients studied. In general, the levels of N, K, Ca and Mg are adequate for high levels of animal production but S levels may not be (Minson 1990). Levels of P and Na are insufficient for high levels of production in dairy cows (NRC 1978). The high yielding lines in particular seem to be low in Na (except 78). Using gliricidia as a supplementary feed over a long period of time (especially for dairy cows) may require mineral supplementation if Na deficiency is to be avoided. It may be possible to select genotypes with particular chemical characteristics but compromises may need to be made with regard to dry matter production (e.g. line 56, although low yielding, has a high Na content of 0.28%).

Overall, based on both yield and quality data, CPI 113739 is the outstanding accession tested in these experiments. This is consistent with the outstanding performance of this accession at other sites in the OFI series (A. Simons, personal communication). CPI 60796, used in many other experiments, was one of the poorer lines tested.

Table 4. Chemical composition and digestibility of a range of gliricidia accessions grown at Utchee Creek. Data shown are the ranges for the whole collection, plus individual values for five high-yielding accessions.

Accession	Chemical composition							Digestibility
	N	P	K	Na	Ca	Mg	S	
				%				%
113738	3.73	0.20	1.18	0.04	0.98	0.33	0.14	75
113739	4.15	0.24	1.32	0.05	1.12	0.40	0.16	79
113742	3.61	0.18	0.79	0.10	1.13	0.34	0.15	77
113748	3.71	0.20	1.25	0.17	1.06	0.36	0.13	78
113749	3.93	0.19	0.75	0.12	1.20	0.33	0.17	75
From all 28 accessions:								
Mean	3.63	0.19	0.91	0.13	1.01	0.33	0.14	75
Maximum	4.15	0.25	1.32	0.28	1.21	0.45	0.17	80
Minimum	2.94	0.15	0.59	0.03	0.69	0.24	0.09	68

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