Regional evaluation of herbaceous and tree legumes in West Java, Indonesia

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Abstract

The agronomic performance of 88 herbaceous legumes, including 65 different species in 19 genera, was evaluated in one experiment and 39 shrub and tree legumes, including 18 different species and 3 unidentified species from 10 genera, were evaluated in 2 experiments, in small, single-row plots over 3 years at Ciawi, West Java. A number of agronomic attributes were measured or estimated by visual ranking at monthly intervals to assess establishment/persistence, vigour, yield, disease/pest resistance, habit, drought resistance and reproductive capacity. Multivariate classification analysis was used to group accessions with similar agronomic performance in 2 experiments. A fourth experiment contained only 13 tree accessions and therefore did not warrant classification analysis. Leaf damage to *Leucaena* accessions caused by the leucaena psyllid in the three tree experiments was assessed.

Following initial assessment without defoliation, the herbaceous and tree legume experiments were cut 4 times over a 17-month period and 5 times over a 20-month period, respectively. The most persistent and highest yielding herbaceous legume species were: *Stylosanthes guianensis* cvv. Graham, Cook and Endeavour, *S. scabra* cv. Seca, *S. hamata* cv. Verano, *Neonotonia wightii* cvv. Tinaroo and Clarence, *Clitoria ternatea* and *Pueraria phaseoloides*. Promising species for possible use in communal grazing areas and in cropping systems were also identified. The highest yielding tree species was *Calliandra calothyrsus*. High yields were also produced by *Leucaena leucocephala* prior to the appearance of the leucaena psyllid insect early in 1986. Some variation in susceptibility to the psyllid was recorded between accessions. Other promising species were: *Gliricidia sepium*, *Sesbania formosa*, *S. sesban*, *Desmodium rensonii* and *Codariocalyx gyroides*.

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Introduction

Leguminous herbs, shrubs and trees can potentially provide a high quality source of forage for ruminant livestock. In West Java, many farmers cut-and-carry forage to feed penned or tethered animals. Leguminous forages can be used to supplement these poorer quality forages obtained from non-cropping areas (roadsides and communal grazing lands) and under plantation crops and as residues from cropping lands. In addition, legumes can be sown in monocultures or with grasses in swards for intensive cut-and-carry systems or used as relay, alley and inter-crops (Siregar and Semali 1982) in cropping systems or oversown or planted into communal grazing areas. Leguminous trees also have other multipurpose uses, such as living fences, shade, timber or fuelwood. These widely divergent forage production systems and uses demand different types of forage species. There was a need therefore to evaluate herbaceous and tree species which covered a wide range of growth habits, growth and phenological characteristics and seed production potential.

Research on forages in this region has concentrated on intensive, high production systems based on highly fertilised grasses (Siregar *et al.* 1974, 1980; Verna and Manurung 1976; Manurung 1977). Previous evaluations of the adaptation and productivity of herbaceous and tree legumes in this region have been confined to a relatively small number of species. Although there has been some assessment of the yield of individual herbaceous and tree legume species and the effects of cutting management on yield (Siregar 1983; Semali *et al.* 1983; Horne *et al.* 1986) there has been no comparative assessment of the wide range of herbaceous and tree legumes that are potentially available for animal feeding (Williams 1983; Brewbaker 1986).

A national research project, sponsored by the Australian International Development Assistance Bureau, commenced in 1983 to improve forages for animal feeding in Java, Sumatra, Sulawesi and Nusa Tengara. As part of the project, a series of regional programs to evaluate grasses and herbaceous and tree legumes was undertaken (Ivory *et al.* 1986). This paper reports on the evaluation of 88 herbaceous legume accessions and 45 tree and shrub legume accessions in 4 experiments over 3 years in West Java. These accessions were chosen to provide a contrast in growth habit, seed production and perenniality. Whilst productivity and persistence were important criteria in this evaluation, many other phenological and agronomic attributes were measured at regular intervals in order more completely to assess variation in performance between accessions at this location as well as comparative performance at other locations in Indonesia.

Materials and methods

The agronomic performance of herbaceous and tree legume accessions was evaluated in 3 experiments at Ciawi (6° 40'S, 106° 50'E, altitude 480 m and average annual rainfall 3700 mm) from November 1983–June 1986. Short periods of moisture stress were experienced during periods of lower rainfall in July 1984 and August 1985 (Table 1). The average annual maximum/minimum temperature was 30/21 °C, with little variation throughout the year.

The soil type was a red-brown clay (latosol) of volcanic origin. The surface soil pH was 5, with increasing acidity at depth. Availability of potassium and magnesium was low and of manganese was high (Table 2).

Accessions

In this preliminary evaluation, emphasis was placed on identifying species and genera which have a potential for high levels of forage production in various farming systems and ecological situations within the local region. While most of the accessions were introduced from overseas, a number of native or locally naturalised species were included. The 88 herbaceous legume accessions evaluated in experiment 1 represented 19 genera and 65 different species (Table 3). The 39 tree legume accessions evaluated in experiments 2 and 3 represented 10 genera and 18 known and 3 unidentified species (Table 4). A further 5 *Leucaena* accessions were included in a fourth evaluation experiment on tree legumes, but only reaction to the leucaena psyllid insect is reported here.

Table 1. Rainfall (mm) at Ciawi, West Java, Indonesia during 1983–86 and long-term average rainfall.

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total
1983										482	421	533	
1984	484	411	518	437	283	166	85	215	362	179	190	577	3907
1985	466	263	317	325	312	265	191	73	318	385	181	153	3249
1986	479	309	506	275	141	149	294						
Long-term average	543	452	431	356	351	146	168	116	223	252	302	280	3700

Table 2. Chemical composition and pH of soil at Ciawi, West Java, Indonesia.

Depth	pH[1]	K[2]	Ca[2]	Mg[2]	P[3]	S[4]	Cu[5]	Zn[5]	Mn[5]
(cm)			(meq/100 g)				(ppm)		
0–5	5.0	0.41	5.74	0.75	49	63	1.8	2.7	66
15–30	4.5	0.25	3.68	0.47	25	73	1.2	1.7	58
30–60	4.4	0.64	1.42	0.24	14	65	0.9	1.7	26

[1] (1:5 soil:water). [2] BaCl2/NH4Cl. [3] Bicarbonate extraction. [4] Ca-P extractable. [5] DPTA extractable.

Table 3. Herbaceous legume species sown at Ciawi, West Java, Indonesia.

FRP accession number[1]	Species	Introduction number[2]	Seed size classification[3]	Rhizobium strain
004	*Aeschynomene americana*	40017	s	CB 756
002	*Aeschynomene falcata*	cv. Bargoo	s	CB 756
003	*Aeschynomene indica*	26709	sm	CB 756
007	*Alysicarpus longifolius*	79603	s	CB 278
008	*Alysicarpus monolifer*	52359	s	CB 278
009	*Alysicarpus ovalifolius*	CQ 512	s	CB 278
010	*Alysicarpus procumbens*	60619	s	CB 278
005	*Alysicarpus rugosus*	52356	s	CB 278
006	*Alysicarpus rugosus*	52357	s	CB 278
011	*Alysicarpus vaginalis*	33216	s	CB 278
012	*Arachis burkatii*	58109	l	CB 756
013	*Arachis monticola*	CQ 990	l	CB 756
015	*Arachis pintoi*	58113	l	CB 3036
014	*Arachis pusilla*	58116	l	CB 756
016	*Calapogonium mucunoides*	'calopo'	sm	CB 756
020	*Cassia pilosa*	57503	s	CB 1483
017	*Cassia rotundifolia*	34721	s	CB 1483
018	*Cassia rotundifolia*	49713	s	CB 1483
019	*Cassia rotundifolia*	Q 10057	s	CB 1483
026	*Centrosema acutifolium*	94303	sm	CB 1923
024	*Centrosema pascuorum*	55697	m	CB 1923
054	*Centrosema pascuorum*	cross 2/2	sm	CB 1923
028	*Centrosema plumieri*	58568	m	CB 1923
021	*Centrosema pubescens*	'centro'	sm	CB 1923
022	*Centrosema pubescens*	58575	sm	CB 1923
029	*Centrosema sagittatum*	82277	sm	CB 1923
023	*Centrosema schiedianum*	cv. Belalto	m	CB 1923
025	*Centrosema schottii*	55705	m	CB 1923
027	*Centrosema virginianum*	40057	sm	CB 1923
030	*Clitoria ternatea*	50973	m	CB 756
044	*Desmodium adscendens*	67221	s	CB 627
046	*Desmodium barbatum*	76072	s	CB 627
045	*Desmodium barbatum*	87818	s	CB 627
049	*Desmodium heterocarpon*	86277	s	CB 2085
104	*Desmodium heterophyllum*	cv. Johnstone	s	CB 627
050	*Desmodium intortum*	cv. Greenleaf	s	CB 627
105	*Desmodium ovalifolium*	cv. Serdang	sm	CB 627
051	*Desmodium uncinatum*	cv. Silverleaf	sm	CB 627
043	*Desmodium* sp. (type A)	92555	s	CB 627
055	*Lablab purpureus*	cv. Highworth	l	CB 1024
056	*Lablab purpureus*	cv. Rongai	l	CB 1024
061	*Lotononis angolensis*	62205	s	CB 1323
060	*Lotononis bainesii*	cv. Miles	s	CB 376
062	*Macroptilium atropurpureum*	cv. Siratro	sm	CB 756
063	*Macroptilium atropurpureum*	CQ 1382	sm	CB 756
066	*Macroptilium bracteatum*	49747	sm	CB 756
064	*Macroptilium lathyroides*	cv. Murray	sm	CB 756
065	*Macroptilium lathyroides*	27766	sm	CB 756
114	*Macroptilium lathyroides*	ex Cimanggu	sm	CB 756
067	*Macroptilium martii*	55786		CB 756
068	*Macroptilium* sp.	78451	s	CB 756
069	*Macroptilium* sp.	78453	s	CB 756
070	*Macroptilium* sp.	78454	s	CB 756
073	*Macrotyloma africanum*	24972		CB 1024
071	*Macrotyloma axillare*	cv. Archer	m	CB 1024
074	*Macrotyloma daltonii*	60303	m	CB 1024
072	*Macrotyloma uniflorum*	cv. Leichhardt	m	CB 1024
075	*Neonotonia wightii*	cv. Clarence	sm	CB 1913/19188
076	*Neonotonia wightii*	cv. Cooper	sm	CB 1913/19188
077	*Neonotonia wightii*	cv. Tinaroo	sm	CB 1913/19188
078	*Neonotonia wightii*	cv. Malawi	sm	CB 1913/19188
103	*Pueraria phaseoloides*	'puero'	sm	CB 756
079	*Rhynchosia minima*	36696	sm	CB 756
080	*Rhynchosia minima*	71865	sm	CB 756
081	*Rhynchosia hondurensis*	76218	sm	CB 756
082	*Rhynchosia pyramidalis*	90871	sm	CB 756

Table 3. — *continued*

FRP accession number[1]	Species	Introduction number[2]	Seed size classification[3]	Rhizobium strain
083	*Rhynchosia sublobata*	52727	m	CB 756
085	*Stylosanthes guianensis*	cv. Cook	sm	CB 756
086	*Stylosanthes guianensis*	cv. Endeavour	sm	CB 756
087	*Stylosanthes guianensis*	cv. Graham	sm	CB 756
088	*Stylosanthes guianensis*	cv. Schofield	sm	CB 756
089	*Stylosanthes hamata*	cv. Verano	sm	CB 756
090	*Stylosanthes humilis*	61674	sm	CB 756
091	*Stylosanthes scabra*	cv. Seca	sm	CB 756
119	*Stylosanthes subsericea*	38605	sm	CB 756
094	*Teramnus labialis*	52794	sm	CB 756
095	*Teramnus labialis*	60380	sm	CB 756
092	*Teramnus uncinatus*	52803	sm	CB 756
093	*Teramnus uncinatus*	77005	sm	CB 756
113	*Trifolium semipilosum*	cv. Safari	s	CB 756
116	*Vigna luteola*	cv. Dalrymple	m	CB 756
096	*Vigna parkeri*	CQ 1374	sm	CB 1717
098	*Vigna oblongifolia*	60430		CB 756
097	*Vigna triloba*	50749	sm	CB 756
099	*Vigna unguiculata*	60452	sm	CB 756
100	*Vigna vexillata*	17457	sm	CB 756
101	*Vigna vexillata*	52908	sm	CB 756
102	*Vigna vexillata*	60454	sm	CB 756

[1] Forage Research Project (FRP) accession number.
[2] Introduction numbers are Commonwealth Plant Introduction (CPI) numbers, unless otherwise indicated.
[3] Seed classified as small (s), small-medium (sm), medium (m) or large (l).

Design and establishment

Accessions were planted in single rows, 4 m in length with 3 m between rows, and replicated twice. Experiments 1 (88 herbaceous legume accessions) and 2 (26 tree legume accessions) were established in November 1983 and experiment 3 (13 tree legume accessions) in December 1983. A further 6 accessions of *Leucaena* species and crosses were established in an adjacent fourth replicated experiment in June 1985. Seed was partially scarified and inoculated with the *Rhizobium* strains listed in Tables 3 and 4. Establishment was from direct sowing of seed in the field in experiments 1 and 2. The weight of seed sown per row was determined by seed size. Seed was classified as small, small-medium, medium or large. The weight of seed sown per 4 m row was 0.5, 1, 2 and 4 g for each of these 4 seed classes, respectively. This provided a compromise between sowing equal numbers of seeds or equal weights of seed, as both of these methods provide unacceptably large differences in numbers of established plants between species. In experiments 3 and 4, plants were established in small polythene bags in the greenhouse before transplanting to the field because of the small amount of seed available. A basal fertiliser of 20 g triple superphosphate, 92 g potassium chloride and 10 g magnesium sulphate was applied in a 50 cm wide strip along the row of each plot at planting.

Measurements

During the experiments, a number of plant attributes were assessed monthly by measurement or ranking procedure to provide a detailed assessment of establishment/persistence, vigour, yield, disease/pest resistance, growth habit, drought resistance and reproductive capacity (Table 5). Plots (rows) in all experiments were undefoliated until October 1984 to allow a full expression of growth and reproductive performance and allow seed set and build up of seed reserves in the soil to assess plant recruitment in the second year. Plots in experiments 1, 2 and 3 were harvested in October 1984, April, June and November 1985 and April 1986. In experiment 1, plants were cut to 5–10 cm height (depending on species) from two 0.25 m^2 areas within each plot for fresh and dry matter yield determination. In experiments 2 and 3, trees were cut to 25, 50 or 100 cm height (Table 4) from two 1 m lengths of tree row within each plot. Tree samples were separated into leaf

Table 4. Shrub or tree legume species sown at Ciawi, West Java, Indonesia.

FRP accession number[1]	Species	Introduction number[2]	Seed size classification[3]	Rhizobium strain	Exp. number	Cutting height
						(cm)
001	*Acacia angustissima*	51615	l	CB 2312	2	25
006	*Albizia falcataria*	local	l	—	2	100
107	*Calliandra calothyrsus*	local	l	CB 756	2	100
031	*Codariocalyx gyroides*	76104	m	CB 627	2	50
032	*Codariocalyx gyroides*	CQ 1465	m	CB 627	2	50
033	*Desmanthus virgatus*	38351	m	CB 3058/3063	2	25
034	*Desmanthus virgatus*	55718	m	CB 3058/3063	2	25
035	*Desmanthus virgatus*	55719	m	CB 3058/3063	2	25
036	*Desmanthus virgatus*	82285	m	CB 3058/3063	2	25
037	*Desmanthus virgatus*	87521	m	CB 3058/3063	2	25
038	*Desmanthus virgatus*	87822	m	CB 3058/3063	2	25
039	*Desmanthus virgatus*	89197	m	CB 3058/3063	2	25
040	*Desmanthus virgatus*	90315	m	CB 3058/3063	2	25
041	*Desmanthus virgatus*	91439	m	CB 3058/3063	2	25
042	*Desmodium* sp.	46556	sm	CB 627	2	—
047	*Desmodium discolor*	39075	sm	CB 627	2	50
048	*Desmodium gangeticum*	52418	sm	CB 627	2	25
052	*Desmodium rensonii*	46562	sm	CB 627	2	50
053	*Desmodium salicifolium*	52427	sm	CB 627	2	50
109	*Flemingia macrophylla*	local	m	CB 756	2	—
111	*Gliricidia sepium*	local	l	CB 3057/3059	2	100
346	*Leucaena diversifolia*	CIAT 17388	l	CB 81	4	100
057	*Leucaena leucocephala*	cv. Cunningham	l	CB 81	2	100
058	*Leucaena leucocephala*	cv. Peru	l	CB 81	2	100
059	*Leucaena leucocephala*	70544 (K8)	l	CB 81	2	100
141	*Leucaena leucocephala*	33029	l	CB 81	3	100
142	*Leucaena leucocephala*	61227	l	CB 81	3	100
143	*Leucaena leucocephala*	85928	l	CB 81	3	100
144	*Leucaena leucocephala*	85929	l	CB 81	3	100
145	*Leucaena leucocephala*	85930	l	CB 81	3	100
146	*Leucaena leucocephala* x *L. pulverulenta*	cv. Cunningham x 22964	l	CB 81	4	100
147	*Leucaena leucocephala* x *L. pulverulenta*	cv. Cunningham x 23145	l	CB 81	4	100
195	*Leucaena leucocephala*	K 636	l	CB 81	4	100
347	*Leucaena leucocephala*	CIAT 17495	l	CB 81	4	100
348	*Leucaena leucocephala*	CIAT 17498	l	CB 81	4	100
132	*Sesbania bispinosa*	81282	m	CB 905/3023	3	100
133	*Sesbania cannabina*	CQ 1697	m	CB 905/3023	3	100
134	*Sesbania cannabina*	30102	m	CB 905/3023	3	100
135	*Sesbania cannabina*	CQ 1433	m	CB 905/3023	3	100
084	*Sesbania formosa*	CQ 1614	m	CB 905/3023	2	100
110	*Sesbania grandiflora*	local	m	CB 905/3023	2	—
136	*Sesbania sesban*	30071	m	CB 905/3023	3	100
137	*Sesbania speciosa*	16036	m	CB 905/3023	3	100
130	*Sesbania* sp.	28114	m	CB 905/3023	3	100
131	*Sesbania* sp.	81283	m	CB 905/3023	3	100

[1] Forage Research Project (FRP) accession number.
[2] Introduction numbers are Commonwealth Plant Introduction (CPI) numbers unless otherwise indicated.
[3] Seed classified as small (s), small-medium (sm), medium (m) or large (l).

Table 5. Agronomic parameters, plant attributes and criteria used in evaluation of legume accessions at Panawangan, Java, Indonesia.

Agronomic parameters	Plant attributes	Numerical range	Criteria
Plant establishment /survival	Number seedlings	0–99[1]	total number plants/row
	Number young plants	0–99[1]	
	Number perennial plants	0–99[1]	
	Number dead plants	0–99[1]	
Plant yield	Yield rating	1–10	(1) lowest to (10) highest
	Leaf proportion	1–9	(1) 10% leaf to (9) 90% leaf
Plant health	Colour rating	1–5	(1) dark green (2) light green (3) green/yellow (4) yellow/green (5) yellow
Disease/pest resistance	Disease & insect rating	0–4	(0) unaffected (1) evidence (2) moderate (3) severe (4) total
	Disease or pest	1–	number assigned for each
	Plant part affected	1–4	(1) leaf (2) stem (3) root (4) pod
Plant habit	Plant height & width	0–	average for row (cm)
Drought resistance	Drought rating	0–5	(0) unaffected (1) wilting (2) little (3) moderate (4) severe (5) total leaf senescence
Reproductive capacity	Flowering	0/1	(0) no (1) yes
	Immature seed	0/1	(0) no (1) yes
	Mature seed	0/1	(0) no (1) yes
	Seed yield rating	0–5	(0) nil (1) very poor (2) poor (3) fair (4) good (5) excellent

[1] 99 is maximum number of plants recorded in row.

and stem for fresh weight measurement. Whole samples of herbaceous legumes and leaf samples of tree legumes were oven-dried at 70 °C for 48 hours for dry matter (DM) determination.

Psyllid damage of leucaena accessions was assessed in experiments 2, 3 and 4 using a 6-scale ranking from no evidence (0) to severe (5) for both insect infestation and plant damage.

Data analysis

The large amount of data collected on plant attributes for all experiments over the 3-year period of intensive observation was entered into a computerised data management system described in Ivory *et al* (1985). Normal statistical analyses were not appropriate to determine the comparative performance of the various legume accessions under evaluation, because of the type and amount of data collected in these experiments. Classification (multivariate) analysis has been used successfully to categorise plant accessions into similar taxonomic or performance groups within a single species or genus on the basis of large numbers of morphological or agronomic (economic) characters (Edye *et al.* 1970, 1973, 1975; Burt *et al.* (1971). In these studies, 2 classificatory (pattern analysis) programs were compared for their ability to categorise the relative performance of all legume accessions on the basis of the morphological, phenological and agronomic data recorded. The programs used were the standardised Euclidean model, with the fusion strategy of Burr (MSED), compared with the Euclidean polythetic divisive program (DIPCOM, previously POLDIV), both of which were available on the computer system of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia. DIPCOM was found to classify the accessions into groups which were more homogeneous with respect to overall agronomic performance of accessions/species and thereby agreed more closely with intuitive groupings. Therefore, only the results of the DIPCOM analyses are presented.

A selected list of agronomic attributes was chosen for the DIPCOM analyses (Tables 6 and 7) because many attributes recorded in the field

Table 6. Mean group values for agronomic attributes used in the DIPCOM analyses for herbaceous legumes (experiment 1) at Ciawi, West Java.

Agronomic criteria	Group 1	2	3	4	5	6	7	8
No. seedlings 1st year	24.7	35.8	16.6	33.9	20.2	38.0	19.6	5.7
No. seedlings 2nd year	6.2	17.7	1.4	72.4	25.8	57.1	8.3	0
Perenniality index	4.2	1.1	0.9	1.0	3.2	2.4	1.2	0.1
Mean colour	1.26	1.34	1.41	1.55	1.34	1.28	0.91	0.45
Maximum colour	2.09	2.83	2.69	3.63	2.22	2.90	1.91	1.75
Yield early 1st year	5.72	3.88	5.88	4.88	4.50	2.80	3.50	1.63
Yield late 1st year	7.34	5.46	7.38	7.38	7.11	4.50	4.13	1.94
Yield early 2nd year	4.72	2.58	2.81	1.13	3.78	3.40	1.47	0.06
Yield late 2nd year	6.00	1.54	1.75	3.00	4.61	3.80	1.44	0.19
Mean yield	5.91	3.09	4.24	4.18	4.94	3.80	2.61	0.85
Mean disease	0.55	0.78	0.99	0.53	0.68	0.34	0.45	0.10
Maximum disease	1.56	2.58	2.31	1.50	1.94	1.30	1.50	0.69
Mean insect	0.99	1.18	1.04	1.13	0.76	0.62	0.94	0.50
Maximum insect	1.91	2.79	2.13	2.50	1.67	1.50	2.78	2.94
Mean flowering	0.37	0.55	0.46	0.75	0.80	0.74	0.39	0.11
Mean mature seed	0.11	0.38	0.25	0.53	0.49	0.30	0.18	0.01
Mean seed yield	0.20	0.98	0.54	1.55	1.46	0.68	0.39	0.03
Maximum seed yield	1.50	3.63	2.81	4.75	4.33	3.30	2.13	0.25

Table 7. Mean group values for agronomic attributes from classification analyses in experiment 2 and grouping for experiment 3 of tree and shrub legumes at Ciawi, West Java.

Agronomic criteria	Experiment 2 Group 1	2	3	4	5	6	Experiment 3 Group 1	2	3
No. seedlings 1st year	64.5	34.5	10.2	20.3	26.4	6.7	79.3	87.5	32.6
No. seedlings 2nd year	99.0	34.8	14.2	33.0	0	0	0	28.8	0
Perenniality index	1.75	2.08	1.33	4.67	3.75	7.7	0.63	0	0.31
Mean colour	1.40	1.45	1.67	1.83	1.28	1.10	1.49	1.43	1.13
Maximum colour	2.50	2.58	3.00	3.67	2.50	2.00	3.0	2.1	1.9
Yield early 1st year	9.00	4.08	2.33	4.00	6.00	4.60	8.0	7.1	1.0
Yield late 1st year	9.00	5.17	3.17	8.50	6.88	6.50	8.3	1.4	4.8
Yield early 2nd year	6.25	3.08	2.33	7.00	3.75	7.20	6.5	0	4.4
Yield late 2nd year	2.75	2.75	1.67	8.17	6.13	8.50	5.3	0	6.1
Mean yield	5.60	3.70	2.47	6.73	5.23	6.66	5.6	1.4	4.5
Mean disease	0.35	0.28	0.37	1.03	0.38	0.30	0.60	0.16	0.37
Maximum disease	1.50	1.50	1.83	2.33	2.13	1.20	2.0	1.1	1.4
Mean insect	1.20	1.00	0.67	0.97	1.00	0.76	1.65	1.42	0.72
Maximum insect	2.50	3.17	2.67	2.33	3.00	3.20	3.3	2.7	2.9
Early drought rating	0	0	0	0	0	0	1.3	0.4	0
Late drought rating	0	0.17	0	0	0	0	1.0	0.3	0.1
Mean flowering	0.85	0.78	0.60	0.40	0.05	0.44	0.57	0.72	0.56
Mean mature seed	0.55	0.43	0.40	0.20	0.01	0.08	0.22	0.56	0.09
Mean seed yield	2.00	1.22	0.93	0.57	0.01	0.24	0.36	1.61	0.09
Maximum seed yield	5.00	4.67	3.17	3.83	0.13	2.00	1.75	4.17	1.00

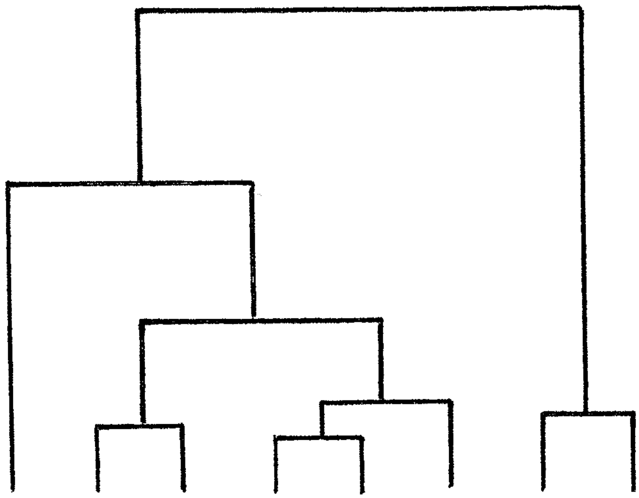
were invariate throughout the experiment or data for the same attribute at different observation times could best be described by the mean, the maximum or a selected value at particular periods of time. In experiments 1 and 2, 10 and 3 legume accessions, respectively, failed to germinate or establish and were excluded from the analyses. Matrices containing 78 legume accessions by the 18 agronomic attributes given in Table 6 and 23 legume accessions by the 20 agronomic attributes given in Table 7 were created for pattern analysis. Multivariate classification analysis was not performed on the 13 accessions evaluated in experiment 3 because of the small number of accessions in this experiment and their natural separation into 3 groups of similar agronomic performance.

Results

Agronomic performance: Experiment 1 — Herbaceous legumes

The DIPCOM hierarchy was truncated at the 15-group level, but it was decided that 8 working groups would be appropriate to summarise the agronomic performance of the heterogenous group of legume species under evaluation (Figure 1). Below this level, several groups were formed which contained only 3–4 accessions.

The first major division in the classification was based on the lower yields of groups 7 and 8 compared with other groups (Figure 1). Within the higher yielding groups the second split was based on the lower seed yield, higher forage yield



Group	1	2	3	4	5	6	7	8
Legume accessions (FRP nos) in each group	021	007	016	004	002	061	003	045
	022	010	025	005	017	086	008	064
	023	011	026	006	018	089	009	070
	028	043	027	065	019	091	024	071
	029	088	054		020	119	046	096
	050	090	079		030		049	104
	056	093	092		051		055	113
	075	095	094		101		060	
	076	098			102		062	
	077	099					063	
	078	100					072	
	080	114					074	
	083						081	
	085						082	
	087						097	
	103						105	

Figure 1. Classification of 77 herbaceous legumes grown at Ciawi, West Java, Indonesia, as defined by 18 agronomic attributes.

and higher degree of perennation of accessions in group 1. The further splitting of the remaining groups was on the basis of higher disease and insect ratings and lower seedling recruitment in groups 2 and 3 and the higher seed yield, plant yield and disease and insect ratings of groups 4 and 5 compared with group 6. Mean values for the 18 agronomic attributes for each of the 8 groups are given in Table 6. The characteristics of the various groups formed were as follows:

Group 1 — This was the highest yielding group of accessions, which were characterised by fair seedling establishment but infrequent flowering, low seed production and low numbers of seedlings recruited in the second year. Plants were strongly perennial with high disease and insect resistance. This group included 16 accessions covering 11 different species in the genera *Centrosema*, *Desmodium*, *Lablab*, *Neonotonia*, *Rhynchosia*, *Stylosanthes*, *Teramnus*, *Vigna* and *Macroptilium*.

Group 2 — This was a moderate yielding group of accessions, with plant yield gradually decreasing over time. Good seedling establishment was recorded with moderate seed production and moderate seedling recruitment in the second year. Highest disease and insect susceptibility occurred in this group with some indications of nutrient or *Rhizobium* deficiencies. This group included 12 different species in the genera *Alysicarpus*, *Desmodium*, *Stylosanthes*, *Teramnus*, *Vigna* and *Macroptilium*.

Group 3 — This group of accessions was similar to group 2 with moderate overall yield, but yield decreased to a greater extent with time. Seedling establishment was only fair with flowering occurring infrequently, with moderate seed production but very poor seedling regeneration. Plants exhibited moderate resistance to disease and insect pests. This group included 8 different species in the genera *Calopogonium*, *Centrosema*, *Rhynchosia* and *Teramnus*.

Group 4 — This moderate yielding group of accessions exhibited similar agronomic performance to groups 2 and 3, but with yield decreasing to a lesser extent with time. Seedling establishment was high, with frequent flowering and the highest seed yields and seedling recruitment recorded in any group in the second year. This group contained only 4 accessions (*Aeschynomene americana*, *Alysicarpus rugosus* (2) and *Macroptilium lathyroides*), which were all annual or weakly biennial species.

Group 5 — This group contained 9 accessions (6 species) in the genera *Aeschynomene*, *Cassia* (4), *Clitoria*, *Desmodium* and *Vigna* (2). All species were strongly perennial and maintained moderate–good yields throughout. Flowering was frequent, with good seed production and seedling recruitment. Disease and insect resistance were also good.

Group 6 — This small group of accessions contained 4 *Stylosanthes* species and *Lotononis angolensis*. Yields were moderate–good throughout, although the yields of *L. angolensis* and *Stylosanthes subsericea* declined significantly with time and were less than the other 3 accessions. All accessions were strongly perennial, flowered frequently with moderate–good seed production. Seedling recruitment in the second year was good with high disease and insect resistance.

Group 7 — This was a large group of 16 accessions from 15 species in the genera *Aeschynomene*, *Alysicarpus*, *Centrosema*, *Desmodium*, *Lablab*, *Lotononis*, *Macroptilium*, *Macrotyloma*, *Rhynchosia* and *Vigna*. Many species were annuals. Yields were moderate initially but decreased markedly with time. For annual species, this was due to a moderate level of flowering and seed production and poor seedling recruitment. Insect damage was moderate and although diseases were generally minimal, species such as *Macroptilium atropurpureum* suffered badly from *Rhizoctonia* disease during extended wet periods.

Group 8 — This was a very poor yielding group of accessions in 7 species in the genera *Desmodium*, *Macroptilium*, *Macrotyloma*, *Trifolium* and *Vigna* that had poor initial establishment, very poor flowering and seed set and did not perennate well.

Agronomic performance: Experiment 2 — Tree legumes

The DIPCOM hierarchy was truncated at the 15-group level but it was decided that 6 working groups would be appropriate to summarise the agronomic performance of the tree legume accessions evaluated. Below this level groups were formed that contained only one accession.

The first major division in the classification was based on the higher mean mature seed, mean seed yield and maximum seed yield and lower late second year yield, mean yield and pereniality indices of groups 1, 2 and 3 compared with groups 4, 5 and 6 (Figure 2). Group 1 was distinguished from groups 2 and 3 on the basis of greater numbers of seedlings established initially and higher mean yield and first year yields. Group 3 had less insect damage, lower yield and lower numbers of seedlings established initially than group 2. Amongst the higher yielding accessions, groups 4, 5 and 6 separated on the basis of a decreasing level of mean mature seed, maximum seed yield and mean seed yield, respectively. Mean values for the 20 agronomic attributes for each of the 6 groups are given in Table 7. The agronomic characteristics of the various groups formed were as follows:

Group 1 — This group contained 2 accessions of *Desmanthus virgatus* that gave high initial yields but yields decreased following repeated defoliation. They gave the highest frequency of flowering, seed production and seedling recruitment of all accessions, with relatively low levels of disease or insect damage.

Group 2 — This was a moderate yielding group of 5 *D. virgatus* accessions and *Desmodium salicifolium*, the yield rating of which decreased with time. Flowering, seed production and seedling recruitment were good.

Group 3 — This was the poorest yielding group containing 2 *D. virgatus* accessions and *Desmodium gangeticum*. Flowering and seed production were moderate-good and seedling recruitment fair.

Group 4 — This high yielding group of 3 accessions had fair-good flowering and seed production and good seedling recruitment. *Desmodium rensonii* had only fair leaf colour and the 2 *Codariocalyx gyroides* accessions showed signs of moderate-severe leaf disease.

Group 5 — This was generally a high yielding

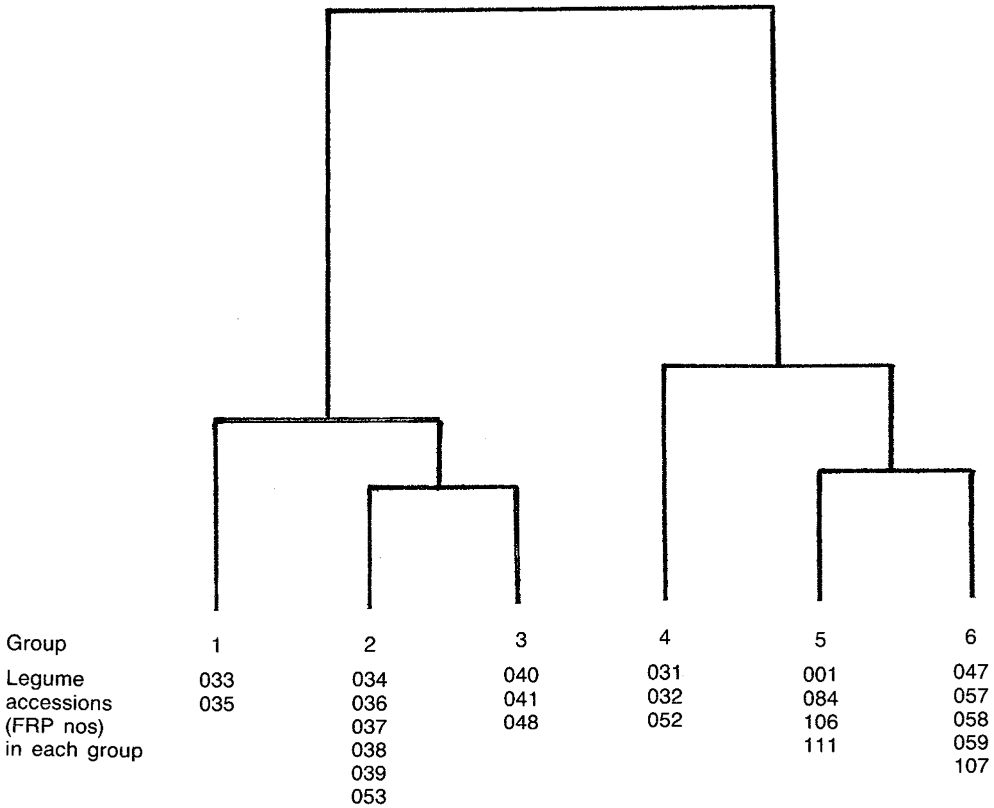


Figure 2. Classification of 23 shrub and tree legumes grown at Ciawi, West Java, Indonesia, as defined by 20 agronomic attributes.

group of 4 accessions, with very poor flowering, seed production and seedling recruitment. Yield was high prior to defoliation, but following the first cutting, initial regrowth yield was poor but gradually improved with time. *Acacia angustissima* gave lower yields than *Gliricidia sepium*, *Albizia falcataria* and *Sesbania formosa*.

Group 6 — This was a high yielding group of 5 accessions, the relative yield ranking of which improved with time. *Desmodium discolor* was much lower yielding than the 3 cultivars of *Leucaena leucocephala* and *Calliandra calothyrsus*. All accessions had poor establishment, moderate flowering, but poor seed production under the cutting regime imposed

Agronomic performance: Experiment 3 — Tree legumes

The 13 accessions in this experiment fell into 3 distinct performance groupings with very little variation in agronomic attributes of accessions within groups. Mean group values for the same 20 attributes used in experiment 2 are given in Table 7. The characteristics of the 3 groups were as follows:

Group 1 contained 2 perennial *Sesbania* accessions (FRP 130 and FRP 136) that showed good seedling establishment, high initial yield that gradually decreased with time, moderate flowering, but poor seed production. Both accessions were susceptible to termite damage.

Group 2 consisted of the 6 *Sesbania* accessions that were annual species. They had high seedling establishment and good flowering, seed production and seedling recruitment. Yield was initially high but all accessions were short-lived.

Group 3 comprised the 5 *L. leucocephala* accessions. They had fair–good seedling establishment but suffered reasonably high seedling mortality and hence their perenniality indices were low. Early growth rates were much lower than for the *Sesbania* accessions, but yield improved with time. Flowering was moderate but seed production was very poor under the cutting regime used.

Forage production: Experiment 1 — Herbaceous legumes

All accessions were cut in November 1984, after 11 months of uninterrupted growth since planting. By that time, 12 accessions (FRP 003, 007, 008, 070, 071, 072, 074, 080, 096, 097, 098 and 104) had failed to persist. Therefore only 64 accessions were included in the yield assessment under cutting. DM yields varied greatly between accessions at the first cutting, with *Stylosanthes scabra* cv. Seca giving the highest standing total yield of 14 860 kg/ha (Table 8). However, only 30 percent of this yield was leaf, while other species had much higher leaf:stem ratios. In the following 17 months, accessions were defoliated 4 times. The highest total regrowth yield for this period was produced by *S. guianensis* cv. Graham (19 820 kg/ha). The most productive 10 species under a lenient cutting regime were *S. guianensis* cvv. Graham, Cook and Endeavour, *S. scabra* cv. Seca, *S. hamata* cv. Verano, *Neonotonia wightii* cvv. Tinaroo and Clarence, *Clitoria ternatea* FRP 030, *Pueraria phaseoloides* FRP 103 and *Centrosema pubescens* FRP 022.

Forage production and psyllid damage: Experiments 2, 3 and 4 — Tree legumes

All accessions that had survived to October 1984, in experiments 2 and 3, were defoliated, following 10 and 9 months uninterrupted growth, respectively. Yields of leaf at this time varied greatly between accessions (Table 9), due to inherent differences in productivity and some differences in spread of branches of the different accessions. Highest leaf yields were recorded from *A. falcataria*, followed by *C. calothyrsus*, *S. sesban*, *S. formosa* and *L. leucocephala* cvv. Peru and K8.

Following this initial defoliation, leaf production was measured over 4 regrowth periods during the following 20 months. The highest average rate of leaf production was from *C. calothyrsus* and this accession was twice as productive as the next group of accessions (*L. leucocephala* cv. Peru and *G. sepium*), followed by lower rates of growth for 3 other *Leucaena* accessions (FRP 144, K8 and cv. Cunningham) and *A. falcataria*. Many accessions, such as *D. virgatus*, had lower leaf growth rates following repeated cutting. Only *C. calothyrsus*, *G. sepium* and *S. formosa* maintained uniformly high rates of production. An apparent inverse relationship between growth rate and cutting interval suggested that *D. rensonii* would have had higher leaf production rates with shorter cutting intervals.

Table 8. Yield of herbaceous legumes under an irregular cutting regime at Ciawi, West Java, Indonesia, during 1984–86.

FRP accession number[1]	DM yield					
	29-10-84	5-4-85	10-6-85	15-11-85	1-4-86	Total regrowth
			(g/m²)			
002	595 (33)[2]	271	128	230	144	773
004	358 (13)	97	61	95	127	380
005	622 (28)	376	61	299	60	796
006	571 (31)	292	141	161	71	665
009	231 (72)	0	0	0	0	10
010	459 (43)	170	45	49	16	280
011	263 (43)	40	32	71	34	177
016	361 (46)	166	58	115	123	462
017	260 (49)	130	76	190	167	563
018	435 (44)	100	45	153	102	400
019	288 (51)	157	100	81	103	441
020	227 (62)	216	120	124	112	572
021	438 (56)	348	143	253	211	955
022	634 (47)	337	166	257	279	1039
023	492 (58)	261	191	335	250	1037
024	250 (60)	104	0	0	28	132
025	110 (47)	38	0	0	30	68
026	419 (52)	156	44	258	88	546
027	259 (42)	249	52	141	18	460
028	454 (50)	119	113	208	231	671
029	342 (56)	196	74	139	52	461
030	634 (41)	317	224	347	181	1069
045	202 (44)	0	0	0	0	0
046	306 (20)	0	16	50	18	84
049	239 (34)	156	33	13	31	233
050	400 (35)	237	197	221	200	855
051	571 (50)	230	76	244	0	550
054	78 (53)	211	22	75	74	382
055	432 (19)	364	162	250	216	992
056	576 (31)	212	128	201	230	771
060	366 (56)	134	20	110	58	322
061	253 (60)	67	17	90	48	222
062	298 (51)	282	96	210	102	690
063	228 (50)	84	60	126	80	350
064	1080 (14)	0	37	130	106	273
075	621 (45)	342	227	314	229	1112
076	426 (46)	294	159	236	225	914
077	418 (59)	334	191	456	274	1255
078	359 (54)	201	173	217	130	721
079	171 (60)	207	56	42	46	345
081	675 (51)	302	106	299	158	865
082	263 (44)	163	84	86	39	372
083	385 (31)	278	143	167	179	767
085	1106 (27)	356	311	412	240	1319
086	659 (29)	239	199	374	351	1163
087	840 (44)	655	293	634	400	1982
088	514 (35)	128	85	345	232	790
089	342 (48)	417	188	376	332	1313
090	87 (88)	170	54	0	37	261
091	1486 (30)	336	174	794	274	1578
092	455 (63)	131	51	106	24	312
093	201 (38)	220	13	46	174	453
094	339 (51)	56	12	43	6	117
095	435 (62)	163	50	110	59	382
099	300 (48)	198	0	29	34	261
100	160 (73)	228	29	91	122	470
101	178 (53)	122	23	152	93	390
102	201 (41)	122	115	124	53	414
103	514 (61)	399	144	324	179	1046
105	522 (46)	302	87	238	109	736
113	106 (85)	74	18	39	20	151
114	217 (8)	0	41	69	0	110
119	333 (70)	284	51	35	94	464

[1] Forage Research Project (FRP) accession number. [2] Percentage leaf yield.

Table 9. Leaf yield at first cutting and subsequent leaf growth rates of shrub and tree legume accessions during 1984-86 at Ciawi, West Java.

FRP accession number[1]	Leaf yield at first cutting	Leaf growth rates				
		Period				
		1	2	3	4	Mean
	(gDM/m row)	(g DM/m row length/day)				
001	39	1.01	2.87	0.49	0.44	1.20
031	512	2.84	1.28	2.69	1.16	1.99
032	410	1.98	2.08	3.70	1.64	2.35
033	60	1.92	0.49	0.23	0.18	0.71
034	69	0.67	0.44	0.19	0.03	0.33
035	94	2.29	1.26	1.32	0.20	1.27
036	166	1.39	1.62	0.20	0.08	0.82
037	20	0.23	0.28	0.08	0.01	0.15
038	40	0.57	0.89	0.87	0.35	0.67
039	23	0.32	0.45	0.10	0.02	0.22
040	42	0.61	0.20	0.01	0.01	0.21
041	27	0	0.20	0.23	0.19	0.16
047	280	1.42	2.19	2.30	0.43	1.59
048	7	0.50	0.30	0.17	0.05	0.26
052	241	3.00	5.19	3.41	1.33	3.23
053	294	1.97	1.89	1.35	0.29	1.38
057	461	3.36	4.26	6.16	0.40	3.55
058	992	6.26	5.28	6.99	0.68	4.80
059	938	4.97	5.47	6.21	0.28	4.23
084	1053	2.65	3.15	2.91	2.09	2.70
106	2497	2.41	4.54	5.31	1.92	3.55
107	1471	10.71	9.90	8.83	8.52	9.49
111	278	5.80	3.88	3.58	3.31	4.14
130	419	2.28	0.75	0.80	0.84	1.17
136	1410	4.13	3.89	2.70	1.51	3.06
141	195	3.05	3.60	3.79	0.58	2.76
142	33	2.46	4.15	2.84	0.13	2.40
143	183	1.41	1.77	2.35	0.55	1.52
144	290	5.07	3.75	5.30	1.97	4.02
145	57	1.97	3.08	3.91	0.91	2.47

[1] Forage Research Project (FRP) accession number.

Table 10. Ratings for damage to *Leucaena* accessions due to presence of the *Leucaena* psyllid (*Heteropsylla cubana*) in May 1986 at Ciawi, West Java.

FRP accession number[1]	Species	Ratings[2]		Plant age[3]
		Plant damage	Insect level	
346	*L. diversifolia*	0.0	0.0	y
057	*L. leucocephala*	4.0	4.0	m
058	*L. leucocephala*	5.0	3.5	m
059	*L. leucocephala*	3.5	3.5	m
141	*L. leucocephala*	2.5	3.0	m
142	*L. leucocephala*	5.0	4.0	m
143	*L. leucocephala*	3.0	3.0	m
144	*L. leucocephala*	3.0	3.5	m
145	*L. leucocephala*	3.5	2.5	m
146	*L. leucocephala* x *L. pulverulenta*	0.0	2.0	y
147	*L. leucocephala* x *L. pulverulenta*	1.0	2.5	y
195	*L. leucocephala*	1.0	2.0	y
347	*L. leucocephala*	1.5	2.5	y
348	*L. leucocephala*	3.0	3.5	y

[1] Forage Research Project (FRP) accession number.
[2] Ratings are based on 0-5 scale; no evidence (0), evidence (1), fair (2), moderate (3), high (4) and severe (5) insect infestation and plant damage.
[3] Young (y) or mature (m) plants.

Leaf growth rates of *Leucaena* accessions were greatly reduced in the fourth regrowth period (Table 9) due to the presence of the insect pest *Heteropsylla cubana* (leucaena psyllid), which was first recorded in Indonesia at Ciawi in February 1986. Ratings of the degree of insect damage and level of infestation were made in May 1986 (3 months after infestation) on *Leucaena* accessions in the 2 experiments, together with accessions under evaluation in experiment 4 (Table 10). *L. diversifolia* appeared completely resistant to the leucaena psyllid and the younger accessions, in the unreported experiment, appeared much less affected than the older, larger plants in experiments 2 and 3. *L. leucocephala* FRP 141 appeared the most resistant line of the older accessions.

Discussion

Herbaceous legumes

Although plant yield rating was an important attribute in the grouping of herbaceous legume accessions in the multivariate classification, seed yield and insect and disease susceptibility were also important criteria. Thus the accessions assigned to groups were not necessarily homogeneous with respect to overall yield or yield ratings through time. The classification process does not provide a differential weighting to the various agronomic criteria used in the classification, as might happen with an intuitive grouping based predominantly on yield criteria. However, it was obvious that yield rating was one of the more variable and hence influential factors affecting groupings. Thus, amongst the most productive 10 accessions, 7 were placed in group 1 and 3 in group 6, with the major difference for separation into these groups being the higher seed yields of accessions in group 6.

Visual yield ratings were based on the mean of 2 observers. When yield ratings at the time of first cutting were compared with the actual yields measured it was evident that there was some bias in the yield ratings. While overall there was a generally good relationship between these parameters, it was apparent that yields were underestimated in species such as *Stylosanthes* spp., *Lablab purpureus* and *Desmodium ovalifolium*, that had low leaf:stem ratios. Thus the grouping of accessions based on yield criteria (visual ratings) may relate more to leaf yield than total yield.

The results of this evaluation suggest that there are a number of farm situations for which some of these herbaceous legumes have potential use in the region. It is suggested that *Centrosema pubescens*, *C. schiedianum*, *Neonotonia wightii*, *Pueraria phaseoloides*, *Stylosanthes guianensis* and *Clitoria ternatea* should be considered for further evaluation in intensive cut-and-carry systems where these legumes are grown as monocultures or with suitable grass species. Potential species for further evaluation for oversowing into communal grazing areas, roadsides and non-crop areas on farms include *Aeschynomene falcata*, *Desmodium ovalifolium* and *Stylosanthes hamata*. These species have a reasonably low growth habit and show good DM production and moderate-good seed yields. In selecting herbaceous legumes for possible use as relay or inter-crops, species should be characterised by high early growth rates and forage yield and good seed production for resowing. The 4 species which met these criteria were *Lablab purpureus*, *Vigna vexillata* FRP 100, *V. oblongifolia* and *Macrotyloma uniflorum*. These species should be evaluated further in cropping systems in the region.

In general, seed production and seed quality of all legumes were poor-moderate in this environment. Poor seed quality resulted from the continual high rainfall and humidity causing high levels of disease attack to pods and seeds, generally small seed size and low seed germination. Seed production was also poor or absent in many species, possibly because there were few periods of water stress and inadequate variation in daylength (photoperiod) throughout the year, both of which are important factors to the initiation and promotion of flowering in many legume species (Hopkinson and Reid 1979). Thus where any large-scale planting of herbaceous legumes is required there will be a need to identify other environments in Indonesia or systems of seed production management which are more suitable for legume seed production (Hopkinson and Reid 1979; Hopkinson 1986).

Tree legumes

The outstanding tree species for forage production was *Calliandra calothyrsus*, as has been found in other experiments in Java and Sumatra (Panjaitan 1988; Blair *et al.* 1988). Unfortunately, the quality of the leaves of this local accession for animal production is consistently poorer than that of *Leucaena*, *Gliricidia* or *Sesbania* spp. (Mahyuddin 1983; Manurung 1989). In addition, there appears to be little genetic variation within this species in Indonesia. Efforts should therefore be made to introduce many accessions of this and possibly other species of *Calliandra* to widen the genetic base in an attempt to find an accession that has a higher nutritive value than the local ecotype found in Indonesia.

Leucaena accessions and *Gliricidia sepium* were the second most productive group. However, the arrival of the leucaena psyllid in Indonesia has created some doubt as to the future usefulness of leucaena as this pest caused a dramatic reduction in growth and leaf production. The future forage-production potential of this genus will depend on the identification of resistant ecotypes or species of leucaena and the introduction of predators that will provide an effective means of biological control. Some variation in susceptibility was found amongst the *L. leucocephala* accessions under evaluation, with FRP 144 being less affected than the commercial leucaena cultivars, which all appeared very susceptible. *L. diversifolia* appeared completely resistant, but its productivity appears lower and possibly its feeding value is inferior. It was generally observed that the leucaena psyllid caused more severe damage to older trees than to young undefoliated trees or trees in early stages of regrowth following cutting (provided that no other infested trees were nearby). Screening for resistance to the psyllid is proceeding with a wider range of accessions, but this will have to continue for a longer period of time to evaluate fully their resistance and long-term productivity.

Sesbania formosa and *S. sesban* FRP 136 were the most productive accessions amongst the *Sesbania* species. These 2 perennial species seem more persistent and productive under repeated cutting than *S. grandiflora*, which has shown high plant mortality under repeated cutting in a number of different environments in Indonesia (Horne *et al.* 1986; Panjaitan 1988; Ella *et al.* 1989). The annual *Sesbania* accessions had very high growth rates, but quickly became reproductive and were very short-lived. The most productive annual species was FRP 131. The opportunity to use such species as a green manure crop or a fast-growing forage that could be sown after rice at the end of the wet season should be investigated.

Three other species that sustained moderately good production were *Albizia falcataria*, *Desmodium rensonii* and *Codariocalyx gyroides*. The leaf growth rate for *D. rensonii* (period 2) was equivalent to that of *L. leucocephala* when the regrowth period was only 2 months but was less with longer cutting intervals (Table 9). This suggests that this species may be more productive under a system of frequent cutting. It was also indicated from the leaf colour that nodulation may have been inadequate and a more effective strain of *Rhizobium* may further improve productivity of this species. An advantage of using *D. rensonii* for animal feeding, is that the *in vitro* digestibility of leaf and edible stem is high (58–62 percent) compared with other tree legumes (Bulo *et al.* 1985). *C. gyroides* has been found to be susceptible to a number of diseases (Lenné and Stanton 1990), and both accessions suffered moderate–severe leaf disease in this experiment, emphasising the need for selection of more disease-resistant accessions to improve the productivity of this species. However, its low leaf and stem *in vitro* digestibility (Bulo *et al.* 1985) must place some doubt on its usefulness as a forage. The productivity and persistence of *Desmanthus virgatus* accessions and other *Desmodium* accessions were very poor and these should not be tested further in this environment.

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