Production and nutritive value of browse species in semi-arid Kenya

F.P. WANDERA, B.H. DZOWELA[1] AND M.K. KARACHI[1]
KARI-National Dryland Farming Research Centre, Machakos, Kenya.

Abstract

A number of *Leucaena leucocephala* accessions and cultivars, *L. pulverulenta*, and two *Sesbania* species were compared for their growth, dry matter production and nutritive value, in a semi-arid bimodal rainfall environment of eastern Kenya. The total yield of *S. sesban* was greater than other species, and it continued to grow during the dry season after growth of the other species ceased. However its annual yield of edible dry matter was only 60% of that produced by *L. leucocephala* K8, *L. leucocephala* cv. Cunningham and *L. leucocephala* cv. Peru, which yielded 9060 kg, 8900 kg and 8500 kg/ha, respectively. *S. grandiflora* was the slowest growing and least productive. Nitrogen and lignin concentration, which were approximately 4% and 5% of edible dry matter, respectively, were similar for sesbanias and the highest yielding leucaenas.

L. leucocephala cvv. Cunningham and Peru and the accession K8 are the most suitable shrub legumes for this semi-arid environment. However as *Sesbania sesban* has demonstrated potential and is not susceptible to the psyllid pest, further research should be directed towards screening for better adapted accessions of *Sesbania* and developing appropriate management systems for increasing leaf yield.

Resumen

Varias accesiones y cultivares de Leucaena leucocephala, *L. pulverulenta y dos especies de* Sesbania *fueron comparadas en términos de su crecimiento, rendimiento de materia seca y valor nutritivo, en un ambiente semi-árido con precipitación bimodal en la región este de Kenia. El rendimiento total de* S. sesban *fue mayor que el de las otras especies, y continuó su crecimiento durante la estación seca cuando el crecimiento de las otras especies había cesado. Sin embargo, el rendimiento anual de materia seca comestible de* S. sesban *fue únicamente 60% de lo obtenido con* L. leucocephala *K8,* L. leucocephala *cv. Cunningham, y* L. leucocephala *cv. Perú, los cuales rindieron 9060 kg/ha, 8900 kg/ha y 8500 kg/ha, respectivamente. La concentración de nitrógeno y lignina, aproximadamente 4% y 5% respectivamente, fue similar en las sesbanias y en las leucaenas de alto rendimiento.*

Correspondence: Mr F.P. Wandera, KARI-National Dryland Farming Research Centre, P.O. Box 340, Machakos, Kenya.
[1]Present address: International Council for Research in Agroforestry (ICRAF) P.O. Box 30677, Nairobi, Kenya.

Introduction

Livestock production in subsistence farming systems of the semi-arid areas of Kenya is solely dependent on native pasture and crop residues. The pasture available is low in quantity and the quality is poor during the dry season while the crop residues, although providing bulk, are of low feed value (Tessema *et al.* 1985). One of the strategies to increase utilization of these feed resources is by supplementation with legumes (Dzowela 1987). The deeper rooting perennial shrub legumes remain green longer into the dry season than the herbaceous legumes and thus could have an important role in these production systems.

Commercial cultivars of *Leucaena leucocephala* have been used in semi-arid areas of Kenya (Tessema and Emojong 1984) and promotion of *Leucaena* planting for agroforestry in eastern Africa has been done (Torres 1983). However, due to the potential problem of the psyllid (*Heteropsylla cubana*) which has devastated the present commercial cultivars of *Leucaena* in South-East Asia, and reduced the productivity of *Leucaena* in Australia (Bray and Sands 1987), alternative shrub legumes should be identified.

Sesbania species are among the shrub legumes currently being considered as alternatives to *Leucaena* (Tothill 1987; J.F.M. Onim pers. comm.). Growth and production of *Sesbania* has not been studied in detail in the semi-arid, bimodal rainfall environment of Kenya. This paper reports the results of work carried out to compare the growth, productivity and nutritive value of two *Sesbania* species, *L. pulverulenta* and a number of *Leucaena leucocephala* species.

Materials and methods

Site

The experiment was carried out at a research centre belonging to the Kenya Agricultural Research Institute (KARI) situated at Kampi ya Mawe, which is located 200 km S.E. of Nairobi, (1°51'S, 37°40'E; altitude 1145 masl). The soils at the experimental site are classified as chromic luvisols (Mbuvi and Van de Weg 1975). Soil chemical analysis showed pH, 5.7 (1:2.5, soil:water); total soil N, 0.07%; sodium bicarbonate extractable P, 27µg/g; organic C, 0.91%; exchangeable cations (meq/100 g) Ca 3.3; Mg 1.4; K 1.2; Na 0.22.

Climate

The site has a semi-arid climate, mean annual rainfall of 700 mm, bimodally distributed, with peaks in November and April. Dry periods are experienced from mid-May to late October and mid-January to mid-March.

Figure 1 shows the rainfall distribution and temperature during the experimental period. Rainfall was above average with 1103 mm of rain being received between January 1988 and January 1989.

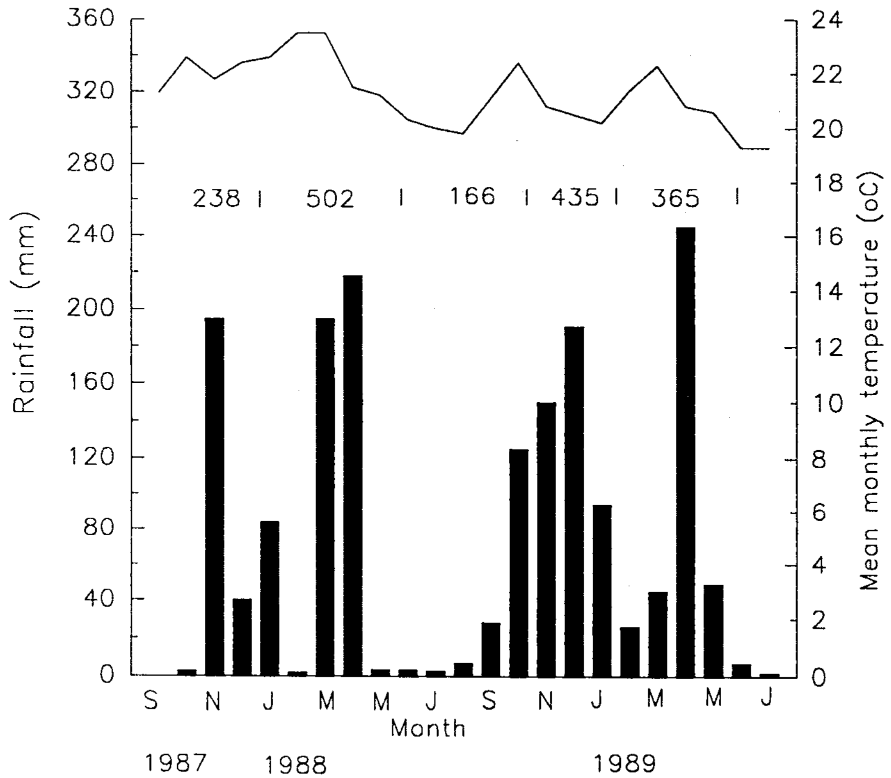

Figure 1. Monthly rainfall totals (■) and mean monthly temperature (—) at Kampi ya Mawe during the experimental period.

Treatments

The shrub legumes used in this experiment were:
1. *Leucaena leucocephala* K8
2. *L. leucocephala* cv. Cunningham
3. *L. leucocephala* CPI 91098
4. *L. leucocephala* CPI 84511
5. *L. leucocephala* cv. Peru
6. *L. leucocephala* CPI 58396
7. *L. pulverulenta*
8. *L. leucocephala* (Katumani selection[1])
9. *Sesbania sesban* var. *nubica*
10. *S. grandiflora*

The field design was a completely randomized block with three replications. Plot size was 10 m × 4 m and the planting arrangement was 1 m between and within rows, giving a stand of 50 plants/plot.

The seeds were germinated at 25 °C and then planted in polythene tubes filled with a mixture of soil and cow dung. The *Leucaena* species were inoculated with the *Rhizobium* strain CB 81, while the *Sesbania spp.* were inoculated with CB 76 at the time of planting in the polythene tubes. The plants were grown in the nursery for eight weeks before transplanting into the field (in November 1987), when 40 kg/ha P was applied as single superphosphate.

Plant measurements

Height. Measurements of the total height of plants were taken at monthly intervals from January to May 1988, and at two- to three-weekly intervals from June 1988 to February 1989. Three plants were measured in each plot. The period to May 30, 1988 was considered as representing growth in the establishment phase while that from May 30, 1988 to November 1, 1988 and then from November 1, 1988 to February 7, 1989, as representing growth of mature plants in the dry and wet season, respectively. At the end of each growth period three new plants were tagged for subsequent growth measurements. The height was measured from the ground level during the establishment phase, and from 50 cm stump height during the dry and wet seasons.

Distribution of leaf and stem. At the end of the establishment phase, May 30, 1988, two plants per plot were cut at 10 cm height and then each plant divided into 20 cm intervals up to 130 cm. The portion from each interval was separated into leaf and stem fractions. After separation the fractions were oven dried.

Yield. All other plants were cut back to 50 cm height on May 30, 1988. Yield determinations were then made on the regrowth from 50 cm height on November 1, 1988 (dry season growth), February 7, 1989 ('short wet season' growth) and June 6, 1989 ('long wet season' growth), from 3 tagged plants per plot. The material from the 3 plants was bulked and weighed in the field. This was then cut into short lengths and a 500 g sample taken for separation of leaf (leaf plus twigs < 6 mm diameter) and stem (twigs > 6 mm) and for moisture determination after drying at 100 °C for 24 hours. All other plants were cut back to 50 cm height after each sampling.

Chemical analysis. At the harvest on May 30, 1989 a separate sample of leaves and edible twigs (< 6 mm diameter) was dried at 65 °C for 48 hours prior to grinding for chemical analysis. The fibre fractions and lignin were determined using the procedures of Goering and van Soest (1970). The nitrogen concentration was determined by a microkjeldahl method.

Results

Seasonal plant growth

The cumulative increase in height of representative species is shown in Figure 2. *Sesbania sesban* attained the greatest height (171 cm) in the establishment period (Figure 2a) though the leucaenas had a similar rate of growth from January. All *L. leucocephala* accessions and *L. pulverulenta* reached heights of between 119 and 125 cm which were not significantly different from each other. *S. grandiflora* was the slowest growing only reaching a height of 69 cm. Growth of most accessions had stopped by the end of June though *S. sesban* continued to make some growth during the dry season (Figure 2b). However visual observation indicated that the *Sesbania* species started dropping their leaves earlier in the dry season than the leucaenas. There was no significant difference in heights between the leucaenas and *S. sesban* during the 'short wet season' (Figure 2c). All reached heights of between 200 and 250 cm in 3 months. However, again *S. grandiflora* grew slower than the other species.

[1] Material collected from a mix of various provenances growing at Katumani Research Centre, Machakos, Kenya.

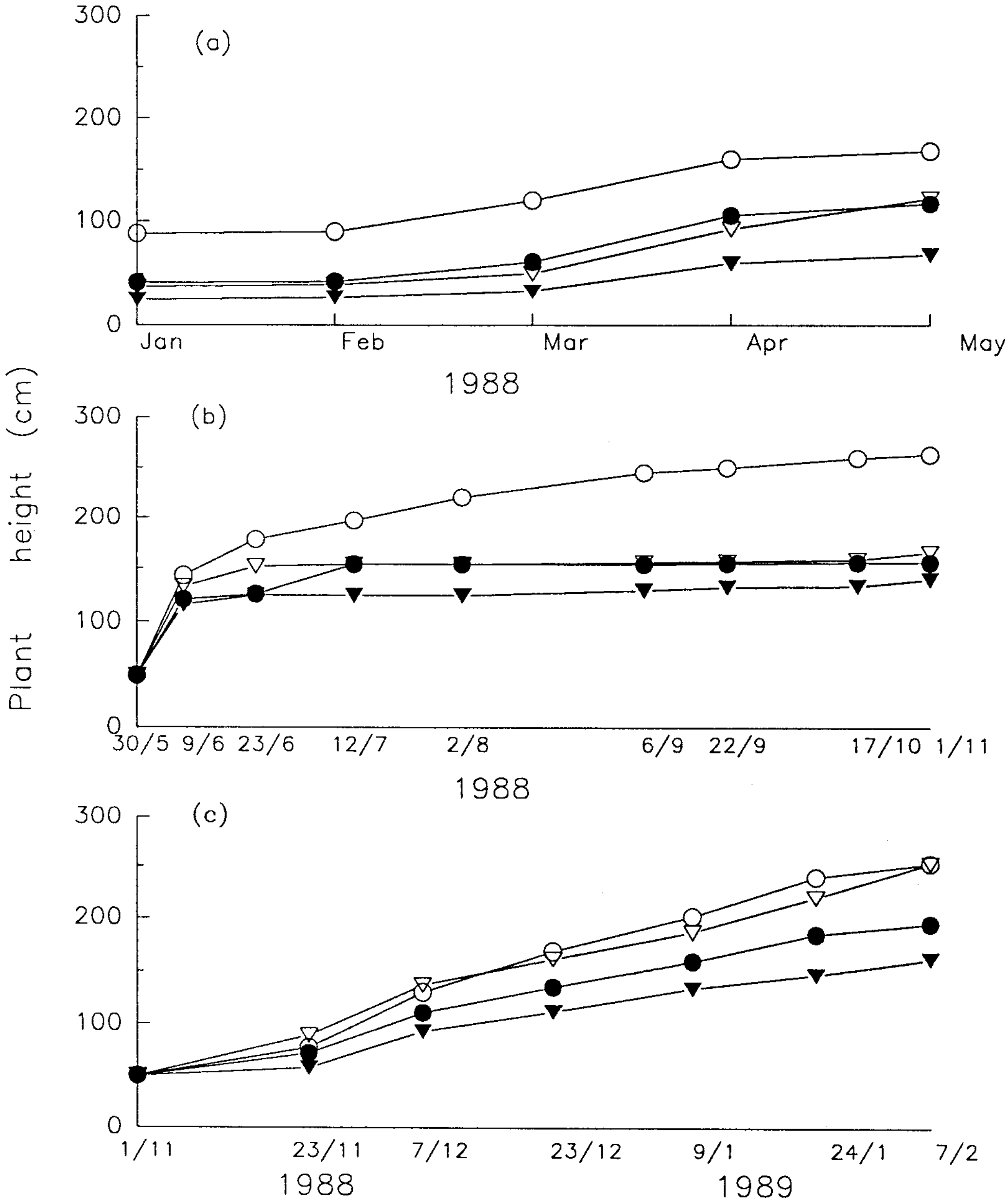

Figure 2. Cumulative growth of browse legumes during the establishment phase (a) and regrowth in the dry season (b) and wet season (c) in semi-arid areas of Eastern Kenya.
O *Sesbania sesban* ● *Leucaena leucocephala* ∇ *Leucaena pulverulenta* ▼ *Sesbania grandiflora*

Height measurements were not continued during the 'long wet season'. However, on observation of plant growth, it was noted that there was 'dieback' in up to 40% of the branches of *S. sesban*.

Distribution of leaf and stem

Figure 3 shows the partitioning of dry matter into leaf and stem at different height intervals at the end of the establishment period (May 30, 1988).

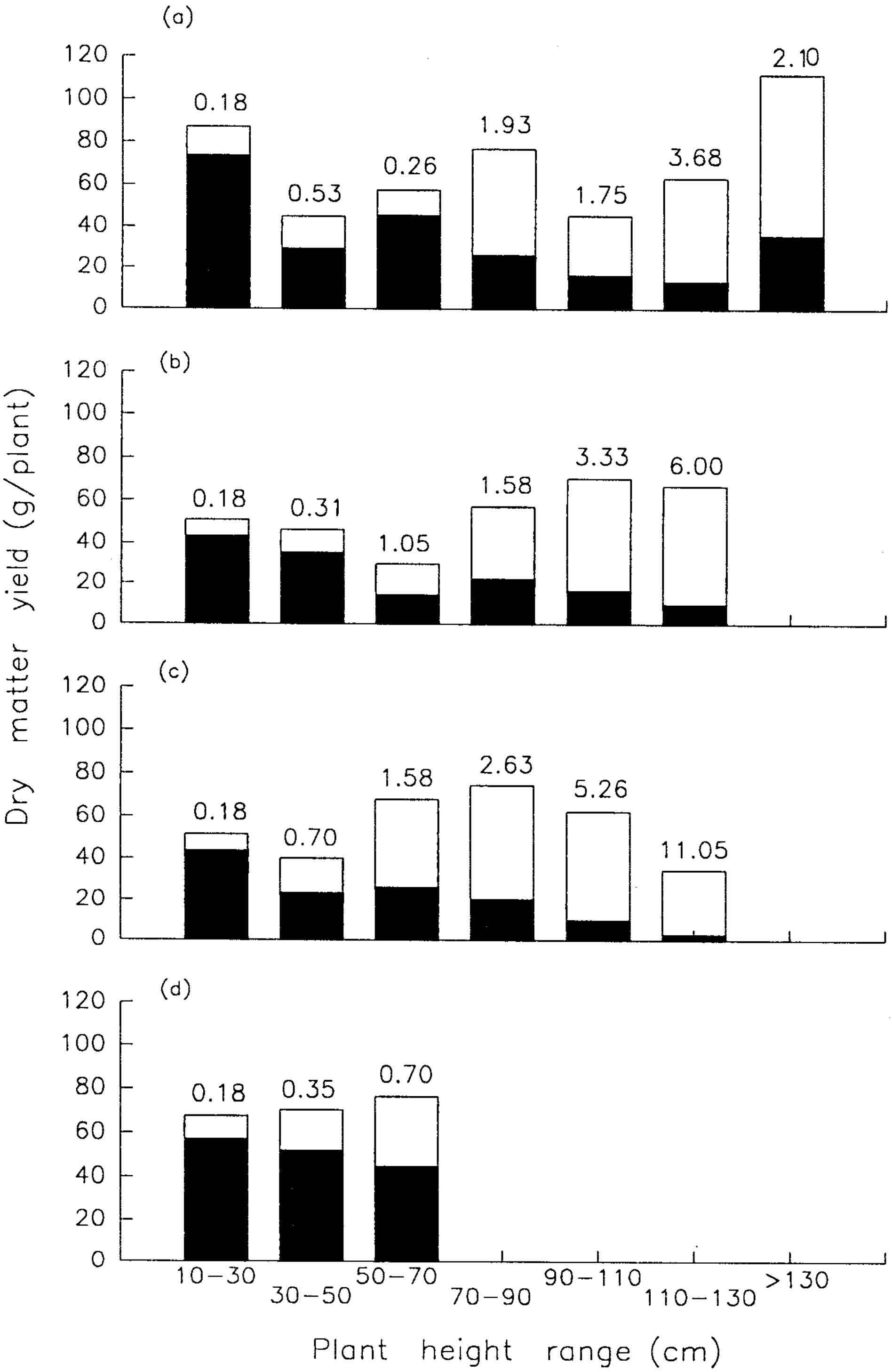

Figure 3. Distribution of dry matter into leaf (□) and stem (■) at increasing plant height during the establishment phase. Numbers on bars represent leaf:stem ratio.
(a) *Sesbania sesban* (b) *Leucaena leucocephala* (c) *Leucaena pulverulenta* (d) *Sesbania grandiflora*

A high proportion of leaf:stem (>1.0) was reached by *Leucaena* spp. between a height of 50 and 70 cm (Figure 3b and c) and *S. sesban* between 70 and 90 cm (Figure 3a) while *S. grandiflora* did not even reach a leaf:stem ratio of 1.0 (Figure 3d).

Yield

Dry matter production of material above 50 cm and the proportion of leaf and stem in both dry and wet seasons is presented in Table 1. Despite some leaf fall, *S. sesban* had a high leaf yield during the dry season but not significantly different from several cultivars or accessions of *L. leucocephala*. In the short wet season, while the total yield of *S. sesbania* was higher than the leucaenas, leaf yield was not. In the long wet season, yield of *S. sesban* was lower than the leucaenas. The yield of the leucaenas did not differ significantly, however *L. pulverulenta* yielded significantly less leaf than *L. leucocephala* cv Peru during the long wet season. *S. grandiflora* was the lowest yielding species. Total stem yield of *S. sesban* was higher than that of the leucaenas, however total leaf yield was significantly lower than *L. leucocephala* K8, cv Cunningham, cv Peru, CPI 91098 and CPI 84511, which had similar yields.

Nitrogen, fibre and lignin concentration

The N concentrations of most species approached or were higher than 4% (Table 2). However, *L. pulverulenta* had a low N concentration of 2.7% and also had the highest fibre and lignin content. Both *S. sesban* and *L. pulverulenta* had high fibre concentration and a relatively high N concentration. Among the *L. leucocephala* accessions and cultivars, CPI 84511 and CPI 58396 had the highest lignin concentration.

Discussion

The results have shown that *S. sesban* grows more rapidly than the *Leucaena* species in the establishment period. These results are similar to those observed in more humid and wetter areas of Kenya (J.F.M. Onim, pers. comm.) and in subtropical environments of Australia (Guttridge 1990). The fact that *S. sesban* continued to grow during the dry season (Figure 2b) and gave a high leaf yield (Table 1) is indicative of the potential this species has as a supplement during the dry season. However, its lower proportion of leaf to stem yields compared to *Leucaena* species (Figure 3 and Table 1), and the observed 'dieback' in the long wet season, make it less attractive as a forage plant. The low yield of *S. grandiflora* is similar to that reported by Guttridge (1990). This species is not suitable as a browse legume.

Leucaena leucocephala K8, and cvv Cunningham and Peru, were the most productive species in terms of leaf production and nutritive value (Tables 1 and 2). *L. leucocephala* CPI 91098 and the Katumani selection are equally good; however, there is a need to sort out the Katumani material to identify the provenance(s) that gave the good attributes. Although CPI 84511 yielded as high as the above 5 strains, the high lignin concentration of 7.2% makes it less attractive as a forage plant. On a per hectare basis, the total leaf yields of 9060 kg/ha, 8900 kg/ha and 8500 kg/ha

Table 1. Dry matter yield of stem and leaf fractions in the dry and wet seasons in semi-arid eastern Kenya

Species	Dry		'Short wet'		'Long wet'		Total	
	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf
	(g/plant)							
Leucaena leucocephala K8	64b[1]	55ab	450a	400a	380a	440ab	890b	900a
L. leucocephala cv. Cunningham	33b	34ab	480a	400a	370a	450ab	890b	890a
L. leucocephala cv. Peru	47b	57ab	430a	320a	380a	470a	860b	850a
L. leucocephala CPI 91098	23b	48ab	280a	300a	340a	340ab	630bc	700ab
L. leucocephala CPI 84511	33b	36ab	340a	300ab	260a	400ab	640bc	750ab
L. leucocephala CPI 58396	22b	19b	380a	270ab	270a	320ab	670bc	600bc
L. leucocephala (Katumani)	42b	42ab	320a	290ab	320a	370ab	690c	700bc
L. pulverulenta	46b	26b	360a	290ab	360a	260bc	770b	580bcd
Sesbania sesban var. *nubica*	149a	98a	700b	210ab	400a	230cd	1260a	540cd
S. grandiflora	16b	52ab	240a	140b	120b	70d	370c	270d

[1] Means followed by the same letter within a column are not significantly different at $P < 0.05$.

Table 2. Nitrogen, neutral detergent fibre, acid detergent fibre and lignin concentration in leaves and edible twigs (< 6 mm diam.) at the end of the wet season (June 1989) in semi-arid eastern Kenya

Species	N	NDF	ADF	lignin
		(%)		
Leucaena leucocephala K8	4.4	26.2	18.5	4.8
L. leucocephala cv. Cunningham	4.4	28.6	19.6	4.8
L. leucocephala cv. Peru	3.8	28.9	19.6	6.4
L. leucocephala CPI 91098	3.6	30.5	21.5	6.2
L. leucocephala CPI 84511	3.5	27.5	19.0	7.2
L. leucocephala CPI 58396	4.0	30.6	21.4	8.1
L. leucocephala (Katumani)	4.1	28.4	20.4	5.8
L. pulverulenta	2.7	39.9	28.3	9.5
Sesbania sesban var. *nubica*	3.9	33.7	27.8	6.0
S. grandiflora	4.5	23.2	19.1	4.5

for K8, cv Cunningham and cv Peru, respectively, were much higher than those reported for *Leucaena* species in Western Kenya (J.F.M. Onim, pers. comm.) and in the wet tropics of Australia (Ferraris 1979). The above average rainfall received during the experimental period and its bimodal distribution may be responsible for these differences. The N concentration values of between 3.5 and 4.4% of edible dry matter of *L. leucocephala* are similar to those reported by Ferraris (1979), but lower than the value of 5.3% N reported by Partridge and Ranacou (1973), for pure leucaena leaf material from Fiji. These latter workers also found no differences between strains of *L. leucocephala* in N concentration.

The high N concentration and low fibre and lignin content, for *L. leucocephala* K8 and *L. leucocephala* cv. Cunningham (Table 2) coupled with high leaf yield, suggest these are the best browse legumes for the semi-arid areas of Kenya.

However, as *S. sesban* has demonstrated good early growth characteristics and growth during the dry season, and a high N and low lignin concentration, further research is warranted. This should include screening for better adapted accessions for semi-arid areas and investigation of management systems that may increase the proportion of leaf in the forage.

Acknowledgements

Logistic and financial support were provided by the Kenya Agricultural Research Institute (KARI) and the International Livestock Centre for Africa (ILCA) through its Pasture Network for Eastern and Southern Africa (PANESA). The technical and laboratory assistance were provided by Mr C. Obadia, Mr Migua and Mr E. Mabalu.

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(Received for publication March 17, 1990; accepted October 25, 1991)