23. Evaluation of lesser known *Leucaena* species, provenances and hybrids for fodder production and psyllid tolerance at Tabora and Shinyanga, Tanzania

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Abstract

Leucaena leucocephala is one of the most important browse species in Africa, but its value as a livestock fodder was reduced by the psyllid (*Heteropsylla cubana*) invasion. As part of the search for psyllid-tolerant species suitable for southern Africa, two trials were established in 1993, one at Tumbi, Tabora to evaluate 15 *Leucaena* spp. and provenances, 10 *Leucaena* hybrids and composites, and another trial at Lubaga, Shinyanga, Tanzania to evaluate 22 lesser known *Leucaena* spp. The test materials were planted using seedlings in one-row plots spaced at 0.75 m ′ 1 m in three replications. They were evaluated for fodder production, fodder quality and psyllid tolerance. Significant differences were observed among the *Leucaena* spp., hybrids and composites at both sites for fodder production. At Tabora, fodder production ranged from 1.58 to 5.68 t (dry weight) ha^{-1} during the rainy season and 0.10 to 0.54 t ha^{-1} in the dry season. At Shinyanga, mean fodder production ranged from 0.76 to 6.01 t ha^{-1}. *Leucaena diversifolia* K156 and *L. pallida* K85 consistently maintained high fodder yields ranging from 6 to 9 t ha^{-1}. Significant differences were also observed among the test material in terms of psyllid damage. *Leucaena collinsii* 45/85 and 51/88, *L. diversifolia* 46/87 and *L. esculenta* 47/87 experienced low psyllid damage. *Leucaena pallida, L.* hybrid K x 3A (original), *L. diversifolia* K156 and *L. diversifolia* accession 8 were least affected by the psyllid. Species and hybrids differed significantly in terms of crude protein content and dry matter digestibility, which ranged from 15 to 9% and 490 to 722 g kg^{-1}, respectively. These results indicate that *L. pallida, L. collinsii* 52/87 and *L. diversifolia* have the potential to replace *L. leucocephala* as sources of livestock feed wherever leucaena spyllid poses a threat to the latter.

Introduction

Agropastoralism is an important activity in the miombo ecozone of Tabora and Shinyanga in western Tanzania. The intensity of agropastoralism may vary from area to area but it is generally characterized by low animal productivity due to many factors. Inadequate nutrition, especially during the dry season when fodder is limiting in both quality and quantity, is one of the major causes of low animal productivity.

Leucaena (*Leucaena leucocephala*) is one amongst many multipurpose trees that has been promoted for fodder production in Tanzania (Lulandala and Hall 1987; Otsyina and Dzowela 1995). It is found in many parts of Tanzania and is usually planted along farm boundaries and in homesteads for fodder, soil fertility improvement, and fuelwood. The occurrence of the devastating leucaena psyllid (*Heteropsylla cubana*) has discouraged the spread of leucaena-based fodder production technology.

The leucaena psyllid feeds exclusively on leucaena and has very little effect on other closely related leguminous trees (Madoffe and Massawe 1995). Some leucaena species were reported to possess some tolerance to leucaena psyllid (Otsyina et al. 1997). Efforts in southern Africa in general and Tanzania in particular have been directed towards identifying psyllid-tolerant leucaena species and provenances for use as alternatives to *L. leucocephala* for soil fertility improvement and fodder production. A study was therefore conducted to evaluate growth, fodder production and tolerance to psyllid attack of several *Leucaena* species, provenances, hybrids, and composites in Tabora and Shinyanga regions of Tanzania.

Materials and methods

Site characteristics

One trial was conducted at the Agricultural Research Institute (ARI), Tumbi in the Tabora region and another at Lubaga in the Shinyanga region in northwestern Tanzania. The Tumbi site, situated at about 1199 m above sea level, is characterized by undulating topography and sandy soils. The soils are mostly ferric Acrisols (FAO system) with 80 to 90% sand, low soil pH (4.0), low organic carbon (0.4 to 0.8%), low total nitrogen (0.01 to 0.03%), and low available phosphorus (3 to 12 ppm). The unimodal rainfall from November to May and ranges from 700 to 1000 mm per annum and the rainy season is followed by a long dry season (5 to 6 months). The vegetation is miombo woodland, which occurs throughout the southern interior of Africa. The main feature of the farming system is maize–tobacco rotation, in which maize is grown for 2 to 3 years and then followed by tobacco. Livestock are the second most important source of livelihood to most households.

In the Shinyanga region, eutric Cambisols dominate the uplands and Vertisols occur mostly in the bottomlands. Soils are generally shallow (0.3 to 1.5 m depth) and slightly alkaline (pH 7 to 9). Annual rainfall ranges between 600 and 800 mm. Rainfall is very erratic and characterized by short dry spells, which often is detrimental to crop production. The vegetation following clearing in the 1920s and 1930s is now reverting to open bush savannah. The farming system comprises mainly of livestock and crop production components integrated in many ways.

Leucaena germplasm evaluation at Tumbi, Tabora

The experiment was a completely randomized block with three replications. The plot size was 5 m x 6.75 m with 5 rows of *Leucaena* planted on ridges at a spacing of 0.75 m within and 1.0 m between rows. Sixty-day-old seedlings raised in polythene tubes were transplanted in the field in November 1992. The plots were maintained free of weeds by hand weeding. The plants were allowed to grow for one year before cutting back to 50 cm height in November 1993. Two harvests were made every year, once in March and another in November during the period 1994 through 1997. However, in 1995 and 1996 the trees were also cut back in September in order to assess fodder production potential during the peak dry season.

Leucaena germplasm evaluation at Lubaga, Shinyanga

Twenty-two different species and provenances obtained from the Oxford Forestry Institute (OFI) were evaluated in this trial. Three-month-old seedlings raised in a nursery were transplanted in January 1996. The entries were planted in 4 x 5 m plots at 1 × 1 m spacing in four lines. Each line had five seedlings, which means that there were 20 seedlings per plot. A randomized block design with four replications was employed. All the entries were evaluated for survival, height, root collar diameter, and psyllid tolerance in the first year (Otsyina et al. 1997). In the second year (1997), trees were cut back to 0.5 m height for biomass determination.

Data collection and analyses

Fodder yields at each harvest were estimated from 10 plants per plot, which were selected at random and tagged. The fodder components (leaves and twigs less than 5 mm diameter) were dried separately in an oven at 75°C to constant weight and weighed for dry matter (DM) determination. Psyllid damage was assessed at two-week intervals commencing from the 1993-94 growing season through the 1995-96 season. The damage was assessed on a 1 to 9 rating scale (Wheeler 1998) where 1 means least damage and 9 very severe damage.

Fodder samples were ground using a Wiley mill to pass through a 2mm sieve for chemical analysis. Nitrogen concentration was determined by the macro Kjeldahl method. In-vitro dry matter digestibility was determined using the modified Goering and Van Soest (1970) method of Tilley and Terry (1963). Data on survival, growth (height and root collar diameter), fodder production and nutritive value were subjected to the ANOVA. Differences between treatment means were tested using least significant difference test at 5% probability.

Results

Provenance performance at Tumbi, Tabora

Fodder yields of the lesser-known leucaenas evaluated at Tumbi, Tabora ranged from 1.41 to 5.44 t ha^{-1} in the wet season (Table 1) and from 0.08 to 0.66 t ha^{-1} in the dry season (Table 2). Fodder yields of hybrids and composites ranged from 1.66 to 6.45 t ha^{-1} during the wet season and 0.33 to 0.79 t ha^{-1} during the dry seasons (Table 3). During the wet season, while *L. diversifolia stenocarpa* produced the highest yield (7.66 t ha^{-1}), *L. esculenta esculenta* 47/87 the lowest yield. During the dry season, however, *L. diversifolia stenocarpa* in one year and *L. salvadorensis* 7/91 in another year outperformed the other leucaenas.

Observations on psyllid damage indicated great variability among species, provenances, and hybrids (Tables 2 and 3). Low psyllid damage was recorded in *L. collinsii* 45/85, *L. collinsii* 51/88, *L. diversifolia* 46/

while *L. pallida* and *L. diversifolia* were relatively free from the damage (ICRAF 1994), a finding similar to that observed in the present study.

Crude protein content of *Leucaena* foliage was generally high. While the hybrid Kx3A (Wainamalo) had the highest value (23.1%), *L. pallida* had the lowest value (19. 8%). This trend is consistent with that reported by Gupta et al. (1991) and Austin et al. (1992). The crude protein concentrations of these leucaena germplasm were higher than that recommended (11%) for growth of most young domestic ruminants (NRC 1990). While all species contained high concentrations of protein, dry matter digestibility as estimated by in-vitro methods was much below the 65% level considered good for highly digestible herbage (Jones and Lowry 1991). Leucaena species are usually high in protein (17.8 to 27%) and moderate in digestibility (64 to 68%). However, psyllid tolerant *Leucaena* species such as *L. pallida* were relatively low in protein (17 to 22%) and in-vitro digestibility (54 to 56%) (Austin et al. 1992). *Leucaena pallida* and other psyllid tolerant species contain anti-nutritional factors such as tannin and other alkaloids, which depress digestibility and availability of nutrients (Reed et al. 1990; Lowry et al. 1996).

Feeding trials have to be conducted under several management conditions to validate the preliminary results reported here and to determine the feeding values of these alternate *Leucaena* species in livestock production systems. Research efforts are also needed towards increasing leaf retention, particularly for dry season feeding.

Conclusion

Results of the present studies indicate that *L. pallida, L. diversifolia, L. esculenta esculenta* 47/87 and *L. collinsii* 45/85 are suitable to replace the psyllid susceptible *L. leucocephala* and they can be used to provide high quality fodder to supplement the low quality feedstuffs. Most of the species in the present study, however, performed poorly in the dry season when fodder is most needed. These results clearly indicate that these *Leucaena* materials cannot be entirely relied upon for dry season feeding without developing proper cutting management because of their poor leaf retention. An important option for the extra leaf biomass produced during the wet season is to harvest, dry and store for use as leaf meal during the dry season.

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Table 5. Growth, survival and biomass yield of lesser-known *Leucaena* species, provenances, and hybrids evaluated at Lubaga, Shinyanga, Tanzania.

Species/provenances	Growth at 2 years		Survival at 30	Biomass ($t\ ha^{-1}$)	
	Height (m)	RCD (mm)	months (%)	1997	1998
L. diversifolia 4/91 Erandique	2.59	44.1	28	0.69	0.58
L. diversifolia 83/92 Jalapa De Diaz	2.25	34.7	56	2.29	3.79
L. diversifolia sternocarpa 53/88 Los Guates	1.46	23.4	34	3.04	5.30
L. diversifolia 82/92 Barrillas	2.17	26.7	63	1.52	2.17
L. diversifolia Gede	2.59	44.1	63	2.26	7.50
L. glabrata 34/92 wainamalo	2.63	37.2	67	4.23	7.44
L. shanonnii magnifica 19/84 Chiquimula	2.46	31.9	39	0.64	6.07
L. esculenta 47/87 san Martin Pachivia	1.83	49.8	88	2.56	4.22
L. esculenta 52/87 San Pedro Chapulco	2.01	41.9	50	1.24	2.30
L. esculenta paniculata 79/92 Tamazulapan	2.64	41.4	81	6.23	4.42
L. lempirana 6/91 Cuyamapa	1.83	23.9	59	0.60	2.89
L. macrophylla nelsonii 47/85 San Isdro	2.65	32.9	69	2.37	6.94
L. collinsii Zacapana 56/88 Gualan	2.35	32.0	73	1.41	4.63
L. collinsii 52/87 Narcisco Mandoza	2.25	44.5	46	2.85	11.98
L. salvadorensis 36/88 La Garita	2.35	37.6	54	3.70	11.63
L. trichodes 61/88 Jipijapa	0.92	15.6	36	2.31	2.57
Leucaena hybrid Kx2 UHF5 Families	2.31	43.3	48	3.31	10.36
Leucaena hybrid Kx3	2.45	35.0	64	3.22	6.54
L. leucocephala K8	1.90	36.3	58	2.98	7.31
L. involucrata 87/92 El Novilo	1.85	23.5	53	0.61	1.25
L. pallida 137/94 Unknown	2.28	30.6	84	3.93	4.99
L. lanceolata 43/85 San Jon	2.39	34.0	60	3.36	4.49
SED	4.90	9.4	11.5	1.20	2.62

SED = Standard error of difference of treatment means

Discussion

The present studies identified *L. pallida* 37/94, *L. esculenta* 79/92 and *L. collinsii* 56/88 as the most promising and *L. diversifolia* 4/91, *L. diversifolia* 53/88, *L. trichodes* 61/88 and *L. shanonii* 19/84 to be less adapted to the Shinyanga conditions. *Leucaena* species evaluation in other southern African countries has shown that *L. pallida* and other psyllid tolerant species perform well under different biophysical conditions (Dzowela et al. 1997). Most species in the present studies produced foliar biomass at levels similar to those reported elsewhere (Hill 1971). However, fodder production from these species is lower than that of the conventional species like *L. leucocephala*. The lowest fodder yields were recorded from *L. involucrata* 87/92, *L. lempirana* 6/91, *Leucaena* spp. 6/91, *L. collinsii zacapana* 56/88 and *L. glabrata* 34/94, probably due to psyllid damage as these entries were susceptible to the lecaena psyllid. Mella et al. (1990) and Gunasena et al. (1990) reported the tolerance of the above leucaena species and provenances to psyllid damage. *Leucaena* hybrids and composites indicated different degrees of tolerance to psyllid damage. Most tolerance was observed in *L. pallida* and *L. diversifolia* species, and *Leucaena* hybrid Kx3A (original), which recorded damage scores less than one. These were also among the highest fodder yielding species. The low fodder yield from *L. diversifolia* K156 during the dry season was probably be due to stress from repeated cutting. This material was relatively tolerant to psyllid damage. These results are consistent with the findings of similar studies elsewhere (Bray and Woodroffe 1988; Buranasiipin et al. 1990). Screening at Zomba, Malawi has also indicated resistance of some of the Hawaiian hybrids to psyllid. *Leucaena leucocephala* hybrids were reported to be susceptible to the psyllid attack,

Table 3. Mean fodder production and psyllid damage scores of *Leucaena* species, hybrids and composites 1994–1996 season at Tumbi, Tabora, Tanzania.

Leucaena material	Fodder production (t ha^{-1})		Psyllid damage
	Wet season	Dry season	(Scale: 1–9)
L. diversifolia Acc.8	3.93	0.53	1.00
L. K636 com. (proach Mexico)	3.50	0.33	3.35
L. sp Kx2 (Composite)	4.01	0.79	2.69
L. hybrid (Wainamalo)	3.92	0.44	3.08
L. hybrid Kx3A (Wainamalo)	4.31	0.79	2.85
L. hybrid Kx3C	3.28	0.64	3.88
L. hybrid Kx3A (Original)	3.05	0.67	1.15
L. hybrid K88A (Composite)	2.09	0.44	3.35
L. diversifolia K 156	1.66	0.63	1.12
L. pallida	6.46	0.90	1.00
SED	1.56	0.20	

Psyllid damage: 1 = none; 9 = very high; SED = Standard error of difference of treatment means

Table 4. Nutritional values of psyllid tolerant *Leucaena* species, hybrids and composites used for dry season fodder at Tumbi, Tabora, Tanzania.

Leucaena material	Crude protein (%)	Dry matter digestibility (%)
L. pallida	19.8	48.2
L. diversifolia	20.3	44.3
L. sp. Kx2 (Composite)	21.3	50.2
L. hybrid Kx3A (Origional)	18.8	48.6
L. hybrid Kx3A (Wainamalo)	23.1	46.1
SED	7.0	9.8

The *Leucaena* materials did not differ significantly ($P > 0.05$) in crude protein content and dry matter digestibility (Table 4). These two parameters ranged from 18.8% to 21.3% and 44.3% to 50.2%, respectively for composites and hybrids (Table 4). The crude protein content of the other *Leucaena* species and provenances ranged from 19.8 to 23.6%, but differences between the *Leucaena* germplasm were not statistically significant. The hybrids and composites differed significantly in dry matter digestibility ($P < 0.05$), with values ranging from 49.2% to 64.3%.

Provenance performance at Lubaga, Shinyanga

At the age of 2 years, height of the entries ranged from 0.92 to 2.65 m, the lowest being for *L. trichodes* 61/88 and the greatest for *L. macrophylla nelsonii* 47/85 (Table 5). Differences among entries were significant ($P < 0.05$) in height growth. The outstanding entries were *L. leucocephala* 34/42 (2.63 m), *L. esculenta paniculata* 79/92 (2.64 m) and *L. macrophylla nelsonii* 47/85 (2.65 m). The entries also differed significantly ($P < 0.05$) in root collar diameter. *Leucaena esculenta esculenta* 47/87 (49.5 mm) had the greatest RCD, followed by *L. collinsii* 52/87 (44.5 mm), while *L. trichodes* 61/85 recorded the lowest diameter (15.6 mm).

At the age of 30 months, entries differed significantly in stand survival ($P < 0.05$). Stand survival was moderate (over 50%) in the first two years, except with a few entries (Table 5). *Leucaena pallida* 33/94 had the highest survival (84%) followed by *L. esculenta paniculata* 52/87 (81) and *L. collinsii* 56/88 (73%). The lowest survival (28%) was recorded in the case of *L. diversifolia* 4/91.

There were significant ($P < 0.05$) differences among the entries in fodder yields (Tables 5). Mean leaf biomass yields ranged from 0.60 to 6.23 t ha^{-1} and 0.58 to 11.98 t ha^{-1} in 1997 and 1998, respectively. Outstanding species across years were *L. grabrata* 34/92, *L. salvadorensis* 36/88, *Leucaena* hybrid Kx2, *L. collinsii* 52/87 and *L. diversifolia* Gede. *Leucaena involucrata* 87/92, *Leucaena diversifolia* 4/91 and *L. lempirana* 6/91 produced very low amounts of leaf biomass. Considering the performance at both sites, outstanding species in term of fodder yields were *Leucaena* hzbrid KX2 (composite), *Leucaena* hybrid kx3a (Wainamalo), *L. pallida*, *L. glabrata* 34/92 and *L. lanceolata* 43/85 (Tables 2–5).

Table 1. Wet season fodder production of *Leucaena* species and provenances evaluated during 1994–1997 at Tumbi, Tabora, Tanzania.

OFI Provenance code	Species	Fodder yields (t ha^{-1})				
		March 1994	March 1995	March 1996	March 1997	Mean 1998
53/88	*L. diversifolia stenocarpa*	3.21	6.17	7.66	4.71	5.44
46/87	*L. diversifolia*	0.56	1.19	3.56	0.33	1.41
6/88	*L. glabrata*	1.48	1.67	-	3.99	2.38
34/92	*L. glabrata*	1.89	4.77	3.01	7.42	4.27
47/87	*L. esculenta esculenta*	2.18	3.97	1.19	0.93	2.07
79/92	*L. esculenta paniculata*	2.10	1.19	4.67	1.07	2.26
55/88	*L. macrophylla macrophylla*	2.03	6.98	2.03	1.94	3.25
7/91	*L. macrophylla*	2.01	1.86	3.57	7.61	3.76
6/91	*L. collinsii zacapana*	0.93	2.47	2.23	1.45	1.77
56/88	*L. collinsii zacapana*	1.33	2.41	2.06	4.35	2.54
45/85	*L. collinsii*	2.52	4.06	5.89	2.47	3.74
18/85	*L. salvadorensis*	0.95	6.30	2.48	1.83	4.00
17/86	*L. salvodorensis*	1.13	2.88	5.70	4.67	3.60
43/85	*L. lanceolata*	3.36	3.48	4.56	5.71	4.28
SED		0.85	1.08	0.58	0.63	

SED = Standard error of difference of treatment means

Table 2. Dry season fodder production of *Leucaena* species and provenances and their susceptibility to psyllid damage at Tumbi, Tabora, Tanzania.

OFI Provenance code	Species	Fodder yield (t ha^{-1})		Damage Score (1–9)
		September 1995	September 1996	
53/88	*L. diversifolia stenocarpa*	0.74	0.14	-
46/87	*L. diversifolia*	0.10	0.15	1.13
6/88	*L. glabrata*	0.15	0.27	3.92
34/92	*L. glabrata*	0.38	0.49	2.94
47/87	*L. esculenta esculenta*	0.12	0.08	1.00
79/92	*L. esculenta paniculata*	0.07	0.16	-
55/88	*L. macrophylla macrophylla*	0.19	0.43	1.37
7/91	*L. macrophylla*	0.11	0.66	2.04
6/91	*L. collinsii zacapana*	0.12	0.10	1.40
56/88	*L. collinsii zacapana*	0.16	0.29	3.77
45/85	*L. collinsii*	0.08	0.38	1.00
17/86	*[illegible]lorensis*	0.15	0.14	1.37
[illegible]	*[illegible]lorensis*	0.24	0.15	1.50
[illegible]	*[illegible]olata*	0.48	0.59	2.55
19/84	*L. shannonii magnifica*	0.06	0.40	-
SED		0.02	0.09	0.76

Psyllid damage: 1 = none; 9 = very high; SED = Standard error of difference in treatment means

87 and *L. esculenta esculenta* 47/87 with scores of 1.00, 1,40, 1.13 and 1.00, respectively. Psyllid damage was highly variable ($P < 0.05$) between leucaena hybrids and composites. *Leucaena pallida*, *L. diversifolia* K156, *L. diversifolia* accession 8 and *Leucaena* hybrid K x 3A (original) were tolerant to psyllid damage.

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