The yield and persistence of selected forage legumes in subhumid and semi-arid west Africa

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Abstract

Trials were conducted at 7 sites in northern Nigeria to identify forage legumes as alternatives to *Stylosanthes hamata* cv. Verano. Initial screening of 46 accessions at each site led to the identification of the best 8 for each site. These were then tested for 4 years, the first 2 with careful management (weeding) followed by 2 years without weeding to determine persistence.

S. hamata grew well and persisted at almost all sites but it was possible to identify some other accessions with potential. *S. scabra* showed some promise for wetter subhumid areas such as Makurdi and Jos; *Chamaecrista rotundifolia* and *Centrosema brasilianum* performed well at semi-arid sites (Bauchi and Rano). *Centrosema pascuorum* and *S. humilis* have potential for use in very dry semi-arid areas such as Maiduguri where they may be used in a cut and conserve situation.

Introduction

Poor dry season livestock nutrition is a major constraint to productivity in subhumid and semi-arid west Africa (ILCA 1979). In an attempt to alleviate this problem, fodder banks using *Stylosanthes hamata* cv. Verano and *S. guianensis* ILCA 164[1] have been successfully introduced to agropastoralists in subhumid Nigeria (Mohamed-Saleem and Suleiman 1986), Mali (ILCA 1989) and Cameroon (Tarawali and Pamo 1992).

In Nigeria, the fodder bank concept has been developed and researched by scientists at the International Livestock Centre for Africa (ILCA) and introduced to farmers by the extension service, National Livestock Projects Department (NLPD) who have state and district officers throughout the country. Feedback from NLPD indicated that the forage legumes being used for fodder banks were not the most appropriate for all parts of the country, which includes humid, subhumid and semi-arid regions (ILCA 1987). Initially, ILCA started a forage evaluation program at its subhumid research site near Kaduna, Nigeria to identify suitable alternative forage legumes for use in fodder banks (Tarawali *et al.* 1989; Tarawali 1991), but it became apparent that this single site evaluation was not representative of the whole of central and northern Nigeria. In 1986, trials were established at 6 additional sites (2 subhumid and 4 semi-arid) in Nigeria. It was decided not to include sites in the humid zone, since the alley farming package was more relevant there than the fodder bank (Atta-Krah *et al.* 1986). The present article reports the results of these trials and their implications for fodder resource development in west Africa.

Materials and methods

The trials aimed to identify material that could grow well if managed carefully (i.e. the plots were weeded), and to select accessions that could persist even under harsh competition from the native vegetation (unweeded plots). Yields were generally low and reflected the environmental conditions. The trials at Talata Mafara (Sokoto) and Daura (Katsina) had to be discontinued after 1986 and 1989, respectively, due to servicing difficulties.

[1]ILCA 164 = CIAT 184 = FAO 46004

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The experiments were simple designs so as to minimise supervision and consisted of 2 stages: (i) evaluation of small plots of the same 46 accessions at each site (1986-87); and (ii) more detailed evaluation of the best 8 accessions at each site (1988-89), followed by estimation of their persistence (1990-91).

Sites

A summary of the sites used is presented in Table 1. Details of the rainfall and soil features of the sites are given in Tables 2 and 3, respectively. In all cases, although some were previously cropped, the soils were marginal and poor quality; evaluating material on such soils is, however, realistic since only marginal land is likely to be allocated to forage rather than crop production (Paterson 1989).

Trial (i) — Preliminary evaluation

Forty-six forage legume accessions were selected (Table 4) to cover all the genera that had been tested in Kaduna plus those specifically recommended for subhumid or semi-arid areas. The accessions were planted in a randomised complete block design with 2 replicates at each site. Plots were 1.5 m × 0.5 m and the seeds, which were pre-scarified using sandpaper, were sown in a single row in the centre of the plot. Recommended seeding rates were used (Humphreys 1980). Single superphosphate (150 kg/ha) was incorporated into the soil at the time of planting; this is the recommended fertiliser for fodder banks (Otsyina *et al.* 1987) and it is unlikely that farmers would be willing to apply more than this. Plots were kept weeded during the experiment.

The performance of the accessions was assessed visually (Tarawali *et al.* 1989) and "scored" for 5 parameters as follows (maximum score = 15):

- productivity in the establishment year: 0 (none); 1 (poor); 2 (reasonable); 3 (excellent) as compared with other accessions at the same site.
- resistance to disease: 1 (>50% of plot affected); 2 (10–50% of the plot affected); 3 (<10% of the plot affected).
- regeneration (assessed by scoring the plots early in the second growing season): 0 (none); 1 (poor); 2 (reasonable); 3 (excellent) as compared with other accessions at the same site.

Table 1. Site descriptions for trials (i) and (ii); the precropping details refer to the condition of the land in the year immediately before planting the trial.

Site	Latitude/Longitude	Zone	State	Precropping details	
				Site (i)	Site (ii)
Makurdi	7° 44 'N, 8° 35 'E	subhumid	Benue	fallow	fallow
Jos	9° 54 'N, 8° 53 'E	subhumid	Plateau	maize	maize
Bauchi	10° 20 'N, 9° 47 'E	semi-arid	Bauchi	maize	fallow
Rano	11° 30 'N, 8° 32 'E	semi-arid	Kano	millet	millet
Maiduguri	11° 53 'N, 13° 16 'E	semi-arid	Borno	maize	millet
Talata Mafara	12° 6 'N, 6° 4 'E	semi-raid	Sokoto	cowpea/millet	—
Daura	13° 5 'N, 8° 15 'E	semi-arid	Katsina	—[1]	fallow

[1]Trials not established at these sites.

Table 2. Rainfall at trial sites in central-northern Nigeria.

	1986	1987	1988	1989	1990	1991
	mm d[1]	mm d	mm d	mm d	mm d	mm d
Makurdi	1095 53	1187 47	888 49	1230 63	1182 50	na[2]
Jos	1320 71	1805 67	993 51	1106 63	1216 68	na
Bauchi	1137 43	738 32	na	1075 75	821 66	952 74
Rano	744 41	761 57	914 43	701 52	944 35	1174 45
Maiduguri	380 17	320 17	453 16	385 30	447 37	402 47
Daura	na	na	482 24	na	na	na

[1]Number of days on which rain fell.
[2]Rainfall data not available.

- seed production: 0 (none); 1 (few); 2 (reasonable); 3 (excellent).
- productivity in the second growing season: assessed as described above.

The scores obtained were totalled and those accessions scoring more than 10 were considered for inclusion in trial (ii).

Trial (ii) — Detailed evaluation of yield and persistence

Nine accessions were planted in a randomised complete block design with 3 replications, the best 8 for each site as determined by the preliminary evaluation in trial (i), plus *Stylosanthes hamata* cv. Verano. A selection of accessions with potential for semi-arid areas were used at Daura since there was no trial (i) at that site. Seeds were sown at the recommended rates (Humphreys 1980) at the start of the 1988 growing season in plots 2 m × 3 m. For the first 2 years of the trial, plots were weeded and trimmed as necessary to maintain pure stands of the sown species. Performance of the species was assessed on the basis of dry matter yields at the end of the growing seasons. At the end of the 1988 and 1989 growing seasons, two 1 m^2 quadrats were cut from each plot, weighed and subsamples taken and dried in an oven at 65 °C to determine dry matter yields. In 1990 and 1991, the plots were maintained but not weeded; two 1 m^2 quadrats per plot were harvested at the end of the respective growing seasons and divided into sown legume and other plants.

Results

Trial (i) — Preliminary evaluation

From the total scores, the most promising 8 accessions at each site were selected. A total of 16 accessions from the original 46 were selected and these are shown, together with their total scores for the sites in which they were selected, in Table 5. Generally, the shrubby legumes (*Cajanus cajan*, *Codariocalyx gyroides* and *Leucaena leucocephala*) grew poorly at all sites. Of the herbaceous legumes, *Alysicarpus*, *Centrosema arenarium*, *C. macrocarpum*, *C. pubescens*, *Desmodium ovalifolium*, *Macroptilium lathyroides*, *Neonotonia wightii*, *Stylosanthes capitata*, *S. macrocephala*, *Zornia brasiliensis* and *Zornia* sp. grew poorly at all sites. *Desmodium intortum* grew well at the subhumid sites, but consisted mostly of woody stems with little green leaf. Accessions of *Stylosanthes guianensis* grew well at Makurdi initially but subsequently were severely affected by anthracnose. *Macrotyloma axillare* and *Zornia latifolia* grew well only at Jos; *Stylosanthes humilis* grew well only at Maiduguri. Accessions of *Centrosema brasilianum* grew well at Makurdi and all sites except Jos; *Centrosema pascuorum* accessions grew well in semi-arid sites. *Chamaecrista rotundifolia* grew well at all sites. *Clitoria ternatea*, *Lablab purpureus* and *Macroptilium atropurpureum* performed well only at selected sites (Table 5). *Stylosanthes scabra* grew best at subhumid sites.

Table 3. Soil features of the trial sites in central–northern Nigeria.

		Total N	Organic C	Available P	pH	Texture
		(%)	(%)	(ppm)	(H_2O)	
Makurdi	(i)[1]	0.042	0.14	6.30	5.70	sand
	(ii)[2]	0.049	0.62	1.75	—[3]	sandy loam
Jos	(i)	0.028	0.06	0.70	5.50	clay loam
	(ii)	0.091	1.06	3.85	—	sandy clay loam
Bauchi	(i)	0.056	0.32	7.00	6.00	sand
	(ii)	0.063	0.86	2.45	—	sandy loam
Rano	(i)	0.056	0.18	12.60	5.80	loamy sand
	(ii)	0.049	0.26	6.30	—	sandy loam
Maiduguri	(i)	0.028	0.12	0.70	6.60	sandy loam
	(ii)	0.063	0.28	6.65	—	sandy loam
T. Mafara	(i)	0.084	0.08	4.90	6.00	sand
Daura	(ii)	0.049	0.26	14.00	—	sandy loam

[1]Preliminary evaluation site.
[2]Second, detailed evaluation site.
[3]Data not collected.

Table 4. Accessions planted in trial (i). Other numbers and cultivars (in parentheses) were obtained by cross-referencing using the ILCA germplasm catalogue (ILCA 1985) and the 1989 World Catalogue of *Centrosema* Germplasm (Schultze-Kraft *et al.* 1989). Source refers to the source of the seeds used for this experiment, not the original source of the seeds.

Species	Accession number	Other number(s)	Source
Alysicarpus sp. L.	Indigenous	—	ILCA Kaduna
Cajanus cajan	Local	—	ILCA Kaduna
Centrosema arenarium Benth.	ILCA 12451	CT 5236/CPI 92410	ILCA Addis
Centrosema brasilianum (L.) Benth	ILCA 155	CT 5234/CPI 87993	ILCA Addis
Centrosema brasilianum	ILCA 6773	CT 5211/CPI 55698	ILCA Addis
Centrosema brasilianum	ILCA 9940	CT 5370/CPI 55696	ILCA Addis
Centrosema macrocarpum Benth.	ILCA 12146	CT 5062/CPI 83506	ILCA Addis
Centrosema pascuorum Mart. ex. Benth.	ILCA 9290	N 77060	ILCA Addis
Centrosema pascuorum	ILCA 9857	CT 5924 (Cavalcade)	ILCA Addis
Centrosema pascuorum	ILCA 9863	CPI 400600	ILCA Addis
Centrosema pubescens Benth.	ILCA 152	CT 5126/CPI 87970	ILCA Addis
Centrosema pubescens	ILCA 9034	CT 442	ILCA Addis
Chamaecrista rotundifolia Greene.	ILCA 10915	CPI 37234	ILCA Kaduna
Chamaecrista rotundifolia	ILCA 10916	Q 10057	ILCA Kaduna
Chamaecrista rotundifolia	ILCA 10917	Q 9862	ILCA Kaduna
Chamaecrista rotundifolia	ILCA 10918	CPI 34721 (Wynn)	ILCA Kaduna
Chamaecrista rotundifolia	Indigenous	—	ILCA Kaduna
Clitoria ternatea L.	ILCA 7621	CPI 37195	ILCA Kaduna
Clitoria ternatea	CPI 50973	—	ILCA Kaduna
Codariocalyx gyroides Hassk.	ILCA 12455	CT 3001	ILCA Kaduna
Desmodium intortum Urb.	ILCA 108	—	ILCA Addis
Desmodium ovalifolium	ILCA 100	CT 350	ILCA Addis
Lablab purpureus Sweet	ILCA 147	(Highworth)	ILCA Addis
Lablab purpureus	ILCA 11609	(Rongai)	ILCA Addis
Leucaena leucocephala (Lam.) de Wit	cv H7	—	ILCA Kaduna
Leucaena leucocephala	Local	—	ILCA Kaduna
Macroptilium atropurpureum (DC.) Urb	ILCA 69	(Siratro)	ILCA Addis
Macroptilium atropurpureum	ILCA 109	CT 360	ILCA Addis
Macroptilium lathyroides Urb.	ILCA 6955	(Murray)	ILCA Addis
Macrotyloma axillare (E. Mey) Verdc.	ILCA 6756	(Archer)	ILCA Addis
Neonotonia wightii (Wight. & Arn.) Verdc.	ILCA 6761	(Tinaroo)	ILCA Addis
Stylosanthes capitata Vog.	ILCA 159	CT 1315	ILCA Kaduna
Stylosanthes capitata	ILCA 9023	CT 1693	ILCA Kaduna
Stylosanthes guianensis Sw.	ILCA 1	(Oxley)	ILCA Kaduna
Stylosanthes guianensis	ILCA 2	(Endeavour)	ILCA Addis
Stylosanthes guianensis	ILCA 4	(Cook)	ILCA Addis
Stylosanthes hamata Taub.	ILCA 75	(Verano)	ILCA Kaduna
Stylosanthes humilis H.B.K.	ILCA 7363	(Townsville)	ILCA Addis
Stylosanthes macrocephala Ferreira & Sousa Costa	ILCA 9030	CT 2093	ILCA Addis
Stylosanthes macrocephala	ILCA 12053	CT 2133	ILCA Addis
Stylosanthes scabra Vog.	ILCA 140	(Seca)	ILCA Addis
Stylosanthes scabra	ILCA 441	(Fitzroy)	ILCA Addis
Zornia brasiliensis Vog.	ILCA 171	CT 7485	ILCA Addis
Zornia latifolia D.C.	ILCA 172	CT 728	ILCA Kaduna
Zornia sp.	ILCA 9027	CT 7847	ILCA Addis

Abbreviations as follows: CT, CIAT, Centro Internacional Agricultura Tropical, Cali, Colombia; CPI, CSIRO, Commonwealth Scientific and Industrial Research Organisation, Australia; N, ILCA, International Livestock Centre for Africa, Mali; Q, Queensland Department of Primary Industries, Australia.

Trial (ii) — Detailed evaluation of yield and persistence

Figure 1 shows the results from 1988 and 1989 when the accessions were growing in pure stands; growth in unweeded plots during 1990 and 1991 is shown in Figure 2.

Jos (subhumid). Growth of most of the accessions at Jos was poor, with the exception of *S. scabra* in 1989 (11.8 t/ha). The yields of *Macroptilium atropurpureum*, *Macrotyloma axillare*, *S. hamata* and *Zornia latifolia* increased in the second year (Figure 1). In 1990, only *Macroptilium atropurpureum* (3.5 t/ha) and to a lesser extent *Macrotyloma axillare* (1.7 t/ha) and *Zornia latifolia* (1.1 t/ha) gave yields over 1 t/ha in the presence of weeds (Figure 2). In 1991, the highest legume yield was for

Table 5. The best accessions (plus Verano ILCA 75) selected as promising (+) and suitable for further evaluation (trial (ii)) at each site. Total scores from trial (i) are given in parentheses. Accessions planted in trial (ii) at Daura (where there was no trial (i)) are also indicated.

No.			Makurdi	Jos	Bauchi	Rano	Maiduguri	Daura
1.	*Centrosema brasilianum*	I 6773	+(11)	–	+(12)	+(12)	–	+
2.	*Centrosema brasilianum*	I 9940	+(12)	–	+(12)	+(12)	+(12)	–
3.	*Centrosema pascuorum*	I 9290	–	–	+(11)	+(14)	+(13)	–
4.	*Centrosema pascuorum*	I 9857	–	–	+(12)	+(14)	+(14)	+
5.	*Chamaecrista rotundifolia*	I 10915	–	+(13)	+(13)	+(13)	–	–
6.	*Chamaecrista rotundifolia*	I 10916	–	–	–	–	+(13)	–
7.	*Chamaecrista rotundifolia*	I 10918	+(12)	+(13)	+(12)	–	+(11)	+
8.	*Clitoria ternatea*	I 7621	+(13)	+(10)	–	+(13)	–	+
9.	*Lablab purpureus*	I 147	+(14)	+(10)	–	–	+(14)	+
10.	*Lablab purpureus*	I 11609	+(10)	–	+(13)	+(14)	+(14)	–
11.	*Macroptilium atropurpureum*	I 69	+(13)	+(10)	–	+(12)	–	+
12.	*Macrotyloma axillare*	I 6756	–	+(14)	–	–	–	–
13.	*Stylosanthes hamata*	I 75	+(10)	+(7)	+(8)	+(10)	+(11)	+
14.	*Stylosanthes humilis*	I 7363	–	–	–	–	+(14)	+
15.	*Stylosanthes scabra*	I 441	+(13)	+(13)	+(13)	–	–	+
16.	*Zornia latifolia*	I 172	–	+(13)	–	–	–	–

Stylosanthes scabra ILCA 441 with a yield of 1.3 t/ha; all other yields were below 1 t/ha.

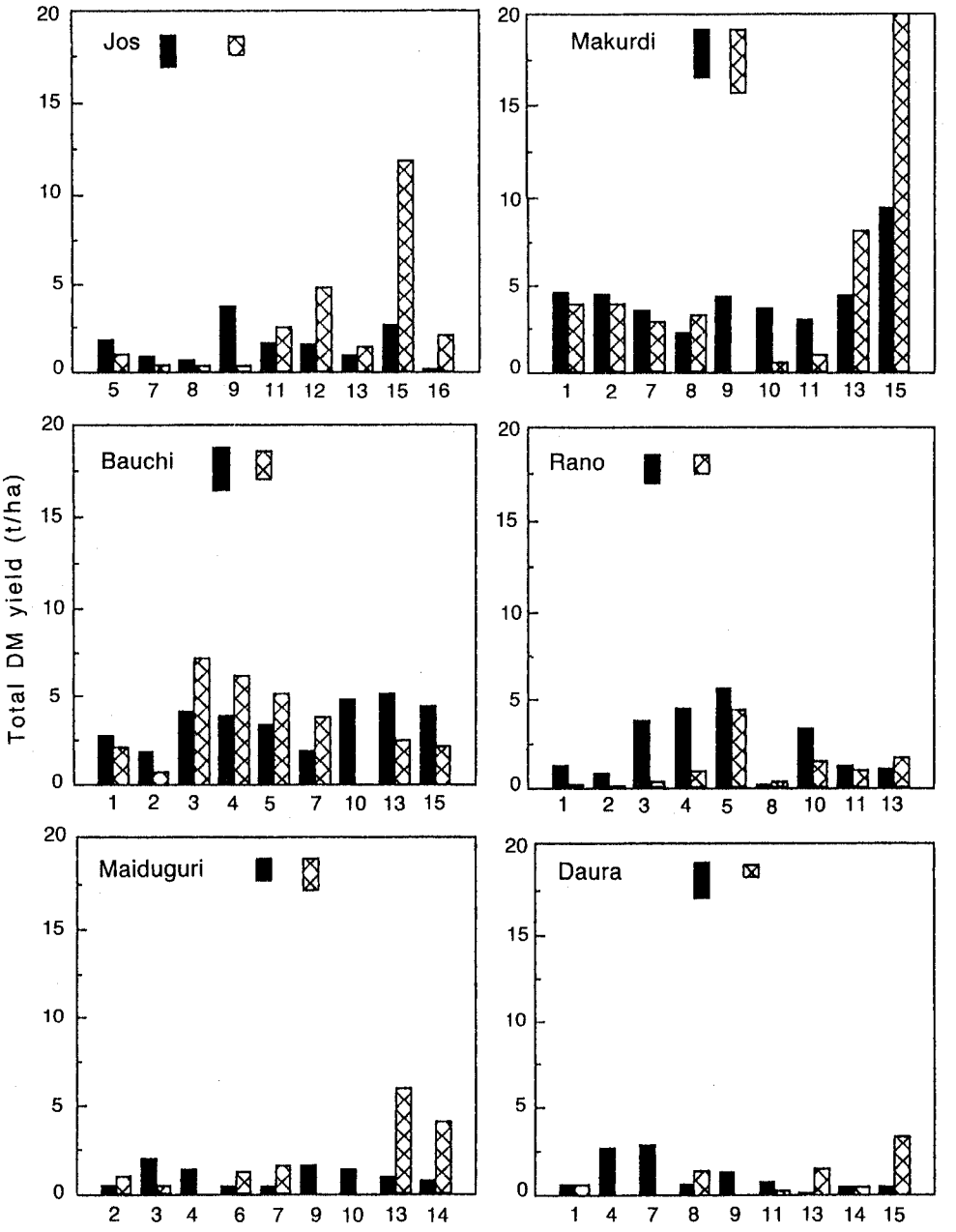
Makurdi (subhumid). Yields at Makurdi were generally the highest of all the sites. In pure stands, *S. scabra* (9.3 and 21.8 t/ha) and *S. hamata* (4.3 and 8.0 t/ha) gave the best yields in 1988 and 1989, respectively (Figure 1). Yields of *Lablab purpureus* and *Macroptilium atropurpureum* were reduced in the second year, the former due to its annual growth habit and the latter because of disease attack (*Rhizoctonia solani*). In competition with weeds (Figure 2), the pattern was similar, with the 2 *Stylosanthes* accessions giving the best legume yields.

Bauchi (semi-arid). Yield differences between the accessions at Bauchi were not marked when grown in pure stands (Figure 1). Yields of the *Centrosema pascuorum* and *Chamaecrista rotundifolia* accessions increased in the second year whereas those for the other accessions decreased; *Lablab purpureus* disappeared completely. In competition with the weeds, total plot yields were low, but in 1990, legume yields for the *Centrosema* species and *S. hamata* made up more than half of the total yield. Best yields were from *Centrosema brasilianum* ILCA 9940 (1.5 and 1.2 t/ha) and ILCA 6773 (2.5 t/ha and 1.0 t/ha) and *S. hamata* (1.7 and 0.7 t/ha) in 1990 and 1991, respectively (Figure 2).

Rano (semi-arid). In the establishment year, *Centrosema pascuorum* ILCA 9857 (4.4 t/ha) and *Chamaecrista rotundifolia* ILCA 10915 (5.6 t/ha) gave the highest yields; the former did not persist but the latter also gave the best yield in 1989 (4.4 t/ha). In the presence of weeds, legume yields were extremely low, with the best yields being for *Chamaecrista rotundifolia* ILCA 10915 (0.3 and 1.7 t/ha), *S. hamata* (0.8 and 0.7 t/ha) in 1990 and 1991, respectively, and *Macroptilium atropurpureum* (0.5 t/ha in both years). These low yields were compounded by the fact that the plots were accidentally grazed lightly during the 1990–91 dry season.

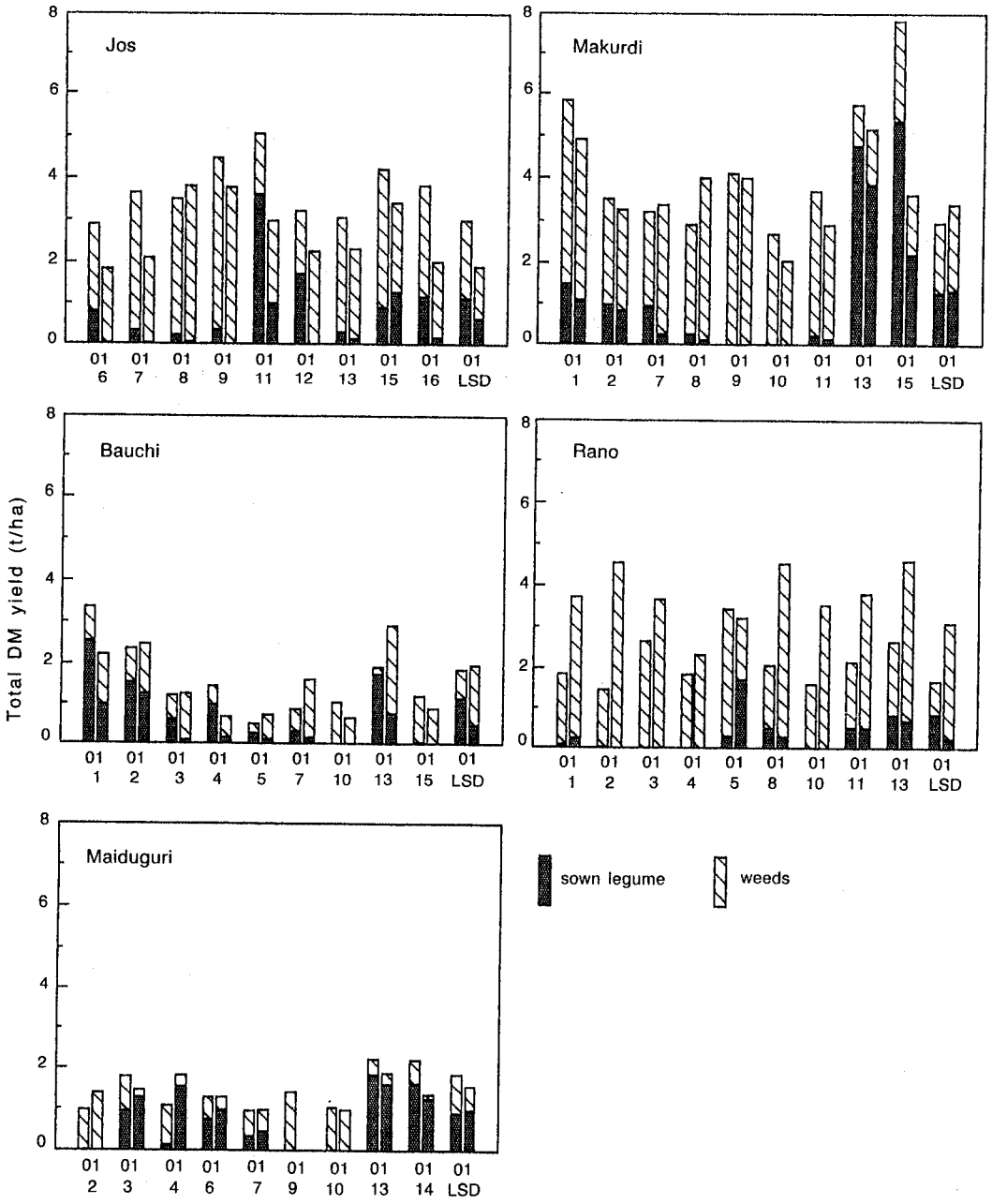
Maiduguri (semi-arid). Yields were generally very low at this site. In pure stands, *S. hamata* (0.9 and 5.9 t/ha) and *S. humilis* (0.7 and 4.1 t/ha) yielded best in 1988 and 1989, respectively. The performance of *Centrosema pascuorum* ILCA 9290 in the establishment year (1.9 t/ha) was good in comparison to the other accessions but it did not persist (Figure 1). *Stylosanthes hamata* (1.8 and 1.6 t/ha) and *S. humilis* (1.6 and 1.2 t/ha) in 1990 and 1991, respectively, grew best in the presence of weeds. The *Centrosema pascuorum* accessions and, to a lesser extent, *Chamaecrista rotundifolia* yielded better in the second year under competition (Figure 2).

Daura (semi-arid). Centrosema pascuorum (2.6 t/ha) and *Chamaecrista rotundifolia* (2.8 t/ha) grew best in the establishment year. In the second year the plots were accidentally grazed, resulting in extremely low yields for all plots except *S. hamata* (1.5 t/ha) and *S. scabra* (3.3 t/ha). The trial was discontinued after 1989.



1 — C. brasilianum I 6773; 2 — C. brasilianum I 9940; 3 — C. pascuorum I 9290; 4 — C. pascuorum I 9857; 5 — C. rotundifolia I 10915; 6 — C. rotundifolia I 10916; 7 — C. rotundifolia I 10918; 8 — C. ternatea I 7621; 9 — Lablab purpureus I 147; 10 — Lablab purpureus I 11609; 11 — Macroptilium atropurpureum I 69; 12 — Macrotyloma axillare I 6756; 13 — Stylosanthes hamata I 75; 14 — Stylosanthes humilis I 7363; 15 — Stylosanthes scabra I 441; 16 — Zornia latifolia I 172.

Figure 1. Dry matter yields (t/ha) of selected forage legumes in 1988 (solid bars) and 1989 (hatched bars). LSD (P = 0.05) values are shown by the additional bars adjacent to the site names.



1 — C. brasilianum I 6773; 2 — C. brasilianum I 9940; 3 — C. pascuorum I 9290; 4 — C. pascuorum I 9857; 5 — C. rotundifolia I 10915; 6 — C. rotundifolia I 10916; 7 — C. rotundifolia I 10918; 8 — C. ternatea I 7621; 9 — Lablab purpureus I 147; 10 — Lablab purpureus I 11609; 11 — Macroptilium atropurpureum I 69; 12— Macrotyloma axillare I 6756; 13 — Stylosanthes hamata I 75; 14 — Stylosanthes humilis I 7363; 15 — Stylosanthes scabra I 441; 16 — Zornia latifolia I 172.

Figure 2. Dry matter yields (t/ha) of selected forage legumes and weeds in unweeded plots; 1990 (0) and 1991 (1).

Weed species. Major weed species on the trial site were typical of those which invade cultivated land in the respective regions, namely:

- At Jos, *Sida* spp., *Ageratum* sp., *Bidens pilosa*, *Tithonia diversifolia*, *Setaria barbata* and *Pennisetum polystachion*.
- At Makurdi, *Eupatorium oderatum*, *Tridax procumbens*, *Andropogon tectorum* and *Imperata cylindrica*.
- At Bauchi, *Chamaecrista rotundifolia*, *Ageratum* sp., *Monechma ciliatum*, *Celosia* sp., *Hyparrhenia rufa* and *Pennisetum pedicellatum*.
- At Rano, *Acanthospermum hispidum*, *Zornia* sp., *Cassia tora*, *Chloris pilosa* and *Pennisetum pedicellatum*.
- At Maiduguri, *Cassia tora*, *Blepharis* sp., *Chloris* sp. and *Pennisetum pedicellatum*.

Discussion

Of the 16 accessions selected from the original 46, only *Clitoria ternatea* and *Lablab purpureus* did not feature at all amongst the best performers in either weeded or unweeded plots. The latter is used widely by farmers in northern Nigeria where the seeds are harvested for human consumption and the hay is conserved for fodder. Fodder yields in these trials were low and with such species there is always a balance required between seed and fodder depending on the individual needs of the farmers. If *Lablab* is to be used successfully for fodder and grain production, a breeding program such as that for cowpea (Akundabweni *et al.* 1990) would be necessary to develop dual purpose cultivars.

Centrosema brasilianum accessions persisted at Bauchi; this species was identified as promising for subhumid Kaduna (Tarawali 1991; Peters 1992) but seed production is often poor. More recently, it has been observed that blister beetles (*Mylabris pustulata* Thunberg) which usually prefer sorghum plants will transfer to *C. brasilianum* and destroy the flowers once the sorghum is harvested (S.A. Tarawali, unpublished data). Evaluation of the world collection of *C. brasilianum* has commenced at Kaduna to identify accessions that have early flowering and seeding to give better yields and avoid the beetles. *C. brasilianum* has been reported as being suitable for the Llanos, Cerrados and subhumid tropics of South America (Miles and Lapointe 1992), all of which are wetter than the semi-arid areas where this species performed well in the present study. Other authors (Okorie *et al.* 1965; Adegbola and Onayinka 1976; Agishi 1983) have advocated the use of *Centrosema pubescens* but this species did not feature beyond the preliminary observation trials in the present study because it was very slow to establish.

Accessions of *Centrosema pascuorum* grew well in semi-arid areas (Rano and Maiduguri) and were able to produce good yields in the short growing season. This agrees with results obtained at Kaduna (Tarawali 1991) where it was identified as one of the most promising accessions for pasture development. However, the species did not persist in the presence of weeds (Peters 1992), showing poor competitive ability.

Chamaecrista rotundifolia was identified as one of the most promising accessions for use in subhumid Nigeria (Tarawali 1991) and has been tested in grazing and seed multiplication trials (ILCA 1991). Its performance at Bauchi and Rano suggests it may also have some value in semi-arid areas. Persistence is good, and it can regenerate quickly at the onset of the rainy season from crowns and seeds. It is a prolific seeder (Peters 1992). Although indigenous, *C. rotundifolia* is relatively unpalatable (Blair-Rains 1963). Ahn *et al.* (1988) reported that *C. rotundifolia* cv. Wynn (ILCA 10918) hay was readily consumed by sheep and cattle and contained no toxic compounds.

When evaluated at Kaduna, *Macroptilium atropurpureum* had low herbage and seed yields and succumbed to the fungus *Rhizoctonia solani* Keuhn (Tarawali 1991). In the present trial, the same disease destroyed the plants at Makurdi and generally yields were low, even at Jos and Rano where it performed best.

Macrotyloma axillare and *Zornia latifolia* were planted only at Jos. The former yielded well in the second and third years but both failed to persist in the presence of weeds.

Stylosanthes hamata ILCA 75 (cv. Verano) is used widely for pastures in northern Nigeria. The results of the present trial suggest that this species compares well with other legumes. At 4 of the 5 sites where the experiments were completed, it was rated as one of the best accessions and was able to persist well even with competition and, at Rano, after grazing. At Makurdi, its performance was surpassed only by *S. scabra* and

at Maiduguri, by *S. humilis*. Only at Jos was the performance of *S. hamata* poor.

S. scabra performed well in the wetter subhumid areas, Jos and Makurdi, where the highest yields from the trials were recorded. It also performed well at Daura in pure stands but its persistence could not be monitored as the trial was discontinued.

Leaf retention and "greenness" during the dry season were not monitored in these experiments. Experience in the subhumid zone of Nigeria with fodder banks of various legumes has indicated that cattle readily consume dry legume in the field (ILCA 1992), although material that remains green (such as *Centrosema brasilianum*) has a higher nutritive value (Peters 1992). In semi-arid areas, none of the legumes remains green in the dry season, and material left on the plots tends to get blown away or destroyed by termites; in these regions, cutting and conserving material would be more suitable than the conventional fodder bank. In both these cases, plants that yield well at the end of the wet season would provide dry season forage.

Since pastures are not usually weeded, the unweeded situation could be considered as more representative of the normal situation. However, 'minimal weed control' is usually imposed on fodder banks in the form of early wet season grazing to control fast-growing grasses, before allowing the legume to bulk up for controlled grazing as a supplement in the dry season (Otsyina *et al.* 1987).

Conclusions

The present study has allowed the identification of accessions that may be suitable for further testing in the subhumid and semi-arid zones of Nigeria, and indeed, of west Africa. For wetter subhumid areas, *S. scabra* could be useful. For semi-arid areas, accessions of *C. rotundifolia* and *Centrosema brasilianum* warrant further testing. In the very dry semi-arid areas such as Maiduguri, *S. humilis* and *Centrosema pascuorum* may be used.

It is noteworthy that, in semi-arid areas, conserving fodder is a familiar concept to the farming community who regularly cut and store the residue from grain legumes. Accessions such as *Centrosema pascuorum*, which are able to produce a significant amount of biomass in the short growing season, may be suitable for cutting and conserving. Under the harsh drought conditions experienced in the far north of Nigeria, it is not feasible to consider a "fodder bank" in the conventional sense of a standing hay crop; conservation is a better option. Another option for species such as this that fail to persist but yield well in the establishment year, is to consider using legume mixtures so as to exploit the good aspects of each species. For example, a mixture of *Centrosema pascuorum* (good in establishment year), *Chamaecrista rotundifolia* (good in wet and early dry season) and *Centrosema brasilianum* (good in the dry season) could give an appropriate combination. This approach needs further research to determine its suitability in these regions.

References

ADEGBOLA, A.A. and ONAYINKA, E.A.O. (1976) A review of range management problems in the southern guinea and derived savanna zones of Nigeria. *Tropical Grasslands*, **10**, 41–50.

AGISHI, E.C. (1983) Forage systems and pasture development in Nigeria. In: Nuru, S. and Ryan, S.G. (eds) *Proceedings of the Nigeria–Australia Seminar on Collaborative Agricultural Research, 14–15 November, 1983, Shika, Nigeria.* ACIAR (Australian Centre for International Agricultural Research) Proceedings, Series 4.

AHN, J.H., ELLIOTT, R. and MINSON, D.J. (1988) Quality assessment of the fodder legume *Cassia rotundifolia*. *Tropical Grasslands*, **22**, 63–67.

AKUNDABWENI, L.S., PETER-PAUL, C. and SINGH, B.B. (1990) Evaluation of elite lines of cowpea (*Vigna unguiculata* (L.) Walp.) for leaf/fodder plus grain (i.e. dual purpose). *Tropical Agriculture (Trinidad)*, **67**, 133–136.

ATTA-KRAH, A.N., SUNBERG, J.E. and REYNOLDS, L. (1986) Leguminous fodder trees in the farming system — an overview of research at the Humid Zone programme of ILCA in southwestern Nigeria. In: Haque, I., Jutzi, S. and Neate, P.J.H. (eds) *Potentials of Forage Legumes in Farming Systems in Sub-Saharan Africa*. International Livestock Centre for Africa, Addis Ababa, Ethiopia. pp. 307–329.

BLAIR-RAINS, A. (1963) Grassland research in northern Nigeria 1952–1962. *Samaru Miscellaneous Paper* No. 1. Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria.

HUMPHREYS, L.R. (1980) *A Guide to Better Pastures in the Tropics and Subtropics*. 4th Edn. (Wright Stephenson and Co. (Australia) Pty Ltd).

ILCA (1979) Livestock production in the subhumid zone of West Africa. A regional review. *ILCA Systems Study* 2. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

ILCA (1985) *ILCA Forage Germplasm Catalogue, Volume 2, Tropical lowland forages*. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

ILCA (1987) *Annual Report, 1986*. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

ILCA (1989) *Annual Report, 1988*. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

ILCA (1991) *ILCA Annual Programme Report, 1990*. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

ILCA (1992) *ILCA Annual Programme Report, 1991*. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

MILES, J.W. and LAPOINTE, S.L. (1992) Regional germplasm evaluation: a portfolio of germplasm options for the major ecosystems of tropical America. In: *Pastures for the Tropical Lowlands: CIAT's Contribution*. (Centro Internacional de Agricultura Tropical: Cali, Colombia).

MOHAMED-SALEEM, M.A. and SULEIMAN, H. (1986) Fodder banks: dry season feed supplementation for traditionally managed cattle in the subhumid zone. *World Animal Review*, **59**, 11–17.

OKORIE, I.I., HILL, D.H. and MCILROY, R.J. (1965) The productivity and nutritive value of tropical grass/legume pastures rotationally grazed by N'Dama cattle at Ibadan, Nigeria. *Journal of Agricultural Science*, **64**, 235–245.

OTSYINA, R.M., KAUFMANN, R. von, MOHAMED-SALEEM, M.A. and SULEIMAN, H. (1987) *Manual on Fodder Bank Establishment and Management*. (International Livestock Centre for Africa: Addis Ababa, Ethiopia).

PATERSON, R.T. (1989) Non conventional evaluation of tropical pasture accessions. *Proceedings of the XVI International Grassland Congress, Nice, France*. **1**, pp. 337–338.

PETERS, M. (1992) *Evaluation of tropical pasture legumes for fodder banks in subhumid Nigeria*. Ph.D. Thesis. Justus Liebig University, Giessen, Germany.

SCHULTZE-KRAFT, R., WILLIAMS, R.J., CORADIN, L., LAZIER, J.R. and KRETSCHMER, A.E. (1989) *1989 World Catalogue of* Centrosema *Germplasm*. (Centro Internacional de Agricultura Tropical: Cali, Colombia).

TARAWALI, G. and PAMO, E.T. (1992) A case for on-farm trials of fodder banks on the Adamawa Plateau in Cameroon. *Experimental Agriculture*, **28**, 229–235.

TARAWALI, S.A. (1991) Preliminary agronomic evaluation of forage legumes for subhumid west Africa. *Tropical Agriculture (Trinidad)*, **68**, 88–94.

TARAWALI, S.A., PETERS, M. and MOHAMED-SALEEM, M.A. (1989) Improving pasture resources in west Africa: evaluation of forage legumes to meet the social and ecological constraints. *Proceedings of the XVI International Grassland Congress, Nice, France*. pp. 1495–1496.

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