Characterization of forage tree and shrub species in semiarid climate of southern Mozambique

E. Cordoví[1], J.V. Ray[1], Otília Tamele[2], S. Nhantumbo[2] and A. Chimbalambala[2]

[1]*Instituto de Investigaciones Agropecuarias Jorge Dimitrov,*

Carretera Bayamo-Manzanillo km 16 1/2, Bayamo 85 100, Granma, Cuba

[2]*Instituto de Investigação Agrária de Moçambique, Maputo, Moçambique*

E-mail: ecordovi@dimitrov.cu

ABSTRACT

In order to characterize the performance of forage tree and shrub species in semiarid climate, a cut and carry experiment was conducted with *Gliricidia sepium*, *Leucaena leucocephala*, *Leucaena pallida*, *Moringa oleifera, Senna siamea* and *Morus alba*, without irrigation. The design was randomized blocks, with four replications, and 12 m^2 plots were used. In the summer, *L. leucocephala*, *L. pallida*, *S. siamea* and *M. alba* produced, as average, more than 12 t of DM per hectare; while in the winter between 9,38 and 11,62 t/ha were obtained, except in *M. oleifera* (5,49 t/ha). The cutting intervals varied between 62 and 65 days in the summer; while in the winter they increased up to 102 and 117 days in *G. sepium* and *M. oleifera*, respectively, and oscillated between 81 and 92 days for the other species. The leaf percentage was higher in the winter and *S. siamea* stood out (62 and 69 % in the summer and winter, respectively). During the winter a high DM production was obtained, in which *G. sepium, M. alba* and *S. siamea* were outstanding (47-50 %). The good performance of these tree and shrub species under semiarid conditions was confirmed, with DM yields higher than 12 t/ha and a stable production during the year. It is recommended to include them in studies with animals in silvopastoral systems and protein banks; as well as to use other planting frames in order to improve their productive potential.

Key words: trees and shrubs, semiarid climate, browsing plants

INTRODUCTION

In Mozambique, as in most tropical climate countries, pastures and forages constitute the main feeding basis for ruminants, because they represent an economical and stable alternative to obtain a high milk and meat yield from the native and improved breeds. Contrary to other crops that are exploited under homogeneous conditions –with similar agricultural and plant management practices– pasture utilization, due to their condition of permanent crops, faces a great diversity of conditions imposed by the environment, the economy and the people (Paretas and González, 1990).

The tree and shrub species have proven to have a high capacity to adapt to different soil conditions and exploitation regimes, even when neither irrigation nor fertilization is used (Toral, Iglesias and Reino, 2006). However, there are limitations regarding the use of agroforestry in animal production, basically due to the low availability of the germplasm used in research as well as in the commercial area (Clavero and Suárez, 2006).

The studies about the adaptation of species to particular ecosystems are a practical and economical way of selection and they have allowed to find high variability among the tropical forage species regarding their regrowth capacity, persistence and biomass production (Cordoví, 1995). In the different ecosystems important changes occur in the distribution of rainfall, temperature, solar radiation and the soil characteristics. Taking these antecedents into consideration, this work was conducted in order to characterize the performance of forage tree and shrub species under semiarid conditions of southern Mozambique.

MATERIALS AND METHODS

Location of the experiment. The work was conducted without irrigation during three years, at the Zootechnical Station Chobela (Magude district, Maputo province), at 25° 00´ South latitude and 32° 14´ West longitude and at 40 m.a.s.l.

Soil characteristics. According to Serno (1988), the soil is sandy loam, deep and well drained. It has a prismatic to columnar structure, a high compaction degree, and is extremely hard when it is dry. It has from low to moderate fertility and its limiting factors are the low percentages of organic matter and nitrogen, as well as the low contents of assimilable phosphorous and exchangeable sodium (table 1).

Climate characteristics. The climate is Dry Tropical (Ministério da Administracão Estatal, 2005), with two well defined seasons: summer and winter. The former is hot and humid and it occurs from November to March; while the latter is cold and dry, with low rainfall levels, and it is from April to October. During the experimental time average rainfall values occurred of 540,4 mm in summer and 220,1 mm in winter; as well as high temperatures and evaporation, which determines the semiarid characteristics of the region (table 2).

Design and treatments. The design consisted in randomized blocks with four replications. Plots of 3 x 4 m = 12 m^2 were used, in which the forage tree species *Gliricidia sepium*, *Leucaena leucocephala*, *Leucaena pallida*, *Moringa oleifera*, *Senna siamea* and *Morus alba* were established.

Soil preparation and sowing. The soil preparation consisted in plowing, harrowing, crossing and harrowing. After crossing, a dose of 20 t of well-decomposed cattle manure was applied per hectare, which was repeated in the summer season every year of exploitation. Three rows were sown in each plot with 0,30 m-high plants at a distance of 1,0 m between rows, 0,40 m between plants and at 0,25 m of depth. The plants were previously established in plastic bags in nursery and sowing was performed in the winter. *M. oleifera* and *G. sepium* were sown four months later; therefore, they were not evaluated during the summer of the first year. After sowing two weedings with hoe were performed, in order to diminish competition and facilitate the establishment of the sown species.

Cuttings. The evaluation started after the establishment cut, when the plants reached about 1,20 m of height. Afterwards, the harvests were carried out every time the plants flowered, to determine the yield in function of the performance of each species. In the periods when these plants did not flower, the cutting was made when the basis leaves turned yellow and began to die, for which the number of cuttings in each season not always coincided in all the species. The cutting was performed with a machete, at a height between 15 and 20 cm above the soil level.

Measurements and observations. In each cutting, the height of five plants per plot was measured, with a metric ruler, from the soil level up to the top of the foliage.

Tabla 1. Chemical characteristics of the experimental soil.

Indicator	Value	Classification
pH (H_2O)	6,60	Slightly acid
Organic matter, %	1,20	Low
Assimilable P, ppm	25,00	Low
Nitrogen, %	0,08	Low
Exchangeable Ca, meq/100 g	7,52	Moderate
Exchangeable Mg, meq/100 g	7,54	Very high
Exchangeable K, meq/100 g	0,36	Moderate
Exchangeable Na, meq/100 g	0,85	Low

Source: Serno (1988).

Table 2. Performance of climate during the experimental period.

Indicator	Summer				Winter			
	Year 1	Year 2	Year 3	Average	Year 1	Year 2	Year 3	Average
Rainfall, mm	481,2	436,8	644,0	540,4	282,2	205,2	172,8	220,1
Maximum temperature, ºC	32,5	33,2	31,9	32,5	29,6	28,0	28,4	28,7
Evaporation, mm/day	4,4	5,2	4,2	4,7	5,9	4,4	4,4	4,9
Relative humidity, %	76,4	75,2	72,0	73,6	61,8	55,0	58,0	58,3

Yield. The green matter yield was determined by weighing all the forage produced in each plot –with a 20 kg-capacity dynamometer scale–; from this a representative sample of 300 g was weighed with a digital scale, and it was divided in leaves and stems to calculate the percentage of each fraction. Later, it was introduced in an air-circulation oven at 65 °C until constant weight to determine the dry matter percentage, from which the dry matter yield was estimated.

Flowering. The flowering was estimated through visual observation at the time of each cutting. The plot was considered flowered when more than 25 % of the plants showed this condition.

Statistical processing. The data of dry matter yield were subject to a variance analysis, with the use of the statistical pack Statistica version 8.3 (Stat Soft, 2008), and the means were compared according to the Student-Newman-Keuls test.

RESULTS AND DISCUSSION

There were differences among the species in both seasons regarding dry matter yield. This could be related to the reserves accumulated by the plants, their utilization capacity and their particular genetic expression (Wencomo and Ortiz, 2011).

In the summer (table 3) *S. siamea, L. leucocephala*, *M. alba* and *L. pallida* stood out, producing more than 12 t/ha as average in the season; while *G. sepium* and *M. oleifera* only produced 9,56 and 8,68 t DM/ha, respectively.

On the other hand, in the winter (table 4) *S. siamea* and *M. alba* stood out, with more than 11 t/ha as average during the evaluated years. Moreover, they were superior ($p < 0,05$) to the others, except *L. leucocephala* that produced 10,7 t/ha. In general all the species had good yields (between 8,54 and 11,64 t/ha), except *M. oleifera* (5,49 t/ha). However, in the third year there was a considerable decrease, possibly due to the lower rainfall during the period.

The DM yields that were obtained in most of the species in the winter constitute an advantage, if it is taken into account that the highest needs of forage supply to the animals are shown in this season, due to the marked decrease of the biomass

Table 3. DM yield of the species in the summer (t/ha).

Species	Year			Mean
	1	2	3	
G. sepium	n. e.	9,68^{bc}	9,43^{bc}	9,56^{c}
L. leucocephala	15,82^{a}	9,39^{b}	13,16^{b}	12,79^{ab}
L. pallida	17,82^{a}	8,21^{b}	10,19^{bc}	12,05^{b}
M. oleifera	11,91^{b}	5,75^{c}	8,37^{c}	8,68^{d}
S. siamea	n. e.	14,44^{a}	12,26^{bc}	13,35^{a}
M. alba	9,22^{b}	9,58^{b}	17,97^{a}	12,26^{b}
SE ±	1,11*	0,58*	1,22*	0,62*

a, b, c, d: different letters in the same column differ at $p < 0,05$, according to Student-Newman-Keuls. n. e.: not evaluated in the period

Table 4. DM yield of the species in the winter (t/ha).

Species	Year			Mean
	1	2	3	
G. sepium	10,10^{b}	13,78^{ab}	4,93	9,60^{bc}
L. leucocephala	15,05^{a}	10,94^{b}	6,10	10,70^{ab}
L. pallida	9,69^{b}	11,26^{b}	4,68	8,54^{c}
M. oleifera	6,22^{c}	4,16^{c}	6,10	5,49^{d}
S. siamea	14,21^{a}	15,00^{a}	5,71	11,64^{a}
M. alba	11,37^{b}	16,74^{a}	6,04	11,38^{a}
SE ±	0,91*	0,96*	0,47ns	0,43*

a, b, c, d: $p < 0,05$, different letters in the same column differ at $p < 0,05$, according to Student-Newman-Keuls.

yield of pastures. This corroborates the statement by Wencomo (2002) that the tree and shrub species are an important alternative for tropical livestock feeding –especially in the seasons of feedstuff scarcity–, because of the high nutritional value of their foliage and their capacity to produce important biomass quantities in drought periods.

The good performance of these species coincides with that reported by several authors for different trees, which showed capacity to produce high biomass yields and to recycle nutrients (Toral, 2005; Sánchez, 2007), as well as to regrow after being grazed or cut and to recover rapidly from the biotic and abiotic stress (Ruiz and Febles, 2001). These aspects are very important in the species subject to intensive exploitation systems. This suggests a lower dependence on the nutrients and the available water in the upper soil layers, due to their deep root system and to the stability regarding the chemical composition of their biomass (González and Cáceres, 2002; Pinto *et al.,* 2002).

During the summer the species were cut with a frequency of 62 and 65 days, according to the methodology used. During this season there was no flowering (table 5). *M. oleifera* had the lowest dry matter percentage (17 %), followed by *G. sepium* (20 %) and *M. alba* (21 %). The leaf percentage varied between 49 and 62 %.

In the winter (table 6) the period between cuttings increased to 102 and 117 days in *G. sepium* and *M. oleifera*, respectively, and oscillated between 81 and 92 days for the rest. Only *L. leucocephala* and *M. oleifera* showed flowering during this season. The species with the lowest dry matter percentage were *G. sepium* and *M. oleifera*, with 20 %.

It is valid to emphasize that *S. siamea* was the species with the highest leaf percentage (62 and 69 % in the summer and winter, respectively). This is extremely important, because a higher leaf proportion indicates a high probability of increasing the photosynthetic process, as well as a better accumulation of reserves for regrowth and a higher availability of growth substances (Herrera, 2008), which suggests a better productive response and stability in the ecosystem where the species develop. This indicator tended to be higher during the winter than in the summer, independently from the fact that the number of regrowth days in the winter was higher.

The different response of the species evaluated in this work corroborates the statement by several authors (Mansur and Barbosa, 2000; Lahlou *et al*., 2003; Abdel-Rahman *et al*., 2010), who reported the selection of species as a strategy to minimize the effects of water lack and other limiting factors for plant growth, which can have mechanisms of physiological tolerance that allow them to adapt to

Table 5. Performance of different indicators in the species, during the summer (mean of the evaluated years).

Species	Height (cm)	DM (%)	Flowering	Regrowth (days)	Leaves (%)
G. sepium	136,1	20	No	65	58
L. leucocephala	168,3	28	No	62	53
L. pallida	159,8	30	No	62	49
M. oleifera	154,0	17	No	64	51
S. siamea	123,4	29	No	65	62
M. alba	154,2	21	No	63	55

Table 6. Performance of different indicators in the species during the winter (mean of the evaluated years).

Species	Height (cm)	DM (%)	Flowering	Regrowth (days)	Leaves (%)
G. sepium	112,4	20	No	102	65
L. leucocephala	118,4	30	Yes	92	54
L. pallida	117,8	27	No	82	49
M. oleifera	71,4	20	Yes	117	50
S. siamea	96,9	26	No	92	69
M. alba	105,1	27	No	81	56

a wide range of edaphoclimatic and management conditions (Toral *et al*., 2006).

It is noteworthy that, in general, all the species tended to produce more dry matter in the summer than in the winter, which can be ascribed to the fact that the increase of light intensity favors the synthesis processes and the accumulation of soluble carbohydrates in the plant (Del Pozo, 2004). The water deficit modifies the biomass partition between the aerial and root part of plants; in addition, it decreases the leaf area and its duration, while an increase in senescence and, as a result, the abscission of leaves, occurs (Vinocur and Altman, 2005).

Regarding temperature, it is known to have a high influence on pasture growth as well as quality. Nevertheless, all the species do not require the same optimum temperature value to fulfill their functions. In this sense, Baruch and Fisher (1991) reported that in tropical grasses the photosynthetic optimum value is between 35 and 39 ºC; and in legumes, between 30 and 35 ºC. Likewise, the latter have high sensitivity to low temperatures, whose negative effects on growth occur between 0 and 15 ºC; this also justifies the yield decrease of the species in winter, if it is taken into account that, historically, in the site where the study was carried out most days in June, July and August show minimum temperatures lower than 15 ºC (Cordoví and Ray, 2009).

CONCLUSIONS

The results confirmed the good performance of tree and shrub species under semiarid conditions, because dry matter yields higher than 8,0 t/ha and a balanced production throughout the year were obtained. In this sense *L. leucocephala*, *M. alba* and *S. siamea* stood out, producing more than 11,0 t as average.

The cutting intervals fluctuated according to the species and season. The leaf percentage was higher during the winter in all the species, especially in *S. siamea*.

RECOMMENDATIONS

It is recommended to include these species in studies with cattle and small ruminants, in systems of associations and/or protein banks; as well as to evaluate them in other planting frames in order to improve their productive potential.

Received: May 27, 2013
Accepted: November 25, 2013