Research note: Production and nutritive value of grasses cultivated in the coastal area of Benin

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Abstract

Six grasses (*Panicum maximum* cvv. C1, T58, 673 and a native accession, *Brachiaria ruziziensis* and *Andropogon gayanus*) were evaluated in small plots in 1997 and 1998 for production and nutritive value in south Benin. The experiment was carried out on a typical gently sloping plateau with poor sandy soils. Rainfall in the first year equalled the annual average for the region (1300 mm), while the second year was particularly dry (775 mm).

Highest production in the first year was recorded with *Panicum maximum* cv. C1 (10.8 t/ha DM). The native *Panicum maximum* and cvv. T58 and 673 of the same species produced 7.0, 6.3 and 6.5 t/ha DM, respectively. *Andropogon gayanus* yielded 3 t/ha DM. *Brachiaria ruziziensis* yielded 4 t/ha DM during the rainy season, but died at the beginning of the 1997–98 dry season.

With the drought during the second year, only *Panicum maximum* cv. C1 and *Andropogon gayanus* survived. Their production (6.3 and 2.6 t/ha DM, respectively) was below that recorded in the first year.

The highest nutritive values were recorded for the native accession of *Panicum maximum* and cv. T58, which contained digestible crude protein concentrations ranging between 11.3–13.3% (DM basis). Compared with the other species, *Brachiaria ruziziensis* and *Andropogon gayanus* had low concentrations of digestible crude protein.

Panicum maximum cv. C1 and *Andropogon gayanus* are recommended for further testing as perennial fodder crops, because of their production capacity on the poor soils and their adaptation to the variable rainfall of the region.

Introduction

Traditionally, the rural activity in the extreme south of Benin is devoted to subsistence agriculture and fishery, with livestock production being secondary. With the high rate of population growth, increased by the rapid urban development along the coast, this situation is now changing. The gradual decline of the available fishery resources, the decrease in soil fertility and the necessity to diversify the sources of income require the development of farming systems integrating livestock and fodder crops.

As a result of its particular situation, the coastal area of Benin is different from other countries of the sub-region such as Guinea, Liberia or southern Nigeria. The coastline of Benin, especially in the west, is almost parallel to the dominant winds, and receives lower and variable rainfall compared with other coastal sectors which are perpendicular to these winds. The testing of new grasses needs therefore to distinguish between this coastal area and the guinean savanna which are located at higher latitudes.

In this area of west Africa, the cultivation of selected grasses is not yet widespread. Several studies in nearby countries have evaluated fodder crops, principally legumes. In the coastal region of Ghana, Barnes (1996) evaluated *Chloris gayana*, *Brachiaria ruziziensis* and *Panicum maximum* while Barnes and Addo-Kwafo (1996) tested *Andropogon gayanus*, several species of *Brachiaria* and 2 cultivars of *Panicum maximum*.

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Due to the particular rainfall conditions and the low soil fertility in the coastal area of Benin, these results cannot be transposed to this region.

This study aimed to identify grasses which can be used by smallholder farmers on the sandy and low-fertility soils of the coastal area of Benin.

Materials and methods

Study area

The experiment was conducted in 1997 and 1998 at the National University of Benin, Abomey-Calavi, near Cotonou. The rainy season extends from March–October with lower rainfall during August (the short dry season). The long dry season lasts 4 months (November–February). Mean annual rainfall of south Benin (1969–1990) is 1300 mm (source; National Meteorological Office). Average minimum and maximum temperatures are 25°C and 30°C, respectively.

The experiment was established on a sandy ferruginous soil with relatively low concentrations of organic matter, N and P. The parent material is typical of the gentle sloping plateaus of the 'continental terminal' located in southern Benin, Togo and Nigeria (Mondjannagni 1969). The soil is generally poorly structured with a low water-retention capacity.

Sampling and measurements

The experiment was carried out from May 1997–December 1998 and included 2 rainy seasons separated by a long dry season. The experimental varieties were 4 accessions of *Panicum maximum* (a native variety collected in a roadside ditch and cvv. C1, T58 and 673), *Brachiaria ruziziensis* (local collection) and *Andropogon gayanus* which was collected in a natural fallow. The experimental layout was a complete randomised block design with 2 replicates per block.

Before cultivation, 4 soil samples (0–40 cm deep) were randomly collected on the experimental area for subsequent analyses (AFNOR 1987). The experimental soil is a sand of pH 6.2 (H_2O) and is poor in available P (0.03%), organic C (0.7%), N (0.05%) and exchangeable cations. The available water content decreases from 15.0% to 2.5% between field capacity (pF = 2.0) and permanent wilting point (pF = 4.2).

The grasses were grown in 20 m^2 plots (4×5 m) spaced 2 m apart from each other. After ploughing and harrowing, the plants were established on May 10, 1997, in 40 cm-spaced holes. *Brachiaria ruziziensis* was sown by seed and stem cuttings were used for the other species.

During grass establishment, 60 kg N, 100 kg P and 60 kg K per ha were provided in 2 applications 2 weeks apart and the plots were weeded manually as necessary. The plots were regularly cut at the stage of 3–4 leaves per tiller during the growing seasons, usually after an 18–30 days growing period. The cuts were made 10–15 cm above ground level for the erect grasses and 6–10 cm for *Brachiaria ruzziziensis*. The plots were also harvested at the end of the rainy season at seed-production, but this material (1081–2103 kg/ha DM) was discarded. Thus, the yields presented in this study include only the regrowth that can be really grazed by animals. After each forage harvest, 50 kg/ha of N was applied in the form of urea. Forage samples (about 1 kg) were collected at each harvest for chemical analyses. The samples were oven-dried for 48 h at 60°C and milled (1 mm sieve).

The chemical composition of the forage samples was analysed by near infrared reflectance spectroscopy (NIRS) using specific predicting equations. The laboratory references used in the NIRS equations were established with a range of tropical grasses which have been analysed for organic matter (OM), crude protein (CP) and crude fibre (CF) concentrations (AOAC 1984).

Digestible crude protein (DCP) concentrations of forage samples were calculated according to the following equation (Rivière 1991) :

$$\text{DCP (\% DM)} = 0.897 \text{ CP (\% DM)} - 3.43.$$

The net energy value (UF: Unité Fourragère) was estimated according to the Dijkstra tables (Dijkstra 1957). Metabolisable energy was calculated by adding 1 cal per kg DM to the net energy of the forage (UF of forage multiplied by net energy of barley or 1 883 cal) and the result was transformed to MJ using the conversion factor of 0.00418 (Rivière 1991).

The results for dry matter production, chemical composition and nutritive value of the harvested forages were subjected to a 2-way analysis of variance.

Results

Monthly rainfall registered during 1997 and 1998 in Abomey-Calavi is presented in Figure 1. The annual rainfall was 1548 mm in 1997 but only 775 mm in 1998. In 1997, 60–80 mm/month was recorded during the short dry season (July–August), but the following long dry season (November 1997–April 1998) was particularly dry with rainfalls under 35 mm/month. Compared with 1997, the short dry season was more pronounced in July–August 1998.

Table 1 presents the dry matter yields recorded during the rainy and dry seasons in 1997 and 1998. The chemical composition and nutritive value of the harvested forage are given in Table 2.

During the first rainy season (May–October 1997), the highest production was recorded with *Panicum maximum* cv. C1 ($P < 0.01$) which yielded more than 8.0 t/ha DM. All other varieties of *Panicum maximum* yielded only 5–6 t/ha DM. During the long dry season (November 1997–April 1998), *Panicum maximum* cv. C1 yielded 2.4 t/ha DM. The yields of the other grasses were significantly lower ($P < 0.01$). Due to the exceptional drought observed between November 1997 and April 1998, only *Panicum maximum* cv. C1 and *Andropogon gayanus* survived until the beginning of the rainy season 1998. During this season, yield of *Panicum maximum* cv. C1 exceeded that of *Andropogon gayanus*, but yields of both species were significantly lower ($P < 0.001$) than those recorded in 1997.

The highest nutritive values were measured in the native variety and cv. T58 of *Panicum maximum* which had digestible crude protein concentrations ranging from 11.3–13.3%, on a DM basis. Digestible crude protein concentrations in *Panicum maximum* cv. C1 were high during the first rainy season but decreased significantly ($P < 0.001$) during the following dry season and both the rainy and dry seasons during the second year. *Brachiaria ruziziensis* and *Andropogon gayanus* had low digestible crude protein concentrations compared with the other species. For all grasses, the crude fibre concentration was significantly higher ($P < 0.001$) during the dry than during the rainy season.

Discussion

All species studied in this experiment are described as growing in areas with 1000 mm rainfall or more and being drought-tolerant (Skerman and Riveros 1990). However, despite a mean annual rainfall of 1300 mm in south Benin, most did not survive the very dry year in 1998. Indeed, the drought conditions encountered

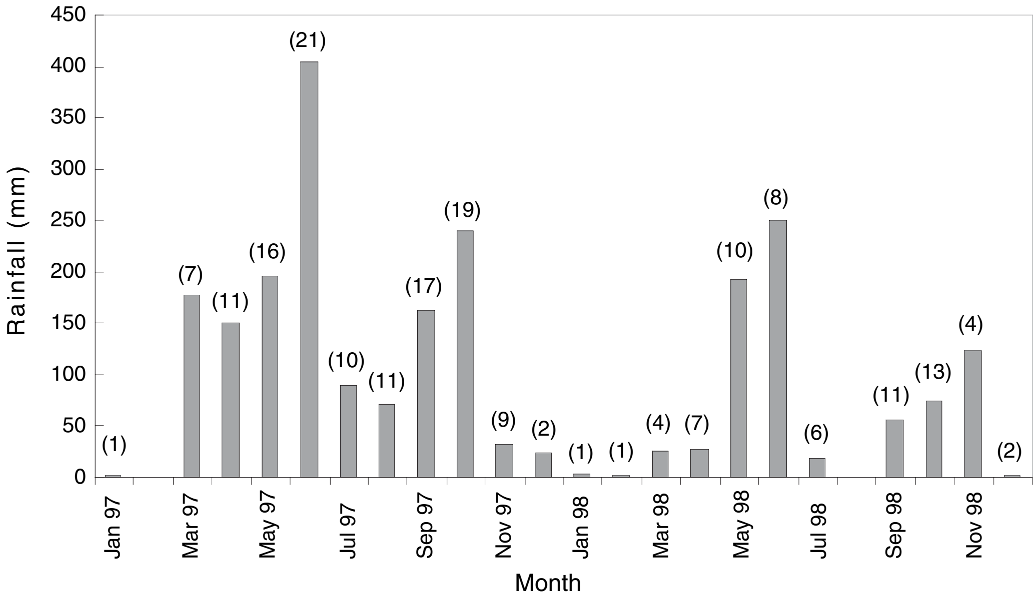

Figure 1. Monthly rainfall registered during the experiment (Raindays in parenthesis).

Table 1. Dry matter yields (kg/ha DM) of the 6 grasses with the number of harvests in each season.

Species	Season			
	First rainy season	First dry season	Second rainy season	Second dry season
Panicum maximum native	5914 a[1] (4)	1079 a (1)	—	—
Panicum maximum cv. C1	8361 b (4)	2449 b (1)	4411 a (4)	1938 a (2)
Panicum maximum cv. T58	5323 a (4)	965 a (2)	—	—
Panicum maximum cv. 673	5378 ac (4)	1141 a (1)	—	—
Brachiaria ruziziensis local	4142 c (4)	—	—	—
Andropogon gayanus local	2012 d (3)	1048 a (1)	1694 b (4)	919 b (2)

[1]Within columns, means followed by different letters are significantly different ($P < 0.05$).

Table 2. Nutritive value of the 6 grasses during 4 seasons (DM basis).

Species/Seasons	Crude protein	Crude fibre	Ash	Digestible crude protein	Metabolisable energy
	(%)	(%)	(%)	(%)	(MJ/kg)
First rainy season					
Panicum maximum native	18.7 a[1] A[2]	27.3 a A	10.5 ab A	13.3 a A	10.1 a A
Panicum maximum cv. C1	18.2 a A	29.8 c A	12.1 c A	12.9 a A	9.3 b A
Panicum maximum cv. T58	18.7 a A	27.0 a A	10.8 a A	13.3 a A	10.2 a A
Panicum maximum cv. 673	17.0 b A	28.0 b A	11.2 d A	11.8 b A	9.9 c A
Brachiaria ruziziensis	15.9 c	25.5 d	10.3 b	10.8 c	10.5 d
Andropogon gayanus	15.1 d A	30.7 e AC	7.6 e A	10.1 d A	9.8 c A
First dry season					
Panicum maximum native	16.5 a B	30.6 a B	13.1 a B	11.3 a B	9.0 a B
Panicum maximum cv. C1	14.4 b B	33.1 b BC	11.4 b B	9.5 b B	8.6 b B
Panicum maximum cv. T58	16.9 a B	29.3 c B	12.8 a B	11.7 a B	9.4 c B
Panicum maximum cv. 673	14.9 c B	30.3 a B	16.6 c B	9.9 b B	8.6 b B
Andropogon gayanus	12.5 d B	30.0 ac AB	9.0 d B	7.8 c B	9.7 d A
Second rainy season					
Panicum maximum cv. C1	14.0 a B	32.5 a B	9.7 a C	9.1 a B	9.0 a B
Andropogon gayanus	13.0 a B	29.5 b B	9.4 a B	8.2 a B	9.8 b A
Second dry season					
Panicum maximum cv. C1	14.5 a B	33.4 a C	9.7 a C	9.5 a B	8.8 a B
Andropogon gayanus	12.5 b B	31.2 a C	10.4 a C	7.6 b B	9.3 b B

[1]Within columns and for each period, means followed by different lower-case letters are significantly different ($P < 0.05$).
[2]Within columns and for each variety, means followed by different upper-case letters are significantly different ($P < 0.05$).

during this year demonstrate the variable rainfall conditions prevailing in the region and their consequence on forage production and plant survival. *Panicum maximum* cv. C1 and *Andropogon gayanus* were the only grasses remaining alive after 6 months of drought, possibly due to their deep root system (Skerman and Riveros 1990; Reynolds 1995).

The severe climatic conditions, compounded by the low soil water-retention capacity, explain the poor performances of the experimental grasses. Mondjannagni (1969) even considered that the soils of the plateaus in south Benin are not suited for cultivation of perennial plants. Nevertheless, all grasses chosen for this experiment, particularly the native varieties, grow at higher latitudes in Benin and are sometimes well adapted to low fertility.

Brachiaria ruziziensis is cultivated successfully in the state farm of Kpinnou in south Benin (Adandedjan 1994), but there it is grown on vertisols characterised by better clay, Ca, P and organic matter contents (Mondjannagni 1969). During the first rainy season of our experiment, the total DM production of this species was above the yield reported in southern Ghana (Barnes 1996) and reached that recorded under open oil palm plantation in south-west Nigeria with N fertilisation (Ezenwa *et al.* 1996). Nevertheless, it did not persist during the long dry season. Other species of *Brachiaria*, especially *Brachiaria decumbens* or *Brachiaria brizantha*, which show better adaptation to low-fertility soils and drought (Reynolds 1995; Lapointe and Miles 1997) could be evaluated in the future.

The yields recorded during the first rainy season for cvv. T58 and 673 and the native variety of *Panicum maximum* equalled those presented by Boudet (1991) for *Panicum maximum* in the sub-humid tropics. The disappearance of these grasses, attributed to the drought, was probably compounded by the excessive cutting of the leaves before the dry season. Skerman and Riveros (1990) state that mowing below 35 cm, especially during mid-autumn, is not favorable to persistence of *Panicum maximum*. Nevertheless, the failure of the local accession of this species (perennial plants collected in a roadside ditch with favourable soil and water conditions) is probably also due to the low fertility and water-retention capacity of the experimental soil.

Andropogon gayanus is of interest because it is native to the Soudanian and Sahelian regions (Boudet 1991) and is well adapted to dry conditions (Skerman and Riveros 1990; Buldgen *et al.* 1995). Some plants of this species grow in fallow on the plateaus in south Benin. Although its total yield was less than the other grasses, this species deserves further study on the plateaus of south Benin as a large number of plants established and seeded during the second experimental year.

In brief, this experiment has shown that adaptation to rainfall and soil conditions in south Benin is the main selection criterion for future evaluation of perennial pasture species. Currently, because of its survival during drought and its higher productivity, *Panicum maximum* cv. C1 appears to be the best perennial grass forage for coastal Benin. Nevertheless, fodder crops of *Andropogon gayanus* must not be overlooked because of its drought resistance, adaptation to poor soils, and high productivity with low N fertilisation (Buldgen and Dieng 1997).

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