FORAGE POTENTIAL OF SOME *CENTROSEMA* SPECIES IN THE LLANOS ORIENTALES OF COLOMBIA

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ABSTRACT

The yield attributes of 18 accessions of Centrosema, *comprising the species,* C. macrocarpum, C. brasilianum, Centrosema *sp. nov. were compared in two experiments under a cutting regime. Small, grazed swards of various* Centrosema *spp. sown with* Andropogon gayanus *in mixture were also studied, with the objective of identifying grass-legume associations adapted to acid-soil savanna conditions and grazing. Stoloniferous forms of* Centrosema *sp. nov. (unnamed species) yielded well under cutting and were also especially good in the grazed swards, outyielding the other three* Centrosema *species in the high stocking rate treatment (3 animals ha^{-1}). From these studies in the Llanos Orientales of Colombia, it is concluded that several species of* Centrosema *are adapted to this high rainfall savanna ecosystem and that the stoloniferous forms can withstand heavy grazing.*

INTRODUCTION

Although the genus *Centrosema* has a wide geographic distribution in tropical and subtropical America, the species currently in commercial use are native to regions with relatively high soil fertility. These species have serious limitations in the infertile Oxisol savannas which stretch across the lowlands of tropical America.

The genus *Centrosema* contains *c.* 35 species (Clements and Williams 1980). Of these 26 are native to Brazil and were described by Barbosa-Fevereiro (1977). In this monograph, several species are listed as endemic to savanna habitats.

Herbarium studies of taxonomy and geographic distribution of *Centrosema* (R. J. Williams, *personal communication* indicate that at least 12 species are native to Colombia and one half of these are endemic in the Llanos Orientales. These species inhabit forest margins or low thickets, and some species forms are frequent on the higher terraces of flood plains along the major river systems in the Llanos Orientales.

While *C. pubescens* is widely recognized as a tropical forage and cover legume, other species of the genus have received little attention as cultivated forage. The systematic search for environmentally adapted species for Oxisol savannas has revealed new variation and adaptive characteristics among species of *Centrosema*, warranting further testing for forage potential.

At present, there are over 1400 accessions of *Centrosema* in the CIAT germplasm bank (Schultze-Kraft 1983).

The evaluation of *Centrosema* species in CIAT's collection was initiated at the Carimagua Research Station in 1978. The evaluation of a wide array of species and ecotypes is summarized by Grof and Thomas (1986). This evaluation has now led to more detailed studies of selected accessions of "key species" best adapted to the Llanos Orientales.

Initially, three species e.g., *C. macrocarpum*, *C. brasilianum* and *Centrosema* sp. nov., were selected for further evaluation. Trailing, non-stoloniferous forms of *C. macrocarpum* produced high dry matter yields of forage and were found to be highly palatable and resistant to drought and major leaf diseases affecting most other species of the genus.

The stoloniferous habit of growth of species forms closely related to *C. pubescens* e.g., a new species, *Centrosema* sp. nov. native to the Llanos Orientales and Central Brazil is a very useful forage trait under excessive grazing.

Persistence and survival of *C. brasilianum* under grazing is largely dependent upon a management system of these swards that permits periodical re-establishment of the legume by self-sown seed.

This paper describes cutting and grazing studies comparing accessions of *Centrosema* representing *C. brasilianum*, *C. macrocarpum* and *Centrosema* sp. nov. The grazed swards were included to determine compatibility of some of these species with *Andropogon gayanus* and the effect of stocking rate on legume yield and persistence.

MATERIALS AND METHODS

The experiments were conducted at Carimagua Research Station 320 km east of Villavicencio, at 4°34 'N, 71°20 'W, and 160 m altitude. The Llanos south of the Meta River are predominantly isohyperthemic, well-drained savannas where the wet season mean temperature is > 23.5°C. The region is defined as a savanna ecosystem by total wet season potential evapotranspiration of 1060 mm and a wet season lasting 8 months (Cochrane *et al.* 1985). Annual rainfall averages 2200 mm, and occurs from April to November. A marked dry season occurs from mid-December to late March. The soil is an Oxisol (pH 4.3–4.5 in H_2O) of low base status, deficient in N, P, K, Ca, Mg, S and some microelements. The cation exchange capacity of the soil is 86% Al-saturated.

The collection and site information for the *Centrosema* accessions included in these studies was recorded by Schultze-Kraft *et al.* (1983).

Cutting trials

Eighteen accessions representing three species of *Centrosema*, i.e. *C. brasilianum*, *C. macrocarpum*, *Centrosema* sp. nov. (new unnamed species) were grown in small plots. Treatments were established in two separate experiments using identical randomized block designs with four replicates. All experiments received P, K, Mg and S at the rate of 20, 20, 12 and 12 kg ha^{-1} at planting. The seeds were inoculated with the appropriate *Rhizobium* cultures.

The plots were sampled for three growing seasons. Seven harvests were taken in each experiment. Forage was harvested by hand shears to a height of 15 cm. After each sampling, the plots were mown with a sickle-bar mower to a uniform height of 15 cm. Dry matter yields were recorded by drying sub-samples to a constant weight at 75°C.

Experiment I

Five accessions of *C. macrocarpum* and three accessions of *Centrosema* sp. nov. were transplanted as 6-week old seedlings in a 50 cm square pattern. Plots and blocks were separated by 1.5 m cultivated strips. Plots were 2.5 × 2.5 m with a sampling area of 1 m^2, the remainder of each plot was cut and discarded.

Experiment II

Three accessions each of *C. macrocarpum* and *C. brasilianum*, and four accessions of *Centrosema* sp. nov., were established from broadcast seed during the wet season of 1982. The experimental procedures were the same as in Experiment I.

Grazed associations

Experiment III

Centrosema macrocarpum CIAT 5065 was established with *A. gayanus* cv. Carimagua 1 as the companion grass on a small-scale grazing trial during the wet season of 1982. The experimental area of 2 ha was subdivided to provide two replicates of the stocking rates 1.5 and 3 animals ha^{-1}. In each main plot of the CIAT 5065—*A. gayanus* combination, four *Centrosema* accessions were also established in subplots, i.e. *C. macrocarpum* CIAT 5062 and 5065, *C. brasilianum* CIAT 5234 and *Centrosema* sp. nov. CIAT 5568. These treatments were arranged in a 4 × 4 latin square design in

plots of 5 × 5 m and 5 × 10 m, according to main plot size. The experiment was rotationally grazed by three Criollo × Zebu cattle on a one-week in and three-weeks out system.

Pasture dry matter yield and botanical composition were estimated on four occasions per year from four 1 m^2 quadrats per treatment cut at 15 cm height.

RESULTS

Cutting trials

Experiment I

In this experiment the three *Centrosema* sp. nov. and one stoloniferous accession of *C. macrocarpum* CIAT 5396 produced more dry matter under the cutting regime than the other four accessions (Table 1).

TABLE 1

Dry matter yields (kg ha^{-1} yr^{-1}) of accessions of Centrosema spp. grown at Carimagua, Llanos Orientales.

Species and accession number		Yield
a)	Experiment I (1982)	*(kg ha^{-1} yr^{-1})*
	C. macrocarpum CIAT 5396	12 667 a*
	Centrosema sp. nov. CIAT 5568	11 072 a
	Centrosema sp. nov. CIAT 5278	10 726 a
	Centrosema sp. nov. origin unknown	9 613 a
	C. macrocarpum CIAT 5743	6 623 b
	C. macrocarpum CIAT 5674	6 356 bc
	C. macrocarpum CIAT 5744	5 684 bcd
	C. macrocarpum CIAT 5392	5 201 bcd
b)	Experiment II (1982)	
	Centrosema sp. nov. CIAT 5610	11 921 a*
	Centrosema sp. nov. CIAT 5277	11 218 ab
	C. brasilianum CIAT 5234	10 962 ab
	C. brasilianum CIAT 5487	10 712 ab
	C. macrocarpum CIAT 5452	10 360 ab
	C. brasilianum CIAT 5712	9 452 ab
	C. macrocarpum CIAT 5434	9 293 ab
	C. macrocarpum CIAT 5065 (control)	9 183 ab
	Centrosema sp. nov. CIAT 5568	8 822 ab
	Centrosema sp. nov. CIAT 5118	8 132 b

*Values within experiments followed by a different letter are significantly different ($P < 0.05$) by Duncan's Multiple Range Test.

TABLE 2

Dry matter yields (kg ha^{-1}) of Centrosema *spp. during the wet and dry season at Carimagua, Llanos Orientales.*

Species	CIAT accession number	Mean dry matter yield	
		Dry season	Wet season
		(kg ha^{-1})	*(kg ha^{-1})*
C. brasilianum	5 234	1 314.3 a*	2 099.6 ab
C. brasilianum	5 487	1 009.5 ab	2 072.6 ab
Centrosema sp. nov.	5 610	933.8 ab	2 346.8 a
C. brasilianum	5 712	822.0 ab	1 868.6 ab
C. macrocarpum	5 434	784.0 ab	1 850.3 ab
Centrosema sp. nov.	5 277	759.0 ab	2 287.9 ab
Centrosema sp. nov.	5 118	745.8 ab	1 591.9 ab
Centrosema sp. nov.	5 568	721.3 ab	1 758.6 ab
C. macrocarpum	5 452	694.0 b	2 138.3 ab
C. macrocarpum	5 065	615.3 b	1 836.1 ab

*Values followed by a different letter are significantly different ($P < 0.05$) by Duncan's Multiple Range Test.

Experiment II

Yield differences between accessions were relatively small in Experiment II. Two *Centrosema* sp. nov. CIAT 5610 and 5277 were the highest yielding accessions in the wet season (Table 2), and within *C. brasilianum* accessions CIAT 5234 and 5487 were better than CIAT 5712. The strongly stoloniferous accession of *C. macrocarpum* CIAT 5452 appeared to be tolerant of close defoliation and was the highest yielding of the three accessions of this species included in the experiment. Species and ecotypes showed marked seasonality in dry-forage production. Accessions of *C. brasilianum* grew well during the dry season. *C. brasilianum* CIAT 5234 produced the highest and two *C. macrocarpum* accessions the lowest dry matter yield during the dry season (Table 2).

Grazed Associations

Experiment III

Dry matter yields of legume species and the legume content of the mixed associations with *A. gayanus* exhibited very highly significant differences (Table 3). The stocking rate (SR) × legume species interaction was also highly significant (Fig. 1).

TABLE 3

Presentation yields of dry matter (kg ha^{-1} yr^{-1}) of four Centrosema *spp.*—A. gayanus *cv. Carimagua 1 associations at Carimagua, Llanos Orientales.*

	Dry matter yield of forage			Legume content in the mixture
	Legume	Grass	Total	
		(kg ha^{-1} yr^{-1})		(%)
Centrosema sp. nov. CIAT 5568—*A. gayanus*	6 152 a*	15 284 b	21 436 bc	30.3 a
C. macrocarpum CIAT 5065—*A. gayanus*	5 476 a	19 156 a	24 632 ab	23.7 ab
C. macrocarpum CIAT 5062—*A. gayanus*	5 420 a	19 800 a	25 224 a	22.2 b
C. brasilianum CIAT 5234—*A. gayanus*	1 776 b	18 308 b	20 084 c	10.6 c

*Values followed by a different letter are significantly different ($P < 0.05$) by Duncan's Multiple Range Test.

Grass dry matter yields in the various associations and total (grass + legume) dry matter yields were significantly different (Table 3). There was a tendency for higher grass yields in the grass/legume associations which had the lower yield of the legume component, e.g. the *C. brasilianum*/*A. gayanus* association showed a higher grass content then the stoloniferous *Centrosema* sp. nov. CIAT 5568/*A. gayanus* mixture. The interaction effects SR × grass yields and SR × total (grass + legume) yields were not significant.

In the high SR treatment (3 animals ha^{-1}) the stoloniferous *Centrosema* sp. nov. CIAT 5568 outyielded *C. macrocarpum* CIAT 5065, CIAT 5062 and *C. brasilianum* CIAT 5234 (Fig. 1a). In the low SR treatment (1.5 animal ha^{-1}) there was no significant yield difference between *Centrosema* sp. nov. CIAT 5568 and the two accessions of *C. macrocarpum*, but all three accessions outyielded *C. brasilianum* (Fig. 1b).

Total (grass + legume) and legume DM yield displayed an increase in the low SR treatment whereas high grass and low legume yields were recorded for the high SR treatment.

Legume content of the mixture reflected changes in legume population and plant size. In the high SR treatment the *C. macrocarpum* accessions were reduced to erect, single-stem plants without the characteristic long, branching and trailing stems.

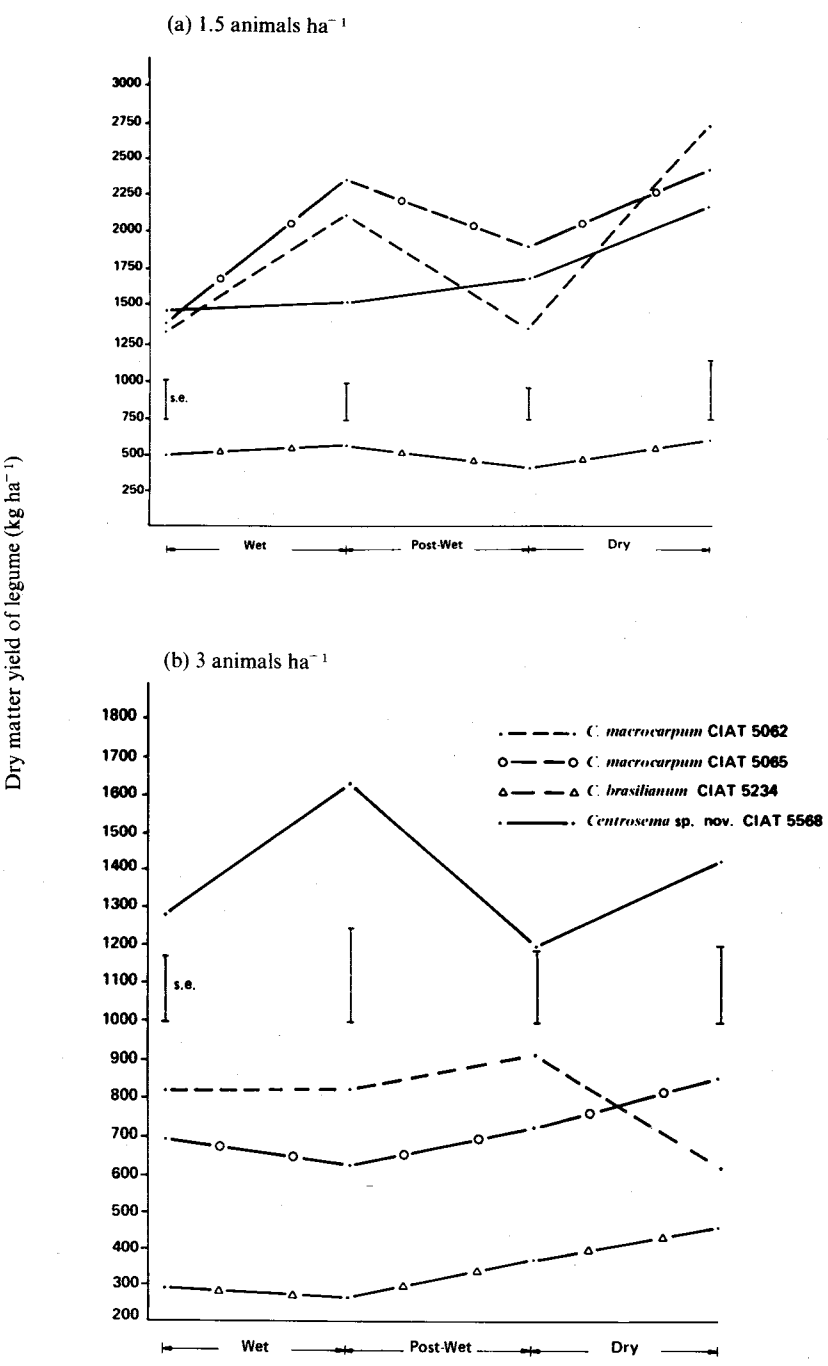

FIGURE 1

Presentation yields of *Centrosema* spp. in association with *Andropogon gayanus* cv. Carimagua 1 at Carimagua, Llanos Orientales at stocking rates of (a) 1.5 animals ha^{-1} and (b) 3 animals ha^{-1}.

DISCUSSION

A major difficulty in developing legume-grass pastures in tropical areas has been to find legumes which are not only well adapted to the environmental conditions but are compatible with aggressive grass species and are able to withstand heavy grazing.

Legume adaptation to heavy grazing is a function of species compatibility as modified by management and/or morphology of species (e.g. trailing vs. stoloniferous habit of growth). The typical trailing tropical legume with its growing points widely separated along the stem axis is more vulnerable to overgrazing and trampling than those with hidden buds and stoloniferous rooting.

The data presented in this paper corroborate this observation. In both cutting experiments, stoloniferous forms of *C. macrocarpum* (CIAT 5396, 5452) and *Centrosema* sp. nov. (CIAT 5568, 5610 and 5277) were in the high yielding group of accessions and outyielded non-stoloniferous forms of both species. One accession of *Centrosema* sp. nov. resisted grazing and yielded better than non-stoloniferous accessions of *Centrosema.*

Centrosema is a genus of major economic potential. Specialized forms of *Centrosema* spp., as shown by the results, are adapted to climatic and soil fertility extremes, such as the Llanos ecosystem. The potential of the genus, however, is far from being exhausted. It is still relatively easy to domesticate "new" species (forms), and much useful variation can be found in species of established value.

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EFFECT OF EARLY SOWING ON ESTABLISHMENT, GROWTH PATTERN AND RUST INFECTION OF ANNUAL SOWINGS OF RYEGRASS (*LOLIUM* SPP.) IN SUB-COASTAL SOUTHEAST QUEENSLAND

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ABSTRACT

*The effect of four sowing times, early March, mid March, late March and mid April, on the establishment, growth pattern and rust incidence of annually sown ryegrass cultivars (*Lolium *spp.) was investigated in irrigated experiments at Gatton in southeast Queensland.*

Late March and mid April sowings gave better plant establishment than earlier sowing dates. Ryegrass establishment was negatively correlated with maximum and minimum daily temperature and with relative humidity.