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ANIMAL PRODUCTIVITY AND PASTURE MANAGEMENT OF *Brachiaria decumbens* STAPF IN THE COLOMBIAN LLANOS

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The productivity and management of *B. decumbens* was evaluated for 4 years in three experiments under continuous grazing with different combinations of stocking rates, ranging from 0.9-3.06 an/ha during the rainy and dry season, respectively, and maintenance fertilization with phosphorus, potash, magnesium and sulphur. The best average animal performance, 146 kg/ha/year, was obtained in one experiment established with 75 kg P_2O_5 per hectare and maintenance fertilization with 20 kg P_2O_5, 15 kg K_2O, 13 kg MgO, and 15 kg S per hectare, and 22 kg K_2O, 18 kg MgO and 22 kg S per hectare after 2 and 4 years, respectively. In the other experiments in which maintenance fertilization was not properly applied every two years, the combinations of stocking rates had nc significant effect on animal productivity. However, in 1979 when all experiments received maintenance fertilization the animal productivity was very similar, 144-147 kg/ha, indicating the importance of management of soil fertility on pasture productivity and management. The persistence of *B. decumbens* was excellent under the range of stocking rates selected and the pastures remained productive and free of weeds with proper maintenance fertilization. Spittlebug (*Aeneolamia, Zulia* and *Deois* spp.) which is a serious pest in South America, was present in these experiments but did not significantly affect pasture productivity. Toxicity symptoms associated with photosensitization were observed only in about 5% of the experimental animals. These results indicate that *B. decumbens* is one of the best grasses adapted to the well-drained savannas in the Colombian Llanos on the basis of its animal productivity and easy management.

Key words: Oxisol, stocking rates, maintenance fertilization, phosphorus, potash, magnesium, sulfur, spittlebug, photosensitization. Brachiaria decumbens

Brachiaria decumbens Stapf is a tropical grass native to East Africa (Bogdan, 1977) which grows naturally in open and bush grasslands with moderately humid climate on fertile soils. It has been introduced to other tropical regions of the world and has been successfully adapted to Australia (Loch, 1977), the Caribbean region (Richards, 1970), Brazil (Serrao and Simao Neto, 1971), and Colombia (Crowder et al 1970). In tropical America its adaptation and high dry matter productivity on acid infertile soils in contrasting climatic conditions such as the Colombian Llanos (Spain, 1979) and the Amazon region (Toledo and Morales, 1979) are quite remarkable.

The crude protein content and dry matter digestibility coefficient of *B. decumbens* are high (Butterworth, 1963; Reid et al 1973; Loch, 1977) compared to other tropical grasses, and the rate of decline of nutritive value with maturity in the leaves fairly low, even under relatively low soil fertility conditions and low amounts of phosphorus and potash fertilizers (CIAT, 1982). No serious palatability problem has been reported when maintained in leafy condition under grazing, resulting in good animal performance with or without nitrogen fertilization (Harding and Grof, 1978). However, toxicity problems associated with continuous grazing in pure stands resulting in photosensitization of the skin, poor animal performance and death of young steers (150-200 kg liveweight), has been reported in tropical America (Richards, 1970; Andrade et al 1978; Paladines and Leal, 1979); although it has not been experienced in North Queensland when fertilized with nitrogen (Teitzel et al 1971).

The present investigation was designed to evaluate the animal productivity and proper pasture management of *B. decumbens* under continuous grazing with different combinations of stocking rates for the dry and wet seasons, with minimum use of fertilizer for pasture establishment and maintenance on an infertile acid soil in the Colombian Llanos.

Materials and Methods

The investigation was conducted at the Centro Nacional de Investigaciones Agropecuarias (CNIA) in Carimagua, 320 km east of Villavicencio, State of Meta. The station is located at latitude 4°37'N, at approximately 175 m above sea level, in an area representative of the well drained savannas of the Colombian Llanos. The climatic and soil characteristics have been described by Spain (1979). The mean temperature is 26°C, with annual rainfall of 2094 mm and mean evapotranspiration potential of 2195 mm, with a distinct dry season from mid-December through the end of March. The soils are Oxisols (Tropeptic Haplustox Isohyperthermic), acid (pH 4.5 in water, 86% Al saturation), low in available P (1 ppm Bray II) and l?w in exchangeable Ca, Mg and K (< 0.2 me/100 g, each), fine-clay, with excellent physical condition.

Three experiments consisting each of unreplicated 5.55, 3.85 and 2.94 ha paddocks, respectively, to generate three different stocking rates while maintaining a constant number of animals in each one, were established with *B. decumbens* using vegetative material in three successive years to study different combinations of management during the dry and wet seasons.

Experiment 1. The pastures were established in 1973 with 75 kg P_2O_5 per hectare from Basic Slag (14% P_2O_5) and grazed continuously with 3 fixed stocking rates, 0.9, 1.3 and 1.7 steers per hectare, respectively, for three years and the results reported by Paladines and Leal (1979). In 1977, a maintenance fertilization consisting of 15 kg P_2O_5, 15 kg K_2O, 13 kg MgO and 15 kg S per hectare, respectively, was applied to each paddock and, as a result of increased forage on offer, the stocking rates were increased the following year to 1.3, 1.8 and 2.4 steers per hectare, respectively. A second maintenance fertilization with 15 kg P_2O_5, 15 kg K_2O, 13 kg MgO, and 15 kg S per hectare, respectively, was applied in 1979.

Experiment 2. This experiment was established in 1974 also with 75 kg P_2O_5 per hectare and grazed continuously with a fixed low stocking rate, 0.7 steers per hectare, during the dry season and variable stocking rates, 1.63, 2.34 and 3.06 steers per hectare during the wet seasons; the results for the first two years were reported by Paladines and Leal (1979). In 1977 a maintenance fertilization consisting of 15 kg P_2O_5, 15 kg K_2O, 13 kg MgO and 15 kg S, per hectare, respectively, was applied to each paddock and the stocking rate was increased to 1.0 and 1.6, 2.3 and 3.0 steers per hectare, during the dry and wet season respectively. A second maintenance fertilization with 22 kg P_2O_5, 22 kg K_2O, 18 kg MgO, and 22 kg S per hectare, respectively, was applied in 1979, and the stocking rates remained the same until the end of the experiment.

Experiment 3. A new experiment was established in 1975 with 75 kg P_2O_5 per hectare and grazed continuously with variable stocking rates, 0.7, 1.0 and 1.4 steers per hectare during the dry season and adjusted to fixed stocking rate of 2.0 steers per hectare in May when the pastures had recovered from grazing with the onset of the rains in April. The first year's results have been published by CIAT (1978). The first maintenance fertilization consisting of 20 kg P_2O_5, 15 kg K_2O, 13 kg MgO and 15 kg S per hectare, respectively, was applied in 1977 and a second one in 1979 consisting of 22 kg K_2O, 18 kg MgO and 22 kg S per hectare, respectively, and the stocking rates remained the same until the end of the experiment.

Management and Sampling. One-year old crossbred Criollo - Brahman steers of about 150-170 kg initial liveweight were used and replaced at the end of each calendar year by a new group of animals. All the animals received mineral supplementation and water ad libitum. The animals were fasted for 16 hrs previous to weighing.

The amount of dry matter on offer was determined during both dry and wet seasons, initially by randomized cut samples and later estimated by the method proposed by Hadydock and Shaw (1976). The material was bulked and dried at 60°C for 48 hrs for dry matter determination.

All the experiments were terminated at the end of dry season in April, 1981.

Statistical Analysis. Analysis of variance over the last four years of the investigation was performed for each experiment considering dry and wet season independently, using daily gains per season as dependent variables and periods (defined as the rainy season in which maintenance fertilization was applied and the subsequent dry season) and stocking rates as sources of variation. The model used was: $Y_{ijk} = \mu + P_i + C_j + e\,(P \times C)_{ij} + e_{ijk}$, where Y_{ijk} = daily gains of steers in jth stocking rate during period i, P_i = effect of period, C_j =effect of stocking rates and e_{ijk} = experimental error composed of variability between individual animals in each period by stocking rate combination. Duncan's Multiple Range test for mean comparison was used for those effects proven significant with error probability of $P < 0.05$.

Results

Experiment 1. The mean liveweight gains of steers grazing at fixed stocking rates during the wet and dry season, respectively, averaged for each period are presented in Table 1. There was not any significant effect ($P < 0.05$) of stocking rates in the range studied in any of the seasons of the year but the effect of periods associated with maintenance fertilization was highly significant ($P < 0.001$) and the interaction period by stocking rate was only significant ($P < 0.05$) during the wet season (Table 4).

During the rainy season the best performance was after the second maintenance fertilization with P, K, Mg and S in 1979. The first maintenance fertilization in 1977 was not done early enough at the beginning of the rainy season to have any significant effect that year, or perhaps was not enough to overcome nutrient deficiencies in the soil after four years of establishment and continuous grazing. The best performance during the dry season was related to those periods in which maintenance fertilization was applied during the wet season (1977 and 1979), indicating a residual effect that was carried over the entire period.

Considering the combined effects of maintenance fertilization on both wet and dry season, there was a significant increase in live-weight gains per animal, 147 kg/an/year, in the period 1979-80, compared to previous years and the effect was carried over the following year, but to a lesser extent (Table 1).

Experiment 2. The mean liveweight gains of steers grazing with fixed and variable stocking rates during the rainy and wet seasons respectively, averaged for each period across stocking rates are presented in Table 2. As in Experiment 1 no effect on animal performance due to stocking rate was observed during the rainy season. However, during the dry season stocking rate had a significant ($P < 0.05$) effect on animal gains. The most significant effect ($P < 0.001$) was again periods associated with maintenance fertilization and there was a significant interaction of period by stocking rate ($P < 0.05$) during the rainy season only (Table 4).

In this experiment the first maintenance fertilization was applied late in the rainy season and did not have any effect on that year but the effect was carried over the following dry and rainy season. The second maintenance fertilization in 1979 which was applied at the beginning of the rainy season, was more effective in improving animal performance the same year and the effect was carried over the following dry and rainy seasons, respectively.

Table 1

Mean liveweight gains[1] of steers grazing on B. decumbens with fixed stocking rates at Carimagua, Experiment 1, 1977-1981.

Period	Rainy season 249 days	Dry season 107 days	Annual 356 days
	---------- g/an/day ----------		kg/an
Year			
1977-78[2]	378 c[3]	57 a	100
1978-79	336 c	-61 c	77
1979-80[2]	570 a	46 a	147
1980-81	505 b	-25 b	123
Average	447	17	112

1 Average for all stocking rates (1.3, 1.8 and 2.4 steers/ha)

2 Maintenance fertilization with 15 kg P_2O_5, 15 kg K_2O, 13 kg MgO, 15 kg S per hectare applied during the rainy season.

3 Numbers in each column followed by the same letter are not significantly different ($P < 0.05$)

Table 2

Mean liveweight gains[1] of steers grazing on B. decumbens with fixed stocking rates during the dry season and variable stocking rates during the rainy season at Carimagua, Experiment 2, 1977-1981.

Period	Rainy season 249 days	Dry season 107 days	Annual 356 days
Year	g/an/day		kg/an
1977-78[2]	273 c[3]	271 a	97
1978-79	384 b	-23 c	93
1979-80[2]	518 a	143 b	144
1980	417 b	-36 c	100
Average	398	89	108

1 Average for all stocking rates (1.0 steers/ha for the dry and 1.6, 2.3, 3.0 for the rainy seasons, respectively).

2 Maintenance fertilization with 15 kg P_2O_5, 15 kg K_2O, 13 kg MgO, 15 kg S per hectare applied during rainy season in 1977; and 22 kg P_2O_5, 22 kg K_2O, 18 kg MgO, 22 kg S per hectare during rainy season 1979.

3 Numbers in each column followed by the same letter are not significantly different ($P < 0.05$)

Table 3. Mean liveweight gains[1] of steers grazing on B. decumbens[2] with variable stocking rates[3] during the dry season and fixed stocking rate during the rainy season at Carimagua, Experiment 3, 1977-1981.

Stocking rate	Rainy season 249 days	Dry season 107 days	Annual 356 days
an/ha[3]	g/an/day		
2.0/0.7	408 b[4]	68 a	109
2.0/1.0	550 a	84 a	146
2.0/1.4	549 a	85 a	146
Average	502	79	134

Average for all periods 1977-1981.

2 Maintenance fertilization with 20 kg P_2O_5, 15 kg K_2O, 13 kg MgO, 15 kg S applied during season in 1977; and 22 kg K_2O, 18 kg MgO, 22 kg S per hectare applied during rainy season in 1979.

3 Rainy/dry season.

4 Numbers in each column followed by the same letter are not significantly different ($P < 0.05$)

Table 4
Analysis of variance results for animal daily gains during rainy and dry seasons for each experiment on B. decumbens at Carimagua, 1977-1981.

Source	DF	F value	
		Rainy season	Dry season
Experiment 1:			
Period (P)	3	19.53**	41.44**
Stocking rate (SR)	2	0.72	1.42
Interaction (PxSR)	6	2.60*	0.94
Experiment 2:			
Period (P)	3	25.91**	4.06*
Stocking rate (SR)	2	1.12	4.06*
Interaction (PxSR)	6	3.06*	1.41
Experiment 3:			
Period (P)	3	1.10	28.30**
Stocking rate (SR)	2	8.82**	0.18
Interaction (PxSR)	6	4.43**	2.55*

* $P < 0.05$ ** $P \leq 0.01$

During the period 1979-80, the combined effects of maintenance fertilization during both rainy and dry season resulted in better animal gain, 144 kg/an/year, compared to other periods, which was similar to the performance in Experiment 1 (Table 2).

Experiment 3. The mean liveweight gains of steers grazing with variable stocking rate during the dry season and fixed stocking rate during the rainy season, averaged across the periods are presented in Table 3. The effect of periods was highly significant ($P < 0.001$) only during the dry season and stocking rate was highly significant ($P < 0.001$) only during the rainy season, with a significant interaction ($P < 0.05$) in both seasons (Table 4).

When maintenance fertilization was applied properly every two years the stocking rate combination of 2 an/ha during the rainy season and 1.0-1.4 an/ha during the dry season, resulted in better performance during the rainy season ($P < 0.05$) with no significant difference during the dry season (Table 3).

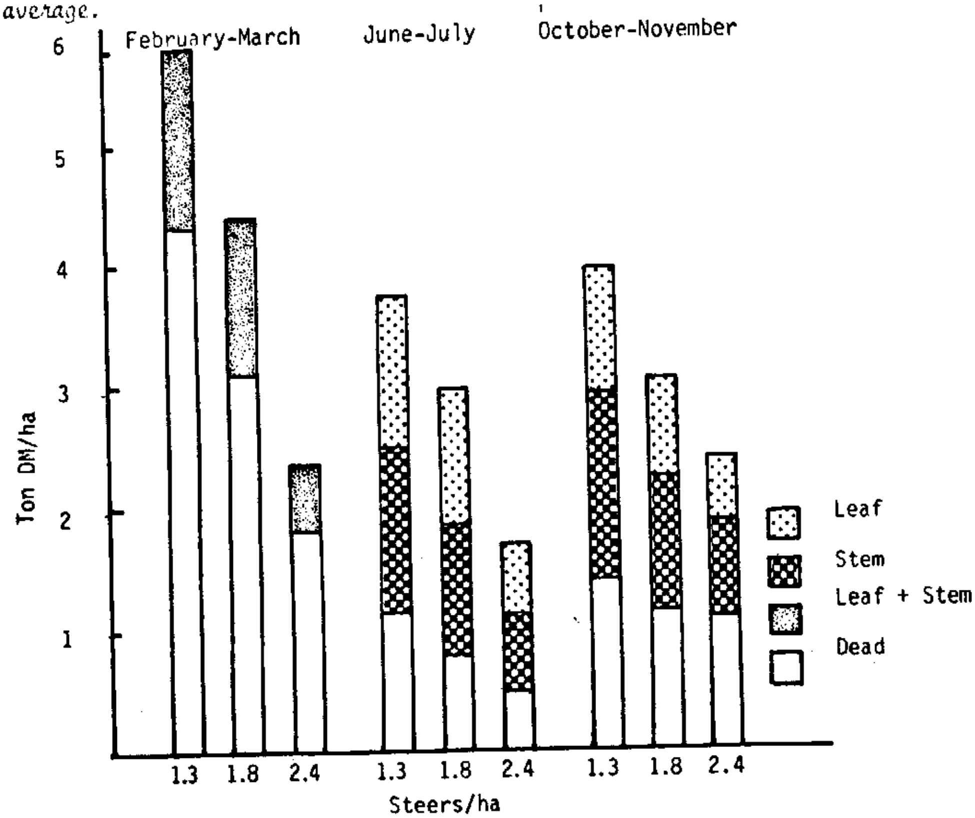
In this experiment the best animal performance, 146 kg/an/year, with proper maintenance fertilization was similar to the best results obtained in 1979 also with maintenance fertilization in Experiment 1 and Experiment 2, 147 and 144 kg/an/year, respectively, with other combinations of stocking rates (Table 3).

Discussion

Pasture measurements should be used to interpret animal production data (Jones, 1981). Campbell (1966) has criticized methods of evaluating grazing management experiments which are based solely on measurement of animal productivity. In the three experiments with *B. decumbens*, the amount of forage on offer that was measured for two years after the second maintenance fertilization in 1979 (Figure 1, 2 and 3) increased compared to the results after the first maintenance fertilization in 1977 (CIAT, 1978), and justified the decision to increase the stocking rates in all experiments. However, it seems that the range of stocking rates especially during rainy season was not sufficiently large to limit pasture potential, explaining perhaps the lack of response on Experiments 1 and 2 (Tables 1 and 2, respectively). In Experiment 3, even though there was a highly significant effect of stocking rate on animal performance during the rainy season, the amount of green forage on offer (Figure 3) did not explain the differences and actually performance was better with the higher stocking rate combinations for rainy and dry season evaluated in this experiment (Table 3).

Figure 1

Forage availability and plant part composition of B. decumbens with three fixed stocking rates at Carimagua. Experiment 1, two years average.



After the first maintenance fertilization in 1977 there was some evidence of improvement in crude protein content of the forage on offer in Experiment 3 during the dry season when the pastures were grazed at a high stocking rate the previous rainy season (ICA-CIAT, 1978) which might explain the better animal performance that year compared to results in Experiments 1 and 2; however, these differences were not consistent throughout the duration of the experiments. It is evident from agronomic experiments conducted on small plots in the area of the grazing experiments, that an improvement in the N:S ratio in the forage results from maintenance fertilization (Salinas, unpublished data). The results were better when the fertilizer was applied every two years after establishment in Experiment 3 explaining perhaps a more consistent result in animal performance from year to year. Fertilization of tropical grasses with potash has been shown to increase not only dry matter production but also cellulose digestibility (Fernández et al 1970) and fertilizer sulfur increased dry matter digestibility and intake of pangola grass (Rees et al 1974) and this might explain results from Carimagua in low fertile soils, where these two elements become deficient very rapidly after pasture establishment.

Very few results of animal performance with *B. decumbens* have been reported in the literature. Harding and Grof (1978) in the wet tropical coast of North Queensland obtained a mean liveweight gain of 208 kg per animal at a stocking rate of 4.55 steers per hectare with 196 kg of nitrogen per hectare compared to 165 kg per animal with 3.45 steers per hectare with no nitrogen fertilization in a rotational grazing system. In the Pie de Monte region of the Colombian Llanos with better rainfall distribution and soil fertility, Alarcon (1979) reported annual liveweight gains of 145 kg per animal with stocking rates of 2.3 steers per hectare on continuous grazing, which is fifteen times the productivity of native pastures with burning. In the same region with fertilization including lime, nitrogen, phosphorus and potash, Vivas (1973) reported animal production of 486 kg per hectare with continuous grazing. The results in Carimagua are much lower with less rainfall but better than those reported by EMBRAPA (1981), where 123 kg/head and 251 kg/ha was obtained in a similar environment in the Brazilian Cerrados where *B. decumbens* was the most productive grass during the dry season.

Although it was shown that nitrogen was limiting *B. decumbens* production in Carimagua grazing trials and that fertilization including lime and micronutrients increased dry matter production from 6 to 15 tons per hectare (CIAT, 1979), the cost of fertilization was not economical according to an evaluation of Nores and Estrada (1979) based on experimental results reported by Paladines and Leal (1979).

The persistence of *B. decumbens* under continuous grazing was excellent for the duration of the experiments under the range of stocking rates selected; higher stocking than used in these experiments, 5 to 7.7 steers per hectare, with high nitrogen fertilization and rotational grazing has resulted in pasture deterioration by trampling during the rainy season in Australia (Harding and Grof, 1978).

The pastures remained free of weeds when maintenance fertilization was applied regularly every 2-3 years after continuous grazing. Spittlebug (*Aeneolamia*, *Zulia* and *Deois* spp) which is a serious insect pest in South

America (Calderón, 1981) was present in Carimagua mainly at the lower stocking rates; however, it did not significantly affect pasture productivity at any time during the trials. Toxicity symptoms associated with photosensitization were observed in about 5% of the young animals during the last 4 years. The incidence was less of a problem compared to a report by Paladines and Leal (1979) at the beginning of the trials in which death of twelve animals ocurred; however, a severe case of toxicity symptoms was observed the following year after the experiments were terminated in 1980, at the beginning of the rainy season especially on older pastures established in 1973, when the whole area had been grazed down to establish a next experiment with legumes.

Conclusions

These results indicate that *B. decumbens* is one of the best grasses adapted to well-drained savannas in the Colombian Llanos on the basis of its animal productivity and easy management. It tolerates a rather wide range of stocking rates under continuous grazing with the potential to produce higher animal production if it is more intensively managed with fertilizer nitrogen and rotational grazing with high stocking rates, should the industry demand it. At the present time, the best management for economical production with minimum inputs seems to be cont'nuous grazing with seasonal stocking rates of 1 and 2 steers per hectare for the dry and wet seasons, respectively, with maintenance fertilization with phosphorus, potassium, magnesium and sulfur every 2-3 years. However, the possibility to include a legume in the pastures to increase soil nitrogen and to improve animal performance during the dry season should be considered as an alternative to nitrogen fertilization for economical animal production.

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