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Evaluation of a Forest-Grazing System on a Pre-Fattening Cattle Farm

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Abstract

Context: The productivity of cattle production systems has tended to decrease as a consequence of climate change. The forecasts indicate that rainfall must drop by 60%, so the utilization of leguminous trees constitutes a way of improving feed supply and quality.
Aim: To evaluate the behavior of a rotational forest-grazing system made of gramineous and leguminous plants (Pennisetum purpureun cv. CT 169 and Sacharum Oficinarum) on a pre-fattening cattle farm.
Methods: The study took place at a Cooperative of Credits and Services, on brown-grayish soil. A randomized block design was used. The average weight for treatment A (25 animals) was 232 kg, whereas the animals in treatment B (25 animals) averaged 236 kg (Holstein-Zebu). The animals were weighed on days 90 and 212, and the evaluations were made in the dry season, using SPSS, version 15.1. At the end of the experiment, the following economic criteria were evaluated: Cost of animal purchasing, cost of salary, sales price, the value of production, and cost-effectiveness.
Results: The conversions were acceptable, with favorable live-weight gains, especially in treatment B (516 g/day average) throughout the experiment. The economic-productive results of the forest-grazing system were higher than the results observed using the traditional system. Cost-effectiveness was 23.32% higher than the ones produced by the traditional system.
Conclusions: Forest-grazing systems are a low-input pre-fattening alternative that permits obtaining gains of over 500g/d when compared to the traditional system.

Keywords: *forest-grazing, cattle fattening, pastures and forages, live weight, daily gain, Leucaena-leucocephala.*

Introduction

The inclusion of trees and shrubs is a starting point for modern tropical cattle raising, which on one hand, consists of increasing the production of milk and meat at a faster pace to meet the growing people's demands; and on the other, guarantees the preservation of natural resources and the environment. (Aguirre *et. al*., 2016)

Trees have been studied often as part of research programs on tropical meadows worldwide, which is validated by the high protein values and the possibility of fixing the nitrogen from the atmosphere in the soil, and its utilization as a source of shade and feeds for animals. At present, researchers, professionals, technicians, and farmers have changed their minds in relation to the role of arboreal species, especially multipurpose leguminous plant L. leucocephala, for ruminant nutrition. Some experiences have been oriented to the design of agroforestry alternatives that permit strengthening the interactions between this tree and the cattle systems. López, et al. (2015), claimed that forest-grazing systems are a sustainable choice for modern world cattle raising. However, its success depends on the interactions of its components and the environment, permitting the generation of management strategies according to the ecology of the production system, and therefore brings about improvements to productivity and sustainability of the system, broadening the range of benefits.

In the last 25 years, Central America has shown increases in meat and milk production. However,

higher beef production is more linked to the growth of the animal population and the stocking area. The productivity of cattle beef production systems has a trend to decline due to the implementation of more extensive systems and the addition of less fertile soils in which the species planted failed to adapt, generating a greater proportion of degraded and low productive pastures. López et al., 2015 noted that the causes of this phenomenon were multiple, among them, grazing malpractice, inappropriate stocking rates according to the capacity of ecosystems, lack of soil fertility replacement, the poor role of leguminous plants, burning, invasion of undesirable grass species, pests and diseases, droughts, different types of erosion, etc. Guevara et al. (2001) in a participatory survey applied on 157 farms said that poor knowledge of farmers about the species present in the grassland, and most importantly, the lack of knowledge of their biology and productive behavior, were key factors.

The efficiency of beef production systems must be ensured through proper utilization of feeds and inputs available, minimizing the adverse effects of the tropical environment on cattle, and controlling the main performance indicators of the farm (production, economy). Accordingly, this paper aims to evaluate a pre-fattening forest-grazing system compared to the traditional system, using gramineous plants alone, and to evaluate the production and economic results achieved.

Materials and methods

Location of the experimental area

The study took place on a private farm from the Armando Cardoso Cooperative of Credits and Services, in Caimito. It sits on typical brown-grayish soil, partially saturated, shallow, and not very eroded, on granodiorite. Texture: Loam clay soil, sandy, with little effective depth (14 cm). Almost flat slope (1.1-2.0%). (Provincial Soil Institute, Camagüey, Cuba, 2015).

Climate

Table 1 shows the behavior of the main climatic variables during the experimental period (November-May).

Table 1. Behavior of the climatic variables during the experiment

Indicators	Nov. - May.
Minimum temperature (^{0}C)	19.3-19.6
Mean temperature (^{0}C)	23.7-24.7
Maximum temperature (^{0}C)	28.0-29.8
Relative Humidity (%)	82.8-82.1
Precipitations (mm)	50.2-60.6

Source: Data provided by the Weather Center of Camagüey, 2015

Experimental design

A randomized block design was used in an area with 50 young bulls averaging 232 kg included in treatment A (25 animals), and 236 kg in treatment B (25 animals) (Holstein-Zebu). The animals were weighed at 90 and 212 days to compare the means of the processes and evaluate which was the more efficient treatment in terms of animal nutrition. The evaluations were conducted in the dry season (November-May).

Treatment A consisted of a gramineous plant-based diet.

Treatment B included gramineous + leguminous plants.

In the two cases, salt, sugar cane (Sacharum oficinarum), and Bermuda grass (Pennisetum purpureo), were used as mineral *ad libitum* supplements, while the animals were indoors.

SPSS, version 15.1 was used for statistical processing, to perform a simple analysis of variance for mean comparison.

Measurements in the grassland

Botanical composition

The botanical composition of the grassland was determined by the step method, according to Senra & Sistachs, 1989. Grass availability was estimated by traditional sampling (Senra & Venereo, 1986). The frames (0.25 m^2) were placed 25 in *zig-zag* inside the enclosure of the sampling, which had been previously divided into segments or strata to achieve homogeneity. The grass within the frames was cut and weighed to determine the yields by hectare and enclosure. The samples were collected monthly on the day the animals entered the enclosures for grazing, and on their exit to estimate the residue. At the end of the evaluation, all the enclosures of the systems had been covered.

Leucaena availability

1. The availability of this plant was estimated on the same day the samples were collected from the grassland, in 3% of the trees found in every enclosure (between 9 and 20, depending on the enclosure size), by simulating the trimming done by the animals to the accessible foliage, according to the animal height (Hernández et al., 2000).

The availability of trimmed leaves was estimated in 3% of the trees cut upon the trimming, usually in the rainy season, and depending on pasture availability (trees over 2.5 m high, and following planning). This time all the young and available foliage was included.

Measurements in the animals

The animals were weighed at the beginning, at 90 days (beginning of the experiment) and at 212 days, in the morning to determine the daily live weight gains. Feed balance was performed to determine deficit or excess during the period.

Grazing method

For treatment A

A rotational grazing system was used, including 4 enclosures for 10 days, and 30 days for resting, during the experimental period. The enclosures were 1ha bearing an association with gramineous plants, the time spent in the enclosures was 12 h approximately, and the rest of the animals indoors were given sugar cane (8.8 kg/day/animal), Bermuda grass (5.3 kg/day/animal), salt, and drinking water *ad libitum*.

For treatment B

A rotational grazing system was used, including 4 enclosures for 10 days, and 30 days for resting, during the experimental period. The enclosures comprised 1ha, in association with gramineous + leguminous plants. The animals stayed 12 h in the enclosures approximately. The other animals were 12h indoors and were given sugar cane (10.3 kg/day/animal), Bermuda grass (6.7 kg/day/animal), salt, and drinking water *ad libitum*. The nutritional value of the pastures (DM, Ca, P, ME, CP) used was as reported by Rivera et al. (2015) under similar conditions to this study.

Economic assessment

At the end of the experiment, the following economic criteria were evaluated: Cost of animal purchasing, cost of salary, sales price, the value of production, and cost-effectiveness.

Results and discussion

The animals in the grassland were very selective, so the diet supplied was expected to meet their needs. Additionally, they were not forced to consume parts of the plant with little nutrition.

Table 2 shows the botanical composition of treatment A. The greatest percentage belongs to grazed gramineous plants (80%), and the low infestation of undesirable plants on the farm (up to 5%). Unlike Rivera et al., (2015), who stressed that in recent years the invasion of woody weeds in cattle areas has risen to 50% due to the lack of pasture protection. In this particular case, proper management has been performed in all the areas, with cutting and the proper stocking rate.

Table 2. Botanical composition of the grassland in treatment A

Botanical composition	%
African Bermuda grass (Cynodon lemfuensis)	30%
Bahiagrass (Paspalum notatum)	50%
Other grass	15%
Weeds	5%
TOTAL	100%

Table 3 shows the botanical composition of treatment B. The highest percentage belongs to the Leucaena + grass association (73.4% of the area), and the African Bermuda grass (22.5%), then weeds (4.1%), noting that in this treatment there is 0.9% less infestation of weeds than in treatment A.

Table 3. Botanical composition of the grassland in treatment B

Botanical composition of the grassland	%
African Bermuda grass (Cynodon lemfuensis)	22.5%
Leucaena + Bahiagrass (Paspalum notatum)	54.6%
Leucaena + Other grass	18.8%
Weeds	4.1%

The t/DM/ha yields of the pastures in the period were 3.7, with 37.0 t total availability, as shown in table 4 in treatment A, coinciding with the results achieved by Lopez-Vigoa *et.al.*, 2016 under similar working conditions. Regarding the sugarcane and Bermuda grass, the results achieved were lower due to poor attention to the field and the poor quality of the seeds used in this period.

Table 4. Feed availability in treatment A

Feeds	Ha	Yield (t/DM/ha)	Total availability (t)
Pastures	10.0	3.7	37.0
Forages	1.5	11.1	16.7
Total	11.5	14.8	53.7

Table 5 shows the feed availability in treatment B. The t/DM/ha yields of the pastures in the period were 2.9, with 5.8 t total availability. Sugar cane and Bermuda grass showed lower values than Lopez-Vigoa et.al., 2016.

Table 5. Feed availability in treatment B

Feeds	Ha	Yield (t/DM/ha)	Total availability (t)
Pastures	8.6	2.8	24.65
Forages	2.0	13.07	26.14
Leguminous plants	2.0	2.9	5.8
Total	12.6	18.77	56.59

Table 6 shows the contributions and nutritional requirements for the two treatments The protein contributions were below the required values, with a

483.5 kg deficit for treatment A, and 105 kg for treatment B. However, the metabolizable energy, calcium, and phosphorous underwent excess. The animals were able to reach 415 g daily gain in treatment A, and 516 g in treatment B.

The two treatments evidenced acceptable gains that were conditioned by the contributions of nutrients in the diet (Table 6), coinciding with Hoste et al., (2015), who said that in the systems where pastures and forages take part in more than 60% of the daily diet, the daily gains (LW) were above 400 grams. In Venezuela, when comparing L. leucocephala protein banks systems with the commercial management in the fields (more concentrated pastures, and pastures plus multi-nutritional blocks), García-Hernández et al., (2017) found differences between the systems (P<0,001), as to weight changes of crossbred Holstein calves, in favor of the protein bank.

The results observed are possibly related to the presence of native leguminous plants that were not included in the availability study. Besides, the contribution of the gramineous + leguminous plant association improves the quality of the gramineous plant due to the nitrogen contribution of the leguminous plants to the soil (García-Hernández et al., 2017).

Table 6. Feed balance of the two treatments

		CP (kg)	ME (Mcal)	Ca (kg)	P (kg)
Treat. A	Contribution	2892.5	106 190	247.2	152.7
	Req.	3 376.0	7 4200	127.2	74.2
	Excess or deficit	(483.5)	31 990	120.0	78.5
Treat. B	Contribution	3 794.5	115 982	183.7	112.0
	Req.	3 900.0	80 560	143.1	79.5
	Excess or deficit	(105.5)	35 422	40.6	32.5

Treatments A-PV 320.0 kg Gain LW 415.0 g/day
Treatment B-LW 345.4 kg Gain LW 516.0 g/day

Table 7 shows a comparison of gains between the two treatments, as to pasture quality. It includes the live weight and the mean daily gain. Considering the absence of significant differences at the start of fattening for both treatments, the animals were weighed at 90 days, evidencing that the best results were achieved in the enclosures where the gramineous plants were associated with Leucaena, producing significant differences (P<0.05) for this indicator. These significant differences were also present in the mean daily gain of live weight accumulated throughout the fattening time.

Table 7. Live weight (kg) and mean daily gain (MDG)

Treatments	LW beginning	LW90 days	LW212 days	MDG (g)
Gramineae	232.0 a	276.1b	320.0b	415b
Gramineae + Leguminosae	236.2a	292.1a	345.4a	516a
SE ±	1.23*	4.2*	6.3*	11.3*

Note: a, b Values with uncommon superscripts in the vertical differ from P<0.05 (Duncan, 1955) *P<0.05

During the experimental period, the LW gains recorded by the animals in the two treatments can be explained by the compensatory growth phenomenon that must have taken place during the period, which perhaps caused greater consumption and more efficient utilization of the feeds available (Murgueitio et al., 2015).

The animals that grazed in the Gramineae + Leguminosae association entailed a higher quality diet and time-comfort improvements for the animals, as they grazed in the shade, coinciding with Yong et al. (2017), which brought about average gains higher than others only on gramineous plants.

Table 8 Economic-production analysis of the fattening system applied

Concept	M/U	Treat. A	Treat. B	Dif.
Expenditures on animal purchases	PM	31.9	12.55	0.55
Expenditure on salary	PM	1.84	1.95	+0.11
Other expenditures	PM	4.1 6	5. 22	+1.06
Total Expenses	PM	31.9	39. 62	+1.72
Initial LW	Kg	232.0	236.0	+4.0
End LW	Kg	320.0	345.4	+25.4
Dif. LW	Kg	88.0	109.0	+21.0
Sale price LW	$	5.40	6.30	+0.9
Cost of beef kg	$	4.74	4.59	-0.15
Production value	PM	43. 2	54 .4	+ 11.2
Gain	PM	5. 3:	14 .8.	+9.5
Cost-effectiveness	%	14	37.32	+23.32

Table 8 shows that the sum of total expenditures was higher in MP +1.2 for treatment B, since the initial live weight of these animals was 236 Kg, which entailed more expenses. Other expenditures included feeding, compared to group B, and when measuring the final weight of this treatment, the beef kg was better ($ 0.15) compared to treatment A. Thus the gain in treatment B was higher in MP + 9.5, and cost-effectiveness (23.32%) compared to treatment A. It

corroborates the effect of the diet used on live weight gain (production and economic values); the animals in group B achieved 25.4 kg over, compared to the animals in treatment A.

Conclusions

The forest-grazing systems are a low-input pre-fattening alternative that permits obtaining gains of over 500g/d when compared to the traditional system.

The economic-production results of the forest-grazing system were higher than the results observed using the traditional system, as cost-effectiveness was over 23.32%.

Author contribution

José Manuel Hernández Guerrero: research planning, analysis of results, redaction of the manuscript, final review.

Dania Ramos Rodríguez: research planning, data collection, analysis of the results, redaction of the manuscript, final review.

Conflicts of interest

Conflicts of interest.

Recommendations

The authors recommend further evaluation of the cattle production systems with the inclusion of different types of trees (forest-grazing), as it is a low-input technology that can substitute imports for cattle pre-fattening.

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