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Animal Response and Economic Impact of Tree Inclusion in a Livestock System

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ABSTRACT

A study was conducted at the Roberto Rodríguez CCS (Credit and Services Cooperative), in the municipality of Sierra de Cubitas, province of Camagüey, Cuba, to evaluate the animal response and economic impact of the inclusion of trees in a livestock system under the local edaphoclimatic conditions. The productive performance of animals and the forest system were evaluated, and their economic impact was determined. The mean and SE was determined as well. The results were compared using a T-student test for $P < 0.05$, in order to evaluate animal response in the two systems. The results indicated the superiority of the forest grazing system over the traditional system. It was concluded that the forest-grazing system increased animal productivity and contributed with additional benefits in terms of forestry. The forest-grazing system had a greater economic impact than the traditional system.

Key words: *economic impact, grass productivity, forest-grazing system*

INTRODUCTION

One of the problems that compromise the sustainability of dairy and meat production is the lack of food and its low nutrient contribution. Cost effectiveness of dairy systems is directly associated to the technology used as well as the adoption of new technologies, whose impacts on production are critical elements that may foster development of agriculture and its competitiveness (García, Albarrán, and Avilés, 2015).

Increases in food production to meet the growing demands, should be directed to the eradication of environmental issues, a more efficient use of natural resources, the preservation of biodiversity, the fight against the causes of climate change and the reduction of its consequences, as well as the fight against the growing emission of greenhouse gases, and the control of soil degradation and desertification (Montaigne, Somarriba, Murgueitio, Fassola, and Eibl, 2015).

Trees are important actors that improve the physical, chemical, and biological characteristics of the soil, since they increase the contents of organic matter, improve the cationic and anionic exchange capacities and soil structure, and provide goods and services to humans (Milera, Sánchez and Martín, 2010).

Febles, Ruiz, and Crespo (2003) claimed that today, humanity faces the challenge of implementing sustainable production systems in agriculture. One of the economically appealing and profitable choices at hand is forest-grazing systems due to their possibilities to increase farming and animal and forestry productions, thanks to low costs of maintenance and high sustainability.

Therefore, the aim of this paper was to evaluate the animal response and economic impact of the inclusion of trees in a livestock system under the local edaphoclimatic conditions of the Roberto Rodríguez Cooperative (CCS) in the municipality of Sierra de Cubitas.

MATERIALS AND METHODS

Location of the experimental area, soil, and climate

Location

This study lasted two years (July 2014-September 2016) and it was conducted on two livestock farms from the Roberto Rodriguez CCS, municipality of Sierra de Cubitas, province of Camagüey, Cuba, The CCS is located on 21º 40´ north latitude and 77º 39´ west longitude, 40 m above sea level.

Soil

The soil is brown with typical carbonates, according to the cartographic chart of the site, which was corroborated with the works of Hernández, Pérez, Bosch, and Castro (2015). The pH is slightly acidic (6.4), and the effective depth is 25 cm.

Climate

The local climate is tropical humid of interior plain, with seasonal humidity. The air temperature is high, with mean values of 26.6 ºC; the average annual precipitations are 1 457 mm (Rivero, 2010).

Farm characterization

The farms are engaged in bull fattening since 2008. The study included the establishment of 24 enclosures comprising an average area of 1.1 ha and 0.4 ha of space between enclosures, with a total 26.84 ha for fattening on each farm.

Farm No. 1 was established in previous sugar cane plantation which had remained idle.

Farm No. 2 was also established in a former sugar cane plantation, now planted with *Samanea saman* (Jacq.) Merr. (Cuban algarroba) 10.0 x 10.0 m. Today, it is a forest-grazing system.

Farm No. 1 had 30 animals (15 young bulls and 15 Zebu crossbred bulls); whereas farm No. 2 had 36 animals (18 young bulls and 18 grown bulls).

Evaluations

Evaluation of animal weight in both systems

The animals weighed an average of 287 kg/animal at the beginning. The average weight at the end of this study was calculated by thoracic perimeter and CALRAC software (Roche, Larduet, Torres, and Ajete, 1999).

Additional items (lumber and firewood) on the farms

The volume of lumber use was determined by the Huber equation:

V= (Π /4) x (d 1.3)2 x h x f

Where:

d=diameter at 1.3 m high from the soil

h=height

f=morph coefficient

To achieve that, 96 plots were prepared for temporary sampling (PTM), 144 m^2 each (12 x 12 m); each plot had four trees, totaling 384 forcipulate trees. Plot distribution was made at random.

Production of firewood

The Huber equation was applied to determine the volume of 10 branches with known weight.

V= (Π /4) x d^2 x L

The standard sample used was 0.20 m long, with a diameter of 0.10 m, and 1.06 kg of weight.

These results were extrapolated to the total weight of branches without leaves from each tree (cubic capacity by weighing).

Economic assessment

Economic assessment was made with the data from the years included, which were provided by the Economic Department of the CCS. The indicators calculated were,

- Total income
- Total expenses
- Profits
- Statistical analysis

SPSS 15.0.1 (2006) for Windows was used to determine the descriptive statistics (MEDIA and ES). The results were compared with the T-student test to evaluate animal response in the two systems.

RESULTS AND DISCUSSION

Evaluation of animal weight in both systems

Table 1 shows the final weights of animals after a year of fattening, under traditional grazing without trees and on a forest-grazing system. Remarkably, on the forest-grazing system, the animals increased 180.5 kg, 35 kg more than the animals on the traditional system, with daily increases of 494 and 398 g/animal/day, respectively.

Hernández, Carballo, and Reyes (2000), and Milera (2013) reported zebu fattening in both native grass grazing and forest-grazing systems; these authors observed average annual gains over 400 g/day. In their study, weight gains (419 g/animal/day) were 73% higher than the ones based on native pasture (242 g/animal/day), and did not differ from the ones used in a system that included supplementation in the second half of the dry season, with molasses and 3% urea, and soybean meal (409 g/animal/day).

The results achieved in this study were higher than the reports by the above authors, both in forest-grazing (FG) and native grass (156 g/day); the latter was much better. It must be especially linked to the abundance of native leguminosae, and proper grass availability.

Comparative evaluations made by López, Lamela, and Sánchez (2004) of *Leucaena leucocephala* (Lam.), Wit, *Albizia lebbeck* (L.) Benth., and *Bauhinia purpurea L.* in association with *Panicum maximum* Jacq. demonstrated the high potential of these plants in the soils where they adapt. In male Zebu fattening, live weight gains of 0.7 kg/animal/day were achieved, which is higher than the results of this study.

Various research has proven that the animals under forest grazing have increased consumption of dry matter, protein, calcium, and fat, in comparison to animals fed gramineous monocropping (Solorio, Bacab, and Ramírez, 2011; Molina, Angarita, Mayorga, Chará, and Barahona-Rosales, 2016).

According to reports by López *et al.* (2015), forest-grazing systems can produce abundant quality forage throughout the year, which improves the balance of nutrients in animals. Therefore, an improvement was observed in the body condition and quality of the immune response. In a more favorable surrounding, animal well-being and resilience are higher.

The aim of these studies should be directed to self-sustainability of the system, maximum recirculation of nutrients, and nutrition and maintenance of the environment, with minimum daily weight gains between 500 and 600 g/animal, and yields of 800 kg of beef per hectare every year, with a stocking rate of 2 animals per ha (Iglesias, 2003).

The above supports the findings of Triana *et al.* (2014), who stated that farmers should evaluate the importance of forest-grazing in cattle raising areas.

These results are far from being optimum, since many years are required for trees to acquire economic value and extended shade. Moreover, the establishment of grasslands is longer, and production increases gradually as trees grow, and the grazing system is consolidated.

Lumber volume

Table 2 clearly shows the superiority of forest-grazing systems over traditional grazing, by incorporating additional choices, such as the wood that can be produced at a certain moment, including higher income for the farmer and the farm. On the other hand, the traditional grazing system only deals with animal production.

The feces of forest-grazing animals also provide important quantities of nutrients to the soil, which are limited in nutrient-short forestry practices.

In similar environmental conditions, with other legume species of the Mimosoideae family, Drumond *et al.* (1984), and Lima (1986 and 1994) cited by Ribaski (2003), reported that 8-year old trees (280 trees/ha) reached 6.5 m high, a diameter of 6.5 m on the top, and a diameter at the trunk (D1.3) of 16 cm, totaling 10 m^3 of firewood.

In Petrolina, State of Pernambuco, the same author said that in 5-year old plantations, the mean lumber production accounted for 15 m^3/ha.

The results of these authors differ essentially from this study due to the management conditions withstood by the plants. In other words, the greater number of plants per hectare the more competition, and therefore, higher plants than this study, which made a positive influence on lumber production.

Considering the age of these trees (seven years) with low inputs (no irrigation or fertilization), the mean annual increase of 0.79 m^3/ha/year strengthened the criterion that favors the superiority of forest-grazing systems over traditional grazing (Panadero, 2010).

Production of firewood

Table 3 shows the production of firewood provided by *S. saman* in the forest-grazing system. The density was determined by weighing a standard sample whose values will be used to determine carbon retention (680 kg/m^3), lower that the values observed by Loyola *et al.* (2015) for *Gliricidia sepium* (Jacq.) Kunth and *Bursera simaruba* (L.) Sarg., in the province of Camagüey, with densities of 1 089.01 and 764.1 kg/m^3, respectively.

These values were higher than the values cited by Loyola *et al.* (2014) for *L. leucocephala, with densities of* 0.53 t/m^3.

Individual analysis of trees showed firewood/tree weight values of approximately 9.52 kg/plant, equivalent to 0.014 m^3 and 1.4 m^3/ha for this forest-grazing system, a significant value for an additional by-product of the technology.

Research done by Anguiano, Aguirre, and Palma (2013) indicated that the plantation of 80 000 plants/ha of *L. leucocephala* var. Cunningham in association with pastures produces up to 128.62 tC/ha/year, which is closely related to biomass production.

Economic assessment

Table 4 shows the economic response of the two systems. Plantlet and plantation costs were only available on the farm with the forest-grazing system, which purchased 2 640 plantlets for $871.20, at plantation costs of $396.00. Lumber (4) and firewood (5) incomes were recorded using the same system, based on lumber supply (145.99 m^3 for commercial lumber, and 36.96 m^3 for firewood, which can also be sold).

Income was higher in the forest-grazing system, especially due to additional sales of beef, lumber, and firewood from trees fertilized with the manure produced by the grazing animals. Besides, undesirable plants could also be controlled, which is another advantage of the system.

The previous results showed the advantages of forest-grazing systems, particularly with *S. saman*. Different studies have shown that this species is highly adaptable (survival, growth, strength), to lands unsuitable for reforestation.

Monzote (2005), cited by Loyola (2011), claimed that achieving profitable animal production in harmony with the environment contributed to sustainable agriculture.

CONCLUSIONS

The forest-grazing system showed better animal productivity and contributed with additional favorable benefits in terms of carbon sequestering, and ensued additional benefits to forests.

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Table 1. Results of the T-Student test for animal response variables

System	Initial weight (kg)	Final weight (kg)	Increase (kg)	Mean daily increase (g/d)
FGS	287.0	467.5	180.5	494
TS	287.0	432.5	145.5	398
SE	0.032	1.27	1.27	3.49
Sig.	NS	*	*	*

FGS: Forest-grazing system; TS: Traditional system; NS: not significant *(P <0.05)

Table 2 Daxometric variables of trees

Farms	h (m)	$d_{1.3}$ (m)	v/tree (m^3)	v/ha (m^3/ha)
FGS	4.62 ± 0.009	0.17 ± 0.004	0.055 ± 0.002	5.53 ± 0.002
TS	-	-	-	-

FGS: Forest-grazing system; TS: Traditional system

Table 3 Lumber weight, volume, and density

Species	Density (kg/m^3)	Firewood/tree weight (kg/plant)	Firewood volume (m^3/plant)	Firewood volume (m^3/ha)
S. saman	680	9.52	0.014	1.4

Table 4 Main economic results from each system

Expenses and income ($)	FGS farm	TS farm
(1) plantlet cost	817.20	-
(2) plantation	396.00	-
(3) cost of animals	23 247.00	19 372.50
(4) lumber production	11 679.20	-
(5) firewood production	1 034.88	-
(6) animal production	74 893.50	57 738.75
(7) expenses (1+2+3)	24 460.20	19 372.50
(8) income (4+5+6)	87 607.58	57 738.75
Revenues (8-7)	63 147.38	38 366.25

FGS: Forest-grazing system; TS: Traditional system