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Agroproductive Evaluation of *Moringa oleifera Lam* in Hedges, under Edafo-climatic Conditions

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ABSTRACT

Agroproductive behavior of *Moringa oleifera* Lam was evaluated in edafo climatic conditions in Camagüey, Cuba, in a year-old hedge on typical gray-brown soil. This species contributes with 6.2 kg/year of green matter (MV) and 2.52 kg/year of dry matter (MS), with annual trimming, and 41.09 % of MS; 105 fruits per plant with 19.4 average of seeds per fruit, and approximately 2 037 seeds per plant. Wood production accounts for 0.029 m^3/plant and 19.34 m^3/km of hedges. *M. oleifera* Lam produces significant volumes of forrage and firewood, which valorize hedges in agriforestry systems.

Key Words: Moringa oleifera *Lam, hedges, foliage, firewood, fruits*

INTRODUCTION

Current deterioration of most cattle ecosystems demand serious transformation of exploitation systems, which should be based on agroecological principles, where cattle systems are considered ecosystems, not just technical and economic management (Del Pozo, 2002). The sustainability of these systems internationally does not mean yield increases, but system optimization as a whole (Funes, 2000).

Present-day knowledge has been oriented to designing agroforestry and grazing alternatives, which allow for more intense tree and cattle systems interaction (Ruiz *et al.*, 2000; Simón and Francisco, 2000; Iglesias, 2003; Mejías, 2008). Their main purpose is to develop technological alternatives for soil-tree-animal integration, directed to improve nutritional and productive levels in animals; rational use of resources and evaluation of economic, social and environmental impacts of the alternatives suggested.

Special importance is now given to hedges, since they contribute with a wide variety of products, including stakes for new hedges, animal forrage, firewood, fruit, and bee honey (apiculture), thus turning these systems into an indicator for system sustainability (Hernández, Pérez y Sánchez, 2001; Monzote y Funes-Monzote, 2003).

Within agroforestry techniques *Moringa oleifera* Lam. used for hedges certainly plays a significant role, due to low settling costs and high returns, compared to other types of hedges (Suárez, Simón y Yepes, 1996), apart from increasing availability of firewood, stakes for hedges and forrage (Price, 2000).

However, knowledge on intensive production of the species in the area is still insufficient, especially in terms of benefits. Hence, this study intends to assess the agroproductive behavior of *Moringa oleifera Lam.* in hedges, under edafo-climatic conditions at the Fortified Cooperative of Credits and Services (CCSF) *Renato Guitart* in Camagüey, Cuba.

MATERIALS AND METHODS

The study was developed for a year (March 2012-March 2013), at the CCSF Renato Guitart in the municipality of Camagüey, Cuba, located at 21º34’63” North latitude and 77º89’79” West longitude, 98.7 m above sea level.

The experimental work was performed on typical saturated, half deep, slightly humid, little eroded gray-brown soil, with clay loam texture and effective depth of 40 cm (Hernández *et al.*, 1999).

The climatic conditions of the area correspond to inner plain, tropical, humid, with seasonal humidification and high evaporation (Rivero, 2010); air temperature is high, with minimum values of 18.1-22.9 ºC, and maximum of 28.2-33.8 ºC. Rainfall in the period reaches the 1 235.5 mm, with a variation between March 2012 and March 2013 of 6.4 and 302.6 mm in the dry season (PPLL) and rainy season (PLL), respectively.

Animal foliage production

Following a randomized experimental design, sampling of 60 one-year-old trees of *Moringa oleifera* Lam. var. Plenium (introduced several years ago in Cuba), planted for hedges in March 2012 as plantlets, was carried out. The distance between trees is 1.5 m, with a height of 5.6 m at the time of intervention. Foliage samples were taken a year after plantation (March 2013), that included removal of all leaves and petioles.

The leaves were separated from the petioles and were separately weighed, and then the fresh weight was claculated in percents of the leave/petiole fraction. Yields were calculated using the MS data.

Fruit and seed production

All fruits and seeds per fruit from the trees were counted.

Firewood production

In order to determine this parameter, 10 samples from 0.20 m long branch samples with a diameter of 0.38 and 0.044 m and known weight (0.25 kg), were used. Volume was determined through the Huber formula:

$V= (\prod/4) \times d^2 \times L$

The results were extrapolated to the total weight of branches without leaves from each tree (cubing weight or ponderal index). Wood density (kg/m^3) for carbon sequestration studies was determined with the same parameter.

Statistical analysis

Descriptive statistics (mean and ES) were determined for foliage yields, fruit, seed and firewood production. Analyses were performed with SPSS for Windows, version 15.0.1 (2006).

RESULTS AND DISCUSSION

Foliage production

Table 1 shows the productive results for *M. oleifera Lam.,* regarding the amount of green material produced; as well as its production per hedge km, considering a single annual trimming, since this one is the first trimming done to the trees ever. The species, under edafo-climatic conditions contributes with 6.2 kg/a/trim of MV and 2.52 kg MS/a/trim provided that 41 % of MS assumed for this study, according to the results achieved by Reyes (2006), Palmero (2012) and Loyola *et al.* (2013). If these results are extrapolated to kilometers of total hedges, that could mean values of 1.68 t MS/km of hedge/trim, which may be three or four times higher, well over 5.0 t MS/km/year.

The results achieved in the study are superior to Gálvez (1998), Pedraza and Gálvez (2000) in *Gliricidia sepium* (Jacq.), Kunth ex Walp., (flowered pinnon) for Camagüey, who indicated the possibility that a *G. sepium* tree can produce 2.5 kg/MVa/trim and 10 kg/year of MV, in four trimming passes every 90 days each. However, eadible biomass is reported for *G. sepium*, which may contribute with 4.4 MS/year. It is also important to say that these results have only included one yearly trimiming, in comparison with the above mentioned study, due to their incidence on the carbohydrate reserves present, stage of folliage maturity, and so on.

These results are also higher than results by Palmero (2012) and Loyola *et al.* (2013) for edafo-climatic conditions in the municipality of Santa Cruz, Camagüey province, with over 15-year old trees, planted as stakes. In the above mentioned study, the authors achieved 4.88 kg/a/trim of MV; 1.97 kg of MS/a/trim and 1.31 t of MS/km/trim; all values are 25 % higher for every variable, which may be related to age in this particular case (one year old and possibly biologically stronger). Moreover, these trees grew from seed-produced plantlets, and have deeper and more vigorous roots that help the plant absorb the necessary nutrients from the deep.

If this analysis were made by hectares (t MS/ha) assuming the same plantation framework of 1.5 x 1.5 m; considering 4 444 plants/ha, productions of 27.5 t MV/ha may be achieved from a single trimming, equal to 11.19 t MS/ha from a single trimming. These values may be close to those refered to by Gómez (1994), cited by Loyola *et al.* (2013), for *G. sepium*, who reported annual green forrage productions of 55.5 and 80.6 t/ha, for a single trimming, between 12.5 and 20 t MS/ha.

Pedraza *et al.* (2005) suggested that 1 km of *G. sepium* hedges, 1.5 m between trees may contribute with nutrients (on a costly effective basis) around the year, so that 20 cows in 240 lactation days, consuming average amounts of pasture, and supplemented with minerals could produce around 1 kg/day more of milk, provided water and pasture availability were not a limiting factor. Folliage from hedges may bring about benefits to the ecosystem and farm´s ecology.

Trimming at the end of the rainy period may stop flowering, favor vegetation and produce quite a remarkable amount of edible biomass (Hernández, Benavides and Mochiutti, 1994).

Russo and Botero (1996) have said that folliage from various species of trees and shrubs can improve the quality of diets traditionally used for animal nutrition in developing countries. In countries like India and Nepal, the efficacy of that alternative has been very positively aknowledged.

Fruit and seed production

The evaluation of the species reproductive variables showed that in the March-April period the plant reproduces in the area, reaching up to 105 fruits per plant; as well as intense flowering.

Fitomed Technical Commission (2010) reports that their fruits are in the form of pods, up to 40 cm long and 1 or 2 cm wide, with winged seeds. The results achieved by this commission showed that a dry fruit weighs 17 g, from which seeds make up for 41 %.

The amount of seeds per fruit determined in this research ranged between 15-25 seeds, for an average of 19.4. These results corroborate other results by FAO-OMS (2005) that report 12-25 seeds per pod. These organizations have stated that each tree may produce from 15 000-25 000 seeds per year. In this particular case, during the first evaluation in March, the plants studied accounted, on average, 2 037 seeds per year, which is a significant value, considering they come from very young plants, only one year old.

Seed mean weight is 0.36 ± 0.001 g/seed; hence, according to the results achieved in this research, 1 kg of seeds contain approximately 2 777,7 seeds/kg .

Firewood production

Table 2 shows estimated firewood production, which may be supplied by *M. oleifera* Lam. in this productive system. From the pattern sample, wood density was initially determined, which will be later used for carbon retention determination. In that case, the density achieved is 961.5 kg/m^3, higher than the values reported by Palmero (2012), who had 862 kg/m^3, close to reports by Fors (1965), cited by Loyola *et al.* (2013), who had density values of 1 120 kg/m^3 for the same species. These values are way higher thn the values reported by Hu (1987) and López *et al.* (1987), cited by Fernández (2006), for *Leucaena leucocephala* (Lam) de Wit (Leucaena) and *Guazuma ulmifolia* Lam., whose reports showed densities of 530-570 kg/m^3 for the species.

Separate tree analysis showed significant values in firewood/tree, roughly 28.23 kg/plant, equal to 0.029 m^3/plant, and 19.34 m^3/km of hedge, an important value to consider as additional by-product of the technology, which valorized hedges to a greater extent, especially in this species. These values are lower to the ones reported by Palmero (2012) under other edafo-climatic conditions in Camagüey.

Taking into account the results from this research, there is coincidence with Villanueva *et al.* (2005), who highlights *M. oleifera* Lam. significance as a source of wood products (wood, stakes, charcoal and firewood), which may be consumed on the farm or sold in the market, or both. Foidl *et al.* (2001) also consider that wood from Moringa has an excellent pulp, as well as poplar (*Populus* sp.*)*, wich might be used by the Cuban forestry industry as another choice to diversify their products.

CONCLUSIONS

M. oleifera Lam. produces significant levels of forrage, firewood, fruits and seeds, which valorize hedge use in cattle systems in the region.

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Table 1. *M. oleifera* L. foliage yields in hedges (Mean± ES)

Species	MV/treel (kg/a/trim)	MS/tree (kg MS/a/trim)	t MS/km/trim
M. oleifera L.	6.2 ± 0.003	2.52 ± 0.003	1.68 ± 0.001

Table 2. Estimated firewood production of *M. oleifera* Lam (Mean+ES)

Species	No. of trees/km hedge	Density(kg/m^3)	Weight firewood/tree (kg/plant)	Firewood volume (m^3/plant)
M. oleifera L.	667	961.5 ± 0.003	28.23 ± 0.004	0.029 ± 0.003