Journal of Animal Production 29 (3), 12-17, 2017

Effect of Ecotype and Cutting Frequency on Forage Yields of *Moringa oleifera* Lam in the Cauto Valley

Giselle Rosell Alonso, Diocles Guillermo Benítez Jiménez, José Leonardo Ledea Rodríguez, Ramón Crucito Arias Pérez, Jorge Valentín Ray Ramírez, Yordanis Nuviola Pérez

Jorge Dimitrov Center for Agricultural Research, Experimental Station of Pastures and Forages, Bayamo, Cuba

ABSTRACT

The study took place at the Experimental Station of Pastures and Forages to evaluate the effect of the cut frequency (45 and 60 days) on forage yields of *Moringa oleifera* ecotypes Nicaragua and Criolla, with irrigation and organic fertilization, on fluvisol, in the Cauto Valley. A randomized block design with 2x2 factorial design and four replicas was used. The plants were cut 10 cm high from the ground, and variables plant height, shoot amount and thickness, number of leaves, leaf/stem ratio, total dry matter (DM) yields, and dry leaves and stems, were determined. Except for the number of shoots, all the variables were significant for the cutting frequency ($P < 0.001$). The number of leaves was the only variable with a difference for the ecotype factor ($P < 0.05$). The highest yields in total dry matter were achieved at 60 days (3.8 t.ha-1). However, the experiment only lasted 180 days with gradual reduction in production, caused by the competition between *M. oleifera* and invading graminaceae. The study concluded that the cutting frequency of 60 days produced increased yields of DM. However, the cutting height favored the presence of invading plants, with decreasing yields and sustainability of forage production.

Keywords:*Biomass production, tree-like, Moringa oleifera*

INTRODUCTION

The Cuban eastern region has the most degraded and fragile ecosystems in the country. Most of the soils are saline or eroded, in addition to poor precipitation values in the dry season (Benítez *et al*., 2010). These conditions lead to very low persistence, and poor yields and quality of the main feeding sources of livestock raising systems. It required the introduction of other species (mainly arboreal species) that can enhance animal nutrition. Among the benefits these species bring to livestock are forage production, hedges, shadow, etc. One of the most promising arboreal plants is *Moringa oleifera*, with proven high nutrition values (Garavito, 2008), drought endurance, and acceptable yields (Foidl, Mayorga and Vásquez, 1999).

The aim of this paper was to evaluate the ecotype effect and cut frequency in terms of forage yields, with irrigation and organic fertilization.

MATERIALS AND METHODS

Location, climate, and soil

The experiment was made at the Jorge Dimitrov Station of Pastures and Forages, Center for Agricultural Research, 10 ½ km from the city of Bayamo, Granma, Cuba, on fluvisol in the Cauto River Valley. According to Hernández (1996), the soil is flat, made of soft clay, and good draining conditions; fertility is medium. Annual precipitation is between 800 and 1 200 mm, the mean temperature 26 ºC, and relative humidity is 77% (Rosell *et al*., 2003).

Treatment, design and statistical analysis

The Kolmogorov-Smirnov test was made to check data normality. Variance analyses were made, based on factorial arrangement on a randomized block design with four replicas, which considered the ecotype effects, cut frequency, and their interaction. The height, mean shoot thickness, and yield data were transformed according to log (x) and the number of shoots ($\sqrt{x}$). Statistica 98.0, for Windows, was used for statistical analysis.

Experimental procedure

Irrigation was applied at a rate of 50 mm every 21 days, plus 20 t of organic matter per hectare. Cutting was made 10 cm high from the soil.

Observation of plant growth dynamics took place after the establishment cut, made on January 10^{th}, and it was continued depending on the cutting cycle. Measurements included plant height, re-shoot number and thickness, number of leaves per shoots, whole plant weight, young stem weight, and leaf weight. After the harvest, samples were taken from three plants, and dried in stove at 60 ºC, for 72 h. Then, total DM, and leaf and stem DM were determined according to the dry weights.

ISSN 2224-7920

The experimental units were divided into 9 x 7 m lots with sample units in the mid rows, after the edge effects (the end rows on both sides of the lots), and the plants within the initial 50 cm of the rows were excluded. The rows were 0.5 m, and the plants were 0.25 m apart. The lots were 2 m apart from one other.

The experiment lasted six months, from January to July 2012.

RESULTS AND DISCUSSION

The number of leaves per shoot was significant ($P < 0.05$) for the ecotype factor, Criolla stood out with 10 leaves per plant, in comparison to Nicaragua (9). The standard error of the means evaluated was ± 0.034. The cut age factor showed significant effects for the morphological and yield variables (Table 1.).

The Criolla ecotype had the highest number of leaves, which may be caused by the existing genotypic differences, even among individuals of the same species. It had a preponderant importance, considering that when dried, this tissue contains up to 30% GW, high contents of micro and macro nutrients, minerals, abundant and balanced levels of essential aminoacids (Folkard and Sutherland, 1996). These chemical properties confer high nutritional value to the ecotype in the dry season in Cuba, between November and April.

The variables plant height, mean shoot thickness, and leaves per shoot had the highest values at the 60-day cut, which coincided with the physiological behavior of plants.

However, the values achieved for plant height and shoot thickness were inferior to the values achieved by Alfaro and Martínez (2008), when these variables were evaluated in different Guatemalan ecosystems, using *M.oleifera* ecotypes. The authors noted that the ecosystem effect, planting distance, and planting method, were variables that effected on the variability of the results achieved by Cordoví *et al.* (2013) when they evaluated the height of several arboreal plants in winter and summer, in the south of Mozambique, also above the values for this study. The behavior shown in table 1 for plant height owed to the individual phenotypical responses of the ecotypes, which influenced on physiological development.

The varying number of leaves per shoots had the expected results due to the differences induced by the cut age. As age increased, the plant continued to develop, and the structural differences and agronomic responses increased; hence, the leaf/stem ratio was favored by the 45-day cut. In that sense, Herrera (2004) noted that when the harvest age increased, the leaf/stem ratio dropped.

Regardless of the leaf/stem ratio behavior, the highest yields of total dry matter, leaves, and stems were significantly higher at the 60-day cut, because there was more structural and morphological development in the plant. When passing through this dynamic process, the plants elevated their production, provided there were not external limiting factors. Accordingly, DM production per area was higher, as photosynthesis was more efficient due to larger and heavier leaves (Herrera *et al.*, 2013).

The results for total DM were better than the ones achieved by Palmero (2012), Loyola *et al.* (2013), and Loyola *et al.* (2014), under edaphoclimatic conditions in the municipality of Santa Cruz, province of Camaguey.However, these results were not as good as the ones achieved by Cordoví *et al.* (2013), in the south of Mozambique, particularly due to the edaphoclimatic differences observed during the studies.

Although the stem yields of t.DM.ha-1 was significantly higher than for the 60 days compared to the 45 days, this study recommends the 60-day procedure. This behavior does not compromise the crop´s nutritional quality or its prevalence (Table 1). The yields were also higher in the leaves at 60 days, due to an increase in size and specific weight. Regardless of the rise in the plant fiber as age increased, this behavior did not affect arboreal plants as much as graminaceae; hence, it was not highly considered for this species (Pérez Infante, 2013).

Taking into account that DM yields and its evolution established a variable that comprised agronomic, productive and structural studies of arboreal and non-arboreal plants, their behavior was chronologically studied. At different cut ages and with respective cutting numbers, the behavior observed varied (Fig. 1).

This study only lasted 180 days because the invasion of crawling graminaceae hampered the continuity of the experiments and the persistence of certain plants.

However, the highest yields were observed in the February-April period, at the end of the dry season, and beginning of the rainy season. During the period, the 60-day cut produced 5.8 tDM.ha-1, which doubled the 2.7 tDM.ha-1 achieved for the 45 days. The rainy season began approximately 90 days following the beginning of the experiment, which made possible the invasion of undesirable plants, especially invading graminaceae. Thus, *M. oleifera´*s capacity of response and competition was reduced thanks to the differences observed in the growing and development habits, which hindered the plant´s forage production.

Despite rehabilitation, the losses and the damage underwent by the plants that survived were inevitable, though the statistics were not collected in this study. Reyes (2004) and Pérez *et al.* (2010) noted that when high planting densities are implemented, there is competition among the plants over nutrients, water, light, and vital space, causing the loss of plantlets, which may be between 20-30% per cut, with effects on biomass production. In that sense, Padilla *et al*. (2014), in the west of Cuba, used planting densities of 200 000 plants/hectare, and evaluated the cut height (10, 20, and 30 cm), in structure and DM yields for the species. They concluded that even for the 30 cm high cut, the arvense invasion continued to spread, and the yields were not significantly favored by any of the treatments evaluated, so the planting density was found to be the main cause of poor DM production in relation to the cut height.

Nevertheless, Padilla *et al.* (2014) stated that the highest cut, number of leaves, and plant weight, were achieved in the plants cut 20 cm high from the soil, suggesting that the cut height favored the structure of the plant. It must be considered in further agronomical studies of the species in the Cauto Valley. Moreover, these studies must last longer, and also include the effect of genotype interaction with the cut height and frequencies on the variables that define the plant yields and persistence.

Furthermore, Pérez *et al*. (2010) described that the shoots had a biomass renovating role. In this study, the variable was not significant under any effects or in interaction, and it could be related to the invasion of crawling graminaceae. The number of re-shoots obtained was 1.7 per plant, with a 0.4 variation coefficient.

Ybalmea *et al.* (2000) reported a similar behavior. They embraced the criteria of Araya and Benavides (1994), and attributed this effect to the dominance of more developed shoots, with higher nutrient requirements, combined with the effect of shade on smaller shoots, causing their death, and affecting the number of shoots in the plants.

CONCLUSIONS

The ecotypes studied did not have significant differences in the variables evaluated, except for the cut frequency, which was significantly higher for the 60-day cut. With the start of the rainy season, plant handling stimulated the presence of invading plants and the reduction of *M. oleifera* competition, with a consequent drop in yields.

RECOMMENDATIONS

It is important to change plant cut management, in order to keep high levels of biomass production, as observed during the first cuts.

REFERENCES

ALFARO, C. N., MARTÍNEZ, W. W. (2008). *Uso potencial de la Moringa (Moringa oleifera Lam) para la producción de alimentos nutricionalmente mejorados*. Guatemala: Ed. SERVIPRENSA.

ARAYA, J. y BENAVIDES, J. (1994). Efecto de la procedencia, posición de la rama y tipo de siembra en el establecimiento de Sauce amarillo (*Sambucus canadiensis*) en Puriscal, Costa Rica. EnJ. E. Benavides (Ed) *Árboles y arbustos Forrajeros de América Central*. Costa Rica: Editorial CATIE.

CORDOVÍ, E.; RAY, J. V.; TAMELE, O.;NHANTUMBO, S y CHIMBALAMBALA, A. (2013). Caracterización de especies arbóreas y arbustivas forrajeras en clima semiárido del sur de Mozambique. Rev *Pastos y Forrajes*,*36* (4), 434-439.

BENÍTEZ, D. G.;CATASÚS, L. J.;GÓMEZ, I.;ARIAS, R. C.;FAJARDO, R.;RAMÍREZ, A.;PÉREZ, B. E.;NUVIOLA, Y. y FONSECA, E. (2010). *Cultivares de pastos y forrajes tolerantes a los entornos adversos y degradados de la región oriental cubana*. Cuba: Grupo de Investigaciones de la Estación Experimental de Pastos y Forrajes "La Pitucha".

FOLKARD, G y SUTHERLAND. J. (1996). *Moringa oleifera* un árbol con enormes potencialidades. *Agroforestry Today*,*8* (3), 23-26.

FOIDL, N., MAYORGA, L y VÁSQUEZ, W. (1999). *Utilización de marango (M. oleifera) como forraje fresco para ganado*. Conferencia de la FAO sobre Agroforestería para la producción animal en Latinoamérica, Proyecto Biomasa, Managua, Nicaragua.

GARAVITO, U. (2008). *Moringa oleifera, alimento ecológico para ganado vacuno, porcino, equino, aves y peces, para alimentación humana, también* *para producción de etanol y biodiesel*. Retrieved on March 18, 2015, fromhttp://www.moringa.es.

HERNÁNDEZ, M. (1996). *Los suelos ganaderos de Cuba*. Matanzas, Cuba: EEPF Indio Hatuey.

HERRERA, R. S. (2004).*Fotosíntesis. Pastos Tropicales, contribución a la fisiología, establecimiento, rendimiento de biomasa, producción de biomasa, producción de semillas y reciclaje de nutrientes*. La Habana, Cuba:Ed. EDICA, ICA.

HERRERA, R.; GARCÍA, M.; FORTES, D.;CRUZ, M. A y ROMERO, A. (2013). Influencia de la distancia de muestreo en los indicadores agronómicos de Pennisetum purpureum vc. CT-115. *Rev. Cubana de Cienc. Agríc.*,*47* (2), 189-193.

LOYOLA, O.; TRIANA, D.;CURBELO, L. y GUEVARA, R. (2013). *Producción de follaje y composición bromatológica de cercas vivas sobre sabanas ultramáficas de Camagüey*. V Conferencia Internacional Ciencia y Tecnología por un Desarrollo Sostenible, Camagüey, Cuba.

LOYOLA, O.; PÉREZ, I.; TRIANA, D.; VALIDO, A.;YERÓ, I. (2014). Evaluación agroproductiva de *Moringa oleifera* Lam en cercas vivas en condiciones edafoclimáticas. *Prod.* ,*26*(2), 23-25.

PADILLA, C.; FRAGA, N.; SCULL, I.;TUERO, R y SARDUY L. (2014). Efecto de la altura de corte en indicadores de la producción de forraje de *Moringa oleifera* vc. Plain. *Rev. Cubana de Cienc. Agríc.*,*48* (4), 405-409.

PALMERO, G. (2012). *Evaluación agroproductiva de Moringa oleifera Lam en cercas vivas en condiciones edafoclimáticas del municipio Santa Cruz del Sur*.Tesis de doctorado. Universidad de Camagüey, Cuba.

PÉREZ, A.;SÁNCHEZ, N.;AMERANGAL, N. yREYES, F. (2010). Características y potencialidades de *Moringa oleifera* Lamark. Una alternativa para la alimentación animal. *Rev. Pastos y Forrajes*, *33* (4), 1-16.

PÉREZ-INFANTE, F. (2013). *Ganadería Eficiente. Bases Fundamentales*. La Habana, Cuba: Ed. Asociación Cubana de Producción Animal.

REYES, A. (2004). *Marango. Cultivo y utilización en la alimentación animal*. Managua, Nicaragua: Universidad Nacional Agraria, Dirección de Investigación, Extensión y Postgrado.

ROSELL, P. A.;LEMES, B.; JIMÉNEZ, A.;PEÑA. S. y MILÁN, C. (2003). *Diagnóstico Urbano-Ambiental. Ciudad de Bayamo*. Bayamo, Granma, Cuba: Ed. OPPM.

YBALMEA, R.;SÁNCHEZ, R.;FEBLES, G.y MORA, ENEIDA (2000). Plantación horizontal de la semilla asexual del piñón florido (*Gliricidia sepium*). *Rev. Cubana Cienc. Agríc.*, *34* (1), 73.

.

Received: 7-12-2017
Accepted: 7-20-2017

Table1. Mean of variables for the cut frequency variable

Variables	Cut frequency (days)			
	45	60	±SE	Sig.
Height (cm)	4.4 (83.6)	4.8 (119.9)	1.60	***
Mean shoot thickness (cm)	0.6 (0.8)	0.7 (1.1)	0.17	***
Leaves per shoot	9	10	0.03	***
Leaf/stem ratio	1.4 (2.3)	1.1 (1.1)	0.15	***
Total DM yieldst.*ha*$^{-1}$	1.3 (1.9)	1.7 (3.8)	0.50	***
Leaf DM yieldst.*ha*$^{-1}$	1.1 (1.2)	1.3 (1.9)	0.50	SN

Stem DM yields $t.ha^{-1}$	1.0 (0.7)	1.3 (1.8)	0.50	SN

The data in parentheses correspond to original values
$P < 0.001$***

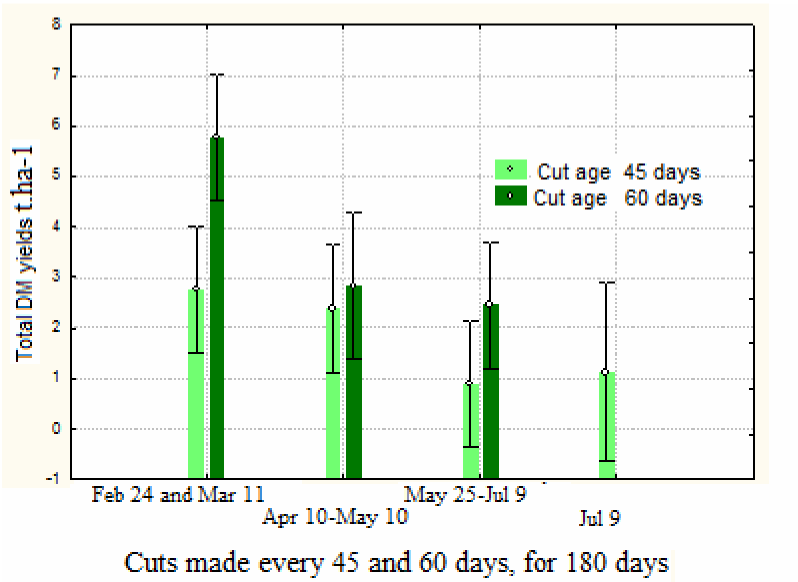

Fig. 1. Evolution of total DM production of 180-day cuts