Effect of cut height on indicators of forage production of *Moringa oleifera* cv. Plain

C. Padilla, Nidia Fraga, IdaniaScull, R.Tuero and Lucía Sarduy
Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, Mayabeque, Cuba
Email: cpadilla@ica.co.cu

In a random block design with four replications, effect of cut height (10,20,and 30 cm) in the biomass production and yield components of *Moringa oleifera* cv. Plain in the indicators plant height, stem and leaf thickness, dry matter yield (DM) and population was studied during four consecutive cuts. The plant height showed irregular performance during the experiment, while the treatments did not affected the stem thickness (7.3-14.1mm) neither the leaf (0.2-0.5mm).The number of primary/ branches plant was higher (8) when was cut at 20-30cm, in the second and third cut .While the number of secondary branches was higher (P<0.001) when was cut at 20 and 30 cm high in the fourth cut. In the first cut, the DM yield was lower (P<0.05) when the plants were cut at 30cm high, without significantly differ among treatments in the remainder cuts. Plants population was no affected by treatments, but showed decrease in time. In the rainy period, the lowest content of phosphorous (P<0.01) was found when was harvested at 30cm high, while the ADF was lower (P< 0.01) when was harvested at 30 cm in the dry period. The remainder bromatological indicators studied were similar for all treatments, in both seasons of the year. The results indicated that the best cut height for this plant should be between 20-30 cm.Further studies are suggested where cut heights and cut frequency were combined to optimize the forage production.

Key words: *Moringa oleifera, cut height, indicators*

Moringa oleifera is originate of the south of Himalaya, northeast of Indian, Pakistan, Bangladesh, Saudi Arabia and Afghanistan and it has been naturalized in most of the tropical countries. In Centroamerica, was introduced and naturalized in 1920 as ornamental tree, and used as live fences and curtains breaks. Romans, Greeks and Egyptians extracted edible oil of their seeds and used it for perfume and lotions. In XIX century, Caribbean countries exported the extracted oil of this plant to Europe for perfume and lubricants (Carballo 2011 and Foidl *et al.*2011).

The importance of the use of this plant as fodder is due to its good nutritionals characteristics and a high yield in production of fresh biomass (Reyes 2006 and Pérez *et al.* 2010). Few studies about the height this plant should be harvested to get good yields and biomass quality are available. In Foidl *et al.* (2011) studies refers that the moringa have high speed and regrowth capacity, and the first cut should carry out to five or six months after sowing. Further cuts are suggested to be done with a sharp machete, every 45 days, in the rainy season, and every 60 days in the dry season, at 20 cm high from the soil. Nevertheless, Santiesteban *et al.* (2012), in studies carry out in Cuba, in alluvial soil of Valle del Cauto, when analyzed cut height (10, 20, 30 and 40cm) and cut frequency (45 and 60 days) in the biomass production for animal intake, found a tendency to values increase regarding to height and frequency cut increase .In this case, the highest values to cut height at 40 cm and cut frequency at 60 days were informed. When high population densities are used, tendency to harvest between 10 and 30 cm high exits (Reyes 2004 and Pérez *et al.* 2010).Nevertheless, the technicians and producers practice experience in Cuba showed that when low densities of sowing are used is recommended to harvest at highest heights to cause thick stems, with higher number of more vigorous regrowth. It is producers and Cuba executives interest, as well as of other tropical regions, to provide the use of *Moringa oleifera* as animal food and human supplement. Nonetheless, a few experience regard to agronomic studies of this plant and it potentials for the forages production exists. The objective of this study was to evaluate the effect of three cut height in the production and biomass quality in the moringa yield components.

Materials and Methods

A random block design with four replications was applied .The treatments consisted on evaluating the effect of cut height (10, 20 and 30 cm) in yield components, biomass production and quality of moringa.

The research was carried out in the "Estación Experimental of Pastos and Forrages Miguel Sistach Naya", of the Institute of Animal Science (ICA), San Jose de las Lajas, Mayabeque, Cuba at 23º 55N, 82W, and 92 meters over sea level. For more information of the climatic data of the experimental area, Álvares *et al.* (2012) carried out a detailed analysis of the precipitations performance in ICA, during the 1970-2009 period, as base for the strategic grass management.

The soil of the experimental area is red ferrallitic, according Hernandez *et al.* (1999) classification. Table 1 shows the conditions of the soil fertility at the beginning of the screening.

Table 2 shows the accumulation of precipitations and the monthly average minimum and maximum

Table 1. Fertility of the soil at the start of the experimental period

Ca	Mg	P (ppm)	OM	pH	Nt
8.61	0.48	38.48	3.48	7.60	0.17

Table 2.Climatic data of the area during the experimental period

Indicators	Year 2011		Year 2012							
	November	December	January	February	March	April	May	June	July	August
Precipitations, mm	4.0	35.5	30.3	6.8	104.2	95.3	178	321.9	178.0	286.8
Days with rain, 1	1.0	3.0	2.0	1.0	4.0	3.0	6.0	5.0	4.0	11.0
Maximum temperature	25.8	26.0	24.3	26.0	29.2	27.3	30.9	27.9	27.3	31.9
Minimum temperature	13.7	9.2	8.0	19.4	20.2	20.0	21.1	22.5	20.7	20.6
Average temperature	19.6	17.4	18.7	22.1	25.2	25.0	25.0	25.3	25.8	24.8

temperatures, during the experimental period. This data were taken from the Meteorological Station of ICA.

The sowing was carry out in November, 2011 in a typical red ferrallitic soil, after carrying out the conventional method, plowing and crossing with alternating harrows. In the last harrowing 20 t/ha of bovine manure were added to the soil, and 10 t/ha were applied after the second cut. Irrigation was applied (200 m^3/ha) every three days during the first month after the sowing and every nine days (300 m^3/ha) during the dry season. Four manual cleaning with a hoe were carried out during the dry season. The cuts in the dry period were carried out every 60 days, and every 45 days in the rainy period. The number of primary and secondary branches per plant, height, thickness of the stem and leaf, DM yield and population were measured.

The number of secondary branches per plant, leaves/plants and thickness of the stem and leaf were measured in ten plants per plots. Population and yield were determined in tall the plots. Bromatological analysis in a cut in the rainy period and in the dry period was carried out. A tractor of 60H, Belarus 510 was used, having a plow ADIS3 and a mean harrow of 600 kg was used.The plowing was carried out with a cultivator of animal traction, in which the palettes were adjusted at 33 cm distance and 5 cm depth. The sowing distance was of 33 x 15 cm, for a prospective population of 20 plants/m^2 (200 000 plants/h.

The statistical package INFOSTAT for data analysis was used, version 2001, (Balzarini *et al.* 2001). The theoretical suppositions of the analysis of variance for the variables were verified by the test of Shapiro and Wilf (1965) for the normality of errors and the variance homogeneity by the test of Levene(1960). The variables did not fulfilled with the theoretical suppositions of the ANAVA, so for count variables the transformations $\sqrt{x}$ were used and arcoseno$\sqrt{x}$ for the variables expressed by percent. Nevertheless, these ones did not improve the fulfilled of these suppositions and non parametric variance analysis in random blocks of Friedman was carried out, and the Conover (1999) test for means comparison was applied.

Results and Discussion

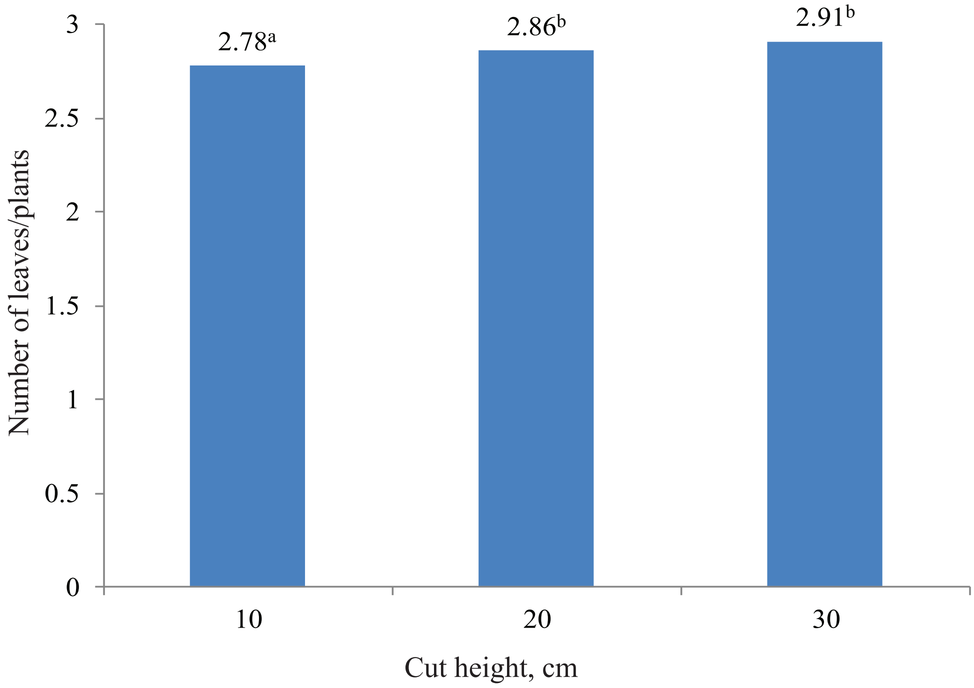
The plant height showed an irregular performance during the screening, while the treatments did not affected the stem thickness (7.3-14.1mm) neither the leaf (0.2-0.5mm).The number of leaves/plant was higher when was cut at 20-30 cm (figure1). In the second and third cut, this measure was not affected by the applied treatments and the values varied between 7.50 and 10.18 leaves/plant.

The plants population (table 3) was higher ($P<0.05$) with cut height at 20 cm, except in the third cut, in which the treatments did not differ among them. When this indicator was analyzed in time (table 4), the lower population in the third and four cut ($P<0.05$) were obtained .The decrease of population in the time was due to the attack of Atta (*Atta insularis*) leaf- cutting ants and fungal, meanly *Fusarium sp*. The arvenses invasion and the damage caused by the cuts done also influenced in this performance. Reyes (2004) and Pérez (2010) showed that when high densities of sowing are used, create competition among plants for nutrients, water, light and vital space, this causes plantlets looses, that can varied from 20 to 30 % per cut and influence in the biomass production.

The number of secondary branches was higher ($P<0.001$) when was cut at 20 and 30 cm high in the fourth cut (table 5)

In the first cut, yield (2.11 t of DM/ha) was lower ($P<0.05$) when plants were cut at 30 cm high. In the remainder cuts, the yield was similar in all treatments.

When the DM average yield in the time was analyzed, is concluded that this one was not affected by the cut height (2.77-2.96 t/ha DM). This indicator was similar in the different cuts and ranged between 2.55-3.10t DM/ha. Reyes (2006) showed that there was not coincidence in the researches, regarding to the



abValues with different letters (P<0.05) (Duncan 1955)
( ) original data

Figure 1. Effect of cut height in the number of leaves/plants (third cut)

Table3. Effect of cut height in the population (plants/m^2)

High, cm	Cut 1	Cut 2	Cut 3	Cut 4
10	2.23^{ab} (4.9)	2.15^{a} (4.6)	2.15 (4.6)	2.15^{a} (4.6)
20	2.41^{b} (5.8)	2.34^{b} (5.6)	2.10 (4.4)	2.34^{b} (5.0)
30	2.12^{a} (4.5)	2.08^{a} (4.3)	2.05 (4.2)	2.05^{a} (4.2)
SE±	0.05*	0.04**	0.04	0.05**

abValues with different letters (P<0.05) (Duncan 1955)
( ) original data

Table 4. The moringa population's variance in the time

Measure	Numberof carried out cuts (means ranges				
	1	2	3	4	Sig.
Plants/m2	0.252^{a} (5.08) DE=0.732	0.723^{ab} (4.79) DE=0.702	0.999^{b} (4.50) DE=0.321	1.100^{b} (4.76) DE=0.736	P<0.05

abValues with different letters (P<0.05) (Duncan 1955)
( ) original data

Table 5. Effect of cut height in the number secondary/plant branches

High, cm	Cut 1	Cut 2	Cut 3	Cut 4
10	-	1.09 (1.2)	1.56 (2.45)	1.19^{a} (1.43)
20	-	1.02 (1.05)	1.60 (2.60)	1.48^{b} (2.19)
30	-	1.01 (1.02)	1.61 (2.75)	1.40^{b} (1.96)
SE±	-	0.03	0.02	0.02**

abValues with different letters (P<0.05) (Duncan 1955)
( ) original data

Table 6. Effect of cut height on the chemical composition (%) of *Moringa oleifera.*

Cut height, cm	Ash	NDF	Ca	ADF	P	Lignin	Mg	Cellulose	CP	CF
Rainy season										
10	10.35	60.8	1.12	45.89	0.39[b]	11.63	0.50	34.03	17.42	44.32
20	8.89	56.44	1.14	44.47	0.41[b]	11.01	0.53	32.59	19.16	41.67
30	8.86	58.76	1.22	44.95	0.35[a]	11.87	0.49	32.96	16.8	44.11
SE±	0.64	2.69	0.04	1.39	0.001**	0.38	0.03	1.31	1.44	2.29
Dry season										
10	11.70	55.3	1.42	38.48[b]	0.44	9.71	0.72	28.71	20.85	34.9
20	11.88	52.19	1.44	38.68[b]	0.45	10.14	0.83	27.62	22.57	32.93
30	12.21	52.95	1.57	32.21[a]	0.41	9.76	0.87	22.67	21.29	30.22
SE±	0.42	1.6	0.06	1.00**	0.01	0.55	0.02	0.79	0.82	1.15

[ab]Values with different letters in column differ at P<0.05 (Duncan 1955)
**P<0.01

response of this plant to the biomass production, when is undergoes to different cut frequencies. This author, in studies carried out in 2004 recommended cuts at 20 cm high. López *et al.* (2012), when evaluating cut height at 5, 10 and 20 cm found that at 5 cm, only 33 % of plants survived, while at 10 and 20 cm, the 100 % was achieved.

The higher height (76cm), number of branches (33) and plants weight (245g) was achieved in the plants cuted at 20 cm high.

The fact that in this experiment the yield was stable in the four cuts indicates stability in the production of moringa biomass. The forage production was not limited in the populations that subsisted in the treatments, and this one coincided with the mean ranges found for this plant. The yields obtained in the different cuts, between 2.25-3.10 t/ha of DM, were above the values found by Garavito (2008).They were similar to the ones indicated by Reyes (2004) in Nicaragua, who applied cut frequencies at 45 and 60 days for the rainy and dry period, respectively. Similar yields informed Pérez *et al*. (2010) for this plant.

In the rainy period, the lower content of phosphorous (P<0.01) was found when was harvested at 30 cm high (table 6), while the ADF was lower (P<0.01) when was harvested at 30 cm in the dry period. The remainder indicators were similar in all treatments, in both seasons of the year.

Foidl *et al.* (2011) found similar values to those of this experiment, regarding to the content of CP, ADF and NDF of this plant, when was harvested at 45 days of age. These authors besides showed, that the moringa have high content of protein in its leaves, branches and stems.

In studies carried out in Venezuela by Garcia *et al.* (2006) and Garcia *et al.* (2008), was evaluated the bromatological composition of moringa and were informed higher contents of Ca, P and Mg that those found in this present experiment, while the contents of PB and ashes were similar. Studies carried out by Castillo *et al.* (2013) in Yucatán, Mexico, found little influence of the cut height in the chemical composition of leaves and stemsof moringa.

In general terms, the results indicated that the cut height does not affected the forage yield, but the higher cut height favored the population enhancement, leaves/plants and secondary branches/plant, in the third and four cut fundamentally. This can be an indicator to cut the moringa to this height, while no other studies are carried out at a long term, in which heights and cut frequencies were combined for optimizing forage production.

It is concluded that the best cut height to this plant should be between 20-30 cm.It is recommended to continue this research.

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