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RESEARCH NOTE

Effects of different poultry manure fertilization levels and cutting times on *Moringa oleifera* production

Mouchili Mouchili[1], Fernand Tendonkeng[1], Emile Miégoué[1], David Fokom Wauffo[1], Hippolyte Mekuiko Watsop[1], Etienne Pamo Tedonkeng[1], and Einar Vargas-Bello-Pérez[2]

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Abstract

M. Mouchili, F. Tendonkeng, E. Miégoué, D. Fokom Wauffo, H. Mekuiko Watsop, P.E. Tedonkeng, and E. Vargas-Bello-Pérez. 2019. Effects of different poultry manure fertilization levels and cutting times on *Moringa oleifera* production. Cien. Inv. Agr. 46(3): 310-318. The effects of different poultry manure fertilization levels and cutting times on the growth of *Moringa oleifera* were evaluated. A factorial design comparing six levels of poultry manure (0, 50, 100, 150, 200 and 250 kg N ha^{-1}) and three cutting times (4, 6 and 8 months) with four replicates was used. One month after sowing, fertilization was performed. At each cutting time, 20 plants were collected per treatment for height and diameter measurements. Stem, leaf and whole plant biomass values were assessed for each plot based on the rate of fertilization with poultry manure and the cutting time. The results showed that irrespective of the cutting time, the largest plant height and diameter were obtained with 200 kg N ha^{-1} (160.37 ± 6.33 cm and 2.37 ± 0.33 cm, respectively). The biomass of stems, leaves and whole plants increased with the level of N fertilization. The highest biomass was obtained with cutting at 6 months and a fertilization rate of 200 kg N ha^{-1} (1.51 ± 0.01, 0.90 ± 0.01 and 2.41 ± 0.05 t MS/ha, respectively, for leaves, stems and whole plants). In conclusion, the application of poultry manure at a rate of 200 kg N ha^{-1} at the vegetative growth stage is optimal for *Moringa oleifera* production.

Key words: Cutting times, fertilization, *Moringa oleifera*, plant biomass.

Introduction

Moringa (*Moringa oleifera*) is a promising food source for animals and humans in the tropics because moringa trees are fully leafed out at the end of the dry season when other foods are typically scarce (Aiyelaagbe, 2011). *Moringa oleifera* can be used as a feed supplement in cattle (Foidl *et al.,* 2001; Fuglie, 2001a), rabbits (Nuhu, 2010) and guinea pigs (Pamo *et al.,* 2005). This plant is an important source of protein (9–35% of dry matter), fat (2–10% of dry matter), fiber (9–28% of dry matter) and starch (Makkar and Becker,

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1997; Foidl *et al.,* 2001). It also contains minerals (0.6–11% dry matter), alkaloids, antibiotics, vitamins A, B, C and E as well as cytokinin phytohormones capable of activating plant growth (Fuglie, 2001b). *M. oleifera* seeds have the ability to purify water, honey and milk (Benkaddour, 2016). In addition, the plant contains almost no toxins and is very drought-resistant (Foidl *et al.,* 2001).

This plant does not grow well in clay soils and at high altitudes, such as soils in Western Cameroon. The intensification of production of this crop involves the use of chemical fertilizers (i.e., nitrates and urea) and organic fertilizers (poultry manure, rabbit manure, cattle manure) (Pamo *et al.,* 2002; Adegun and Ayodele, 2015). However, the use of chemical fertilizers can also be a source of pollution to the environment and considerably increases the production costs of fodder. Faced with this situation, forage producers are increasingly shifting to alternative fertilizer sources that preserve the environment and improve the nutritional quality of the forage (Berkić *et al.,* 2004), such as the use of manure and compost, which from this perspective, provide undeniable assets to different forage crops (Mboko *et al.,* 2013). Previous studies have shown that organic fertilization (125 g plant^{-1} and 10 t ha^{-1}, respectively) can improve the height and biomass of *M. oleifera* (Pamo *et al.,* 2002; Uchena *et al.,* 2015). However, few studies have been conducted on the use of poultry manure at different rates in *M. oleifera* production. We hypothesized that poultry manure at different rates would influence the growth of *M. oleifera*. Therefore, this study was carried out with the aim of improving the production of *M. oleifera* through adequate fertilization and the determination of the ideal cutting time.

Materials and methods

Experimental site

The study was conducted in Dschang in West Cameroon, which located at approximately 1420 m in altitude (5°26'77 "N, 10°26'29"E). The climate is equatorial and has two seasons with a total annual rainfall of 1800–2000 mm. The average annual temperature is 20 °C, with an annual total of 1,200 hours of sunshine. The soil of the study site had a clay soil texture with 62% sand, 10% silt and 28% clay. The soil pH was 4.8, and the C/N ratio is 22. During the trial period (May 2017 to February 2018), rainfall data were collected daily at 0800 h am at the experimental site. The highest (431.6 mm) precipitation was reported in August 2017 (Figure 1).

An analysis of the chemical and textural composition of the soil was performed before the preparation of the soil. Samples were taken from the 0 to 20 cm of soil layer. The chemical analysis of the soil (Table 1) was carried out at the Laboratory

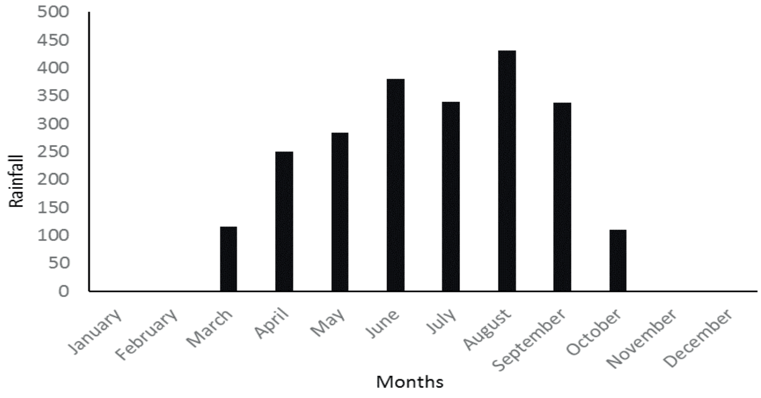

Figure 1: Rainfall (mm) in Dschang, West Cameroon

of Soil Analysis and Environmental Chemistry (LABSAEC) of the University of Dschang following the method described by Pauwels *et al.* (1992).

Table 1. Physico-chemical characteristics of the soil.

Parameters	Values
Depth	0-20 cm
Texture (%)	
Sand	62
Total silt	10
Clay	28
Textural class	L
Ground reaction	
Water-pH	4.8
KCL-pH	4.0
Organic matter	
Cobalt (%)	6.60
Molybdenum (%)	11.35
Total N (g kg^{-1})	2.70
C/N	22
Exchangeable cations (meq 100 g^{-1})	
Calcium	11
Magnesium	3
Potassium	0.70
Sodium	0.08
Sum of bases (SB)	14.78
Cation exchange capacity	
CEC at pH 7	46
Saturation in bases (%)	32
Assimilated phosphorus	
Phosphorus Bray II	21

Description, origin and chemical composition of the fertilizer source

The poultry manure used as a source of N was obtained from a commercial laying hen (birds were eight months of age) farm located in Dschang, Cameroon. The chemical composition of the poultry manure showed that it contained organic matter (5.3 g kg^{-1}), nitrogen (2.4 g kg^{-1}), carbon (3.1 g kg^{-1}), potassium (3382 ppm), sodium (617 ppm) and phosphorus (911 ppm). The plot used for the experiment was plowed manually with a hoe, and 3-m^2 plots spaced 0.5 m apart from each other were made. Then, 25% of simple superphosphate (100 kg ha^{-1}) was applied to all the experimental plots as the basic fertilizer. Seeds from a sweet variety of *M. oleifera* were used. On the eve of sowing, the viable (leathery) seeds were sorted and soaked in cold water. The next day, these seeds were sown at approximately 2 cm deep and at a density of 30 × 30 cm. One month after sowing, 6 levels of N (0, 50, 100, 150, 200 and 250 kg N ha^{-1}) were applied in a completely randomized block design to 72 plots (1.5 × 2 m; 12 per level of N). The quantities of poultry manure corresponding to the N levels applied are shown in Table 2. These quantities were determined by the N contents of the manure obtained after analysis. The experimental site was weeded and cleaned every week. A factorial design comparing six levels of poultry manure corresponding to six levels of N (0, 50, 100, 150, 200 and 250 kg N ha^{-1}) and three cutting times (4, 6 and 8 months) on 3-m² plots with three repetitions in each treatment was used. A total of 72 experimental plots were made.

Table 2. Quantities of poultry manure corresponding to the N fertilizer levels applied to *Moringa oleifera*

Fertilization level (kg N ha^{-1})	Total quantity of applied fertilizer (kg ha^{-1})	Quantity supplied (kg N ha^{-1})
1	0	0
2	2083	50
3	4166	100
4	6250	150
5	8333	200
6	10416	250

Experimental design, data collection and statistical analysis

At 4, 6 and 8 months after fertilization, the biomasses of the leaves, stems and whole plants of *M. oleifera* were evaluated. The height and radial growth were evaluated at the same time. Using a measuring tape, the heights of 20 plants per treatment and their regrowth were evaluated every month. On the same plants, the diameter was taken using a Vernier caliper. After harvest, 20 plants were randomly selected, and the leaves and stems were separated and weighed for determination of leaf and stem biomass. A 500 g sample of leaves and stems was taken and dried at room temperature to constant weight for the determination of dry matter (yield per t DM ha^{-1}).

M. oleifera production data were subjected to two-factor analysis of variance (ANOVA) (poultry manure levels and cutting times) following the General Linear Model (GLM) with SPSS 20.0 statistical software. When there were significant differences between treatments, Duncan's test was used to separate the means. Statistical significance was declared at ($P < 0.05$).

Results

Growth height of Moringa oleifera

Four months after sowing, the plant heights of the plots fertilized with 200 and 250 kg N ha^{-1} of manure were comparable ($P > 0.05$) but significantly higher ($P < 0.05$) than those of the plots fertilized with 150, 100, 50 and 0 kg N ha^{-1}, respectively (Table 3). During this period, the plant heights of the plots fertilized with 150, 100, 50 and 0 kg N ha^{-1} were comparable ($P > 0.05$). At 6 and 8 months, the plant height of the plots fertilized with 200 and 250 kg N ha^{-1} of manure were comparable ($P > 0.05$) but significantly higher ($P < 0.05$) than those of other fertilization levels. Regardless of the fertilization levels, the plant heights obtained at 8 months were significantly higher ($P < 0.05$) than those obtained at 4 and 6 months.

Four months after sowing, the plant diameters of the plots fertilized with 200 and 250 kg N ha^{-1} of manure were comparable ($P > 0.05$) but significantly higher ($P < 0.05$) than those of the plots fertilized with 150, 100, 50 and 0 kg N ha^{-1}, respectively (Table 3). The same result was observed at 6 months. At 8 months, the diameters of the plants fertilized with 150, 100, 50 and 0 kg N ha^{-1} were comparable ($P > 0.05$) but significantly lower ($P < 0.05$) than those fertilized with 200 and 250 kg N ha^{-1}, which were comparable ($P > 0.05$). Regardless of the fertilization levels, the plant diameters obtained at 8 months were significantly higher ($P < 0.05$) than those obtained at 4 and 6 months.

Total biomass, leaf biomass, stem biomass and stem/leaf ratio of Moringa oleifera

The increase in the whole plant biomass based on poultry manure fertilization levels is presented in Table 3. Biomass increased with N level. The highest ($P < 0.05$) yield was obtained with 200 kg N ha^{-1} at all cutting times except at 4 months, where 250 kg N ha^{-1} gave the highest biomass (0.37 t DM ha^{-1}).

Regardless of the cutting time, the biomass of fertilized plants was significantly ($P < 0.05$) higher than that of unfertilized plants. At four months, the biomass obtained from plants fertilized with 100, 150, 200 and 250 kg N ha^{-1} was comparable ($P > 0.05$) (0.32, 0.31, 0.35 and 0.37 t DM ha^{-1}, respectively). The same observation was made for the biomass obtained from plants fertilized with 50, 100 and 150 kg N ha^{-1}. At six months of age, the highest total biomass (2.41 t DM ha^{-1}) was obtained from plants fertilized at 200 kg N ha^{-1}. The second highest biomass was obtained with plants fertilized at 250 kg N ha^{-1}. The biomass obtained from plants fertilized with 50, 100 and 150 kg N ha^{-1} was comparable ($P > 0.05$). At eight months, the total biomass (1.75 t DM ha^{-1}) of plants fertilized at 200 kg N ha^{-1} was significantly ($P < 0.05$) higher than that of plants fertilized at rates of 250, 150, 100 and 50 kg N ha^{-1}, which showed comparable values. The total biomass of plants fertilized with 250 kg N ha^{-1} was reduced by 46.1% compared to that of plants fertilized at 200 kg N ha^{-1}.

The biomasses obtained at 6 and 8 months were comparable ($P > 0.05$) when plants were fertilized at 50, 100 and 150 kg N ha^{-1}. These biomasses were significantly ($P < 0.05$) higher than those obtained at 4 months. In unfertilized plots, the biomasses obtained at 6 months were significantly ($P < 0.05$) higher than those obtained at 4 and 8

Table 3. Effect of poultry manure fertilization levels on total biomass, leaf biomass, stem biomass and stem/leaf ratio production (t DM ha^{-1}) of *M. oleifera* with different cutting times.

Cutting times (months)	0	50	100	150	200	250	SEM	*P* - value
	Plant height (cm)							
4	29.67^{aA}	30.29^{aA}	31.06^{aA}	31.78^{aA}	37.22^{bA}	37.02^{bA}	0.441	<0.05
6	43.63^{aB}	55.23^{bB}	65.54^{cB}	54.87^{bA}	78.43^{dB}	79.03^{dB}	1.393	<0.05
8	128.35^{aC}	141.47^{bC}	146.65^{bcC}	133.59^{bB}	160.38^{cC}	155.47^{cC}	2.414	<0.05
SEM	15.76	17.20	17.41	15.78	18.97	17.61		
P - value	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		
	Plant diameter (cm)							
4	0.58^{aA}	0.65^{bA}	0.70^{bA}	0.66^{bA}	0.79^{cA}	0.79^{cA}	0.008	<0.05
6	0.92^{aA}	0.89^{aB}	1.26^{bB}	1.19^{bB}	1.38^{cB}	1.47^{cB}	0.018	<0.05
8	1.88^{aB}	1.91^{aB}	1.93^{aC}	1.96^{aC}	2.30^{bC}	2.05^{bC}	0.018	<0.05
SEM	0.228	0.193	0.178	0.189	0.221	0.183		
P - value	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		
	Total biomass (t DM ha^{-1})							
4	0.20^{cC}	0.26^{bB}	0.32^{abB}	0.31^{abB}	0.35^{aC}	0.37^{aC}	0.020	<0.05
6	0.41^{dA}	0.67^{cA}	0.75^{cA}	0.74^{cA}	2.41^{aA}	1.11^{bA}	0.030	<0.05
8	0.30^{cB}	0.69^{bA}	0.74^{bA}	0.73^{bA}	1.75^{aB}	0.72^{bB}	0.040	<0.05
SEM	0.030	0.060	0.010	0.050	0.070	0.050		
P - value	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		
	Leaf biomass (t DM ha^{-1})							
4	0.13^{cC}	0.17^{bcB}	0.22^{abB}	0.22^{abB}	0.22^{abC}	0.25^{aC}	0.01	<0.05
6	0.27^{dA}	0.46^{cA}	0.51^{cA}	0.51^{cA}	1.51^{aA}	0.79^{bA}	0.05	<0.05
8	0.19^{cB}	0.38^{bA}	0.44^{bA}	0.48^{bA}	1.21^{aB}	0.49^{bB}	0.05	<0.05
SEM	0.02	0.04	0.03	0.05	0.10	0.08		
P - value	0.05	<0.05	<0.05	<0.05	<0.05	<0.05		
	Stem biomass (t DM ha^{-1})							
4	0.07^{cC}	0.09^{bcC}	0.10^{bB}	0.10^{bB}	0.13^{aC}	0.12^{aC}	0.02	<0.05
6	0.13^{cA}	0.21^{bcB}	0.25^{bcA}	0.26^{bcA}	0.90^{aA}	0.31^{bA}	0.04	<0.05
8	0.10^{cB}	0.30^{bA}	0.30^{bA}	0.25^{bcA}	0.54^{aB}	0.23^{bcB}	0.04	<0.05
SEM	0.02	0.04	0.03	0.03	0.16	0.03		
P - value	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		
	Stem/leaf ratio							
4	0.53^{abB}	0.51^{abB}	0.46^{bB}	0.48^{bB}	0.61^{aB}	0.51^{abB}	0.02	<0.05
6	0.49^{abB}	0.46^{abB}	0.48^{abB}	0.51^{abB}	0.61^{aB}	0.41^{bB}	0.02	<0.05
8	0.92^{abA}	0.92^{abA}	1.05^{abA}	1.15^{aA}	0.99^{abA}	0.83^{bA}	0.04	<0.05
SEM	0.06	0.07	0.08	0.10	0.07	0.07		
P - value	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		

a, b, c, d: In the same column, the assigned values of the same letter do not differ significantly (P>0.05); SEM: Standard Error of Mean; P: Probability. A, B and C: In the same row, the assigned values of the same letter do not differ significantly (P>0.05). 0 = without manure; 50 = 50 kg N ha^{-1} manure; 100 = 100 kg N ha^{-1} manure; 150 = 150 kg N ha^{-1} manure; 200 = 200 kg N ha^{-1} manure and 250 = 250 kg N ha^{-1} manure.

months. The same effect was observed with plants fertilized at 200 and 250 kg N ha^{-1}.

Table 3 shows the *M. oleifera* leaf biomass values. Leaf biomass increased with the fertilization level to reach the highest levels in plants fertilized at 200 kg N ha^{-1} at all cutting times. Regardless of the cutting times, the leaf biomass of the fertilized plots was significantly ($P < 0.05$) higher than that of the unfertilized plots. The leaf biomass obtained with 100, 150, 200 and 250 kg N ha^{-1} was comparable ($P > 0.05$) (0.22, 0.22, 0.22 and 0.25 t DM ha^{-1}, respectively) at four months. The same observation was made for the biomass obtained with 50, 100 and 150 kg N ha^{-1}. At six months of age, the leaf biomass was significantly ($P < 0.05$) highest (1.51 t DM ha^{-1}) in plants fertilized at 200 kg N ha^{-1} and lowest (0.27 t DM ha^{-1}) in unfertilized plants. The biomass obtained with 50, 100 and 150 kg N ha^{-1} was comparable ($P > 0.05$). At eight months, the leaf biomass (1.21 t DM ha^{-1}) achieved with 200 kg N ha^{-1} was significantly ($P <$ 0.05) higher than those values obtained with 250, 150, 100 and 50 kg N ha^{-1}, respectively, which were comparable among each other. The leaf biomass (at 6 and 8 months) of the plants fertilized with 250 kg N ha^{-1} was reduced by 52.3% compared to that of plants fertilized with 200 kg N ha^{-1}.

According to the cutting times, leaf biomasses obtained at 6 and 8 months were comparable ($P>0.05$) when plants were fertilized at 50, 100 and 150 kg N ha^{-1}. These biomasses were significantly ($P < 0.05$) higher than those obtained at 4 months. In unfertilized plots, leaf biomasses obtained at 6 months were significantly ($P < 0.05$) higher than those obtained at 4 and 8 months. The same effect was observed with plants fertilized at 200 and 250 kg N ha^{-1}.

The stem biomass of *M. oleifera* increased with the level of fertilization to reach the maximum yield with plants fertilized at the level of 200 kg N ha^{-1} at all cutting times (Table 3). Regardless of the cutting time, the stem biomass of fertilized plants was significantly ($P < 0.05$) higher than that of unfertilized plants. At four months, stem biomasses obtained from plots fertilized with 200 and 250 kg N ha^{-1} were comparable ($P > 0.05$) (0.13 and 0.12 t DM ha^{-1}, respectively) but significantly ($P < 0.05$) higher than those of plants fertilized at 0, 50, 100 and 150 kg N ha^{-1}. The biomass of the stems obtained from plants fertilized with 50, 100 and 150 kg N ha^{-1} was comparable ($P > 0.05$). The same observation was made for stems of plants fertilized at 0 and 50 kg N ha^{-1}. At six months, the highest stem biomass (0.90 t DM ha^{-1}) was obtained with plants fertilized at 200 kg N ha^{-1}. This biomass was followed by those of plants fertilized at 250, 150, 100 and 50 kg N ha^{-1}, which were comparable ($P > 0.05$). At eight months, the stem biomass (1.21 ± 0.13 DM ha^{-1}) in the plot fertilized at 200 kg N ha^{-1} was significantly ($P < 0.05$) higher than those of plants fertilized at 250, 150, 100 and 50 kg N ha^{-1}, respectively, which were comparable among each other. The biomass of the stems on the plot fertilized at 250 kg N ha^{-1} decreased by approximately 34.44% compared to that of the plants fertilized at 200 kg N ha^{-1}.

Stem biomasses obtained at 6 and 8 months were comparable ($P > 0.05$) when plants were fertilized at 50, 100 and 150 kg N ha^{-1} (Table 3). These biomasses were significantly ($P < 0.05$) higher than those obtained at 4 months. In unfertilized plots, the stem biomasses obtained at 6 months were significantly ($P < 0.05$) higher than those obtained at 4 and 8 months. The same trend was observed with plants fertilized at 200 and 250 kg N ha^{-1}.

The stem/leaf ratio was significantly ($P < 0.05$) influenced by cutting time and fertilization level (Table 3). The stem/leaf ratio obtained at 8 months was significantly ($P < 0.05$) higher than those obtained at 4 and 6 months, which were comparable ($P > 0.05$). At four months, the stem/leaf ratio ranged from 0.46 to 0.61. At six months, the ratio of stems/leaves varied from 0.41 to 0.61, whereas at eight months, it ranged from 0.83 to 1.15. The ratio of stems/leaves obtained at eight months was significantly ($P < 0.05$) higher than that obtained at four and six months. On the other hand, the stem/leaf ratios obtained at four and six months were comparable ($P > 0.05$).

Discussion

At four months after sowing, fertilization at 200 and 250 kg N ha^{-1} resulted in a higher rate of increase in height and diameter than other fertilization rates. This could indicate the beginning of the stimulation of organic matter development in the plant (Pamo *et al.,* 2002). This maximum stimulation of biometric growth realized with the application of poultry manure continued until 8 months after sowing. The fertilization rates of 200 and 250 kg N ha^{-1} explained the multiple effects due to the application of manure on a clay soil. Indeed, manure has a porous and spongy structure (Pamo *et al.,* 2002). Manure increases the aeration and O_2 content of clay soils (Pamo *et al.,* 2002). The decomposition of organic fertilizer enriches the soil with humus consisting mainly of cellulose, hemicelluloses and lignin, which are a source of energy for soil microorganisms (Keeton *et al.,* 1993). In addition, high application rates of manure may inhibit Fe and Mn toxicity (because the excess of these ions is fixed by the ammonium ions; Palm *et al.,* 2001). The results obtained were consistent with those obtained by Foidl *et al.* (2001) and Anamayi *et al.* (2016), who showed that cow manure improved the growth of *M. oleifera* in Nicaragua and Nigeria, respectively. Similarly, Artin and Rice (2002) showed that on very poor and alkaline soil in Haiti, compost fertilization (organic manure) improved the growth of *M. oleifera*.

In this study, fertilization positively influenced the biomass production of *M. oleifera* plants and their various parts. This observation agrees with those of Uchenna *et al.* (2015), who showed that *M. oleifera* plants fertilized with 5 and 10 kg N ha^{-1} of poultry manure had higher biomasses than unfertilized plants. In fact, fertilization increases the speed of vegetative growth, thus increasing production for a given growth stage or reducing the time required to reach a defined yield (Tendonkeng *et al.,* 2011).

In the present study, the biomass of the whole plants, leaves and stems increased with the level of fertilization up to a threshold beyond which it began to decrease. The yield reduction observed following this fertilization threshold agrees with observations by Limani and De Vienne (2001), Tendonkeng *et al.* (2011), who showed that N intake at a rate higher than the potential growth needs of the plant do not increase the forage yield because the N becomes toxic to the plant. This maximum level of fertilization was found to be 200 kg N ha^{-1} in our study. In addition, Maurice *et al.* (1985) had previously reported that N fertilization at rates greater than the potential growth needs of the plant leads to a decrease in biomass production due to ammonium ion toxicity. Similarly, Lawlor *et al.* (2001) noted that when N intake exceeds the plant's needs, the nitrogen use efficiency of the plant decreases because the N has become saturated.

The ratio of stems/leaves obtained at eight months was higher than that obtained at four and six months, and this could be explained by the fact that this cutting period took place in the middle of the dry season (January) and despite the fact that the plants were watered, the latter lost their leaves in favor of stem development. The stem/leaf ratio thus indicates the best period for obtaining leaves or stems for the production of *M. oleifera*. In production*,* the leaves should be harvested 4 and 6 months after sowing, while the stems should be harvested 8 months after sowing and preferably in the dry season.

The main conclusions are as follows. Overall, the application of 200 and 250 kg N ha^{-1} of poultry manure to *M. oleifera* generated the greatest height and stem collar diameter among all levels of fertilization. Similarly, the application of 200 kg N ha^{-1} improved the biomass of whole plants, leaves and stems compared to other levels of fertilization. Based on the study findings, it is suggested that *M. oleifera* be fertilized with 200 kg N ha^{-1} and harvested between 4 and 6 months to achieve the best biomass and stem/leaf ratio.

Resumen

M. Mouchili, F. Tendonkeng, E. Miégoué, D. Fokom Wauffo, H. Mekuiko Watsop, P.E. Tedonkeng, y E. Vargas-Bello-Pérez. 2019. Efectos de diferentes niveles de fertilización con guano de aves y tiempos de corte en la producción de *Moringa oleifera*. Cien. Inv. Agr. 46(3): 310-318. El efecto de diferentes niveles de fertilización con guano de ave y tiempos de corte fueron evaluados sobre el crecimiento de Moringa oleífera. En un diseño factorial con seis niveles con fertilización de guano de ave (0, 50, 100, 150, 200 y 250 kg N ha^{-1}) y tres tiempos de corte (4, 6 y 8 meses) con cuatro replicas fue utilizado. Después de un mes de siembra, se llevó a cabo la fertilización. En cada tiempo de corte, 20 plantas fueron colectadas por tratamiento para las mediciones de altura y diámetro. La biomasa del tallo, hoja y planta entera de Moringa oleífera fue analizada por cada parcela dependiendo de su nivel de fertilización con guano de ave y su respectivo tiempo de corte. Los resultados mostraron que independiente del tiempo de corte, la mayor altura y diámetro de la planta fue obtenida con 200 kg N ha^{-1}. La biomasa del tallo, hoja y planta entera aumentó conforme el nivel de fertilización aumentó. La mejor biomasa se obtuvo en el corte a los 6 meses (1.51, 0.90 y 2.41 t MS ha^{-1} respectivamente para hojas, tallo y planta entera. En conclusión, la utilización de guano de ave a razón de 200 kg N ha^{-1} es la más adecuada para el crecimiento de Moringa oleífera en estado vegetativo.

Palabras clave: Biomasa, fertilización, *Moringa oleifera*, tiempos de corte.

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