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CROP PRODUCTION

Technical and economic viability and nutritional quality of mombasa guinea grass silage production

Fernando Shintate Galindo[1*], Tatiane Beloni[2], Salatiér Buzetti[1], Marcelo Carvalho Minhoto Teixeira Filho[1], Elisângela Dupas[1] and Mariana Gaioto Ziolkowski Ludkiewicz[1]

*[1]Departamento de Fitossanidade, Engenharia Rural e Solos, Faculdade de Engenharia, Universidade Estatual Paulista "Julio de Mesquita Filho", Rua Monção, 830, 15385-000, Ilha Solteira, São Paulo, Brazil. [2]Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, São Paulo, Brazil. *Author for correspondence. E-mail: fs.galindo@yahoo.com.br*

ABSTRACT. The objective of this study was to evaluate the viability of pasture with high production capacity and the potential for production of silage using different sources and doses of nitrogen (N) by quantifying the productivity of dry matter (DM), some qualitative characteristics, the total cost of production (TC) and total operating cost (TOC) of silage production. The experimental design was randomized block in a factorial scheme with four replications including two sources of nitrogen (urea and ammonium nitrate) and five N doses (0, 50, 100, 150, and 200 kg ha^{-1} by cutting). The increase in N provided greater DM and crude protein content and reduced the fiber content in neutral detergent. The source of N did not affect the chemical composition, and therefore, it is recommended to use urea due to the ease of acquisition and higher economic return. The production of Mombasa silage can be economically viable due to high DM and crude protein content combined with low production costs. The smallest TC and TOC were obtained in the absence of nitrogen fertilization; however, the proper management of N ensures high productivity in cattle feed with higher total profit when using 100 kg ha^{-1} N by cutting with ammonium nitrate.

Keywords: nitrogen fertilization; chemical analysis; production cost; tropical grass; *Panicum maximum*.

Viabilidade técnica, econômica e qualidade nutricional da produção de silagem de capim-mombaça

RESUMO. Objetivou-se estudar a viabilidade de uma pastagem com alta capacidade produtiva e o potencial para produção de silagem de capim, utilizando fontes e doses de nitrogênio (N), quantificando-se a produtividade de matéria seca (PMS), algumas características bromatológicas, o custo total de produção (CT) e o custo operacional total (COT) da produção de silagem. O delineamento experimental foi em blocos casualizados, adotando um esquema fatorial com quatro repetições, sendo duas fontes de nitrogênio: ureia, e nitrato de amônio, e cinco doses de N (0, 50, 100, 150 e 200 kg ha^{-1} por corte). O incremento de N propiciou maior PMS e teor de proteína bruta, além de diminuir os teores de fibra em detergente neutro. As fontes de N, não influenciaram na composição química, e desta forma recomenda-se utilizar a ureia em função da facilidade de aquisição e maior retorno econômico. A produção de silagem de capim-Mombaça pode ser economicamente viável em função da elevada PMS e proteína bruta, aliado ao baixo custo de produção. O menor CT e COT foi obtido na ausência da adubação nitrogenada, entretanto, o manejo adequado de N garante boa produtividade e rendimento na alimentação do rebanho, com maior lucro total obtido na utilização de 100 kg ha^{-1} de N por corte com a fonte nitrato de amônio.

Palavras-chave: adubação nitrogenada; análises bromatológicas; custo de produção; gramínea tropical; *Panicum maximum*.

Introduction

Brazil has approximately 180 million hectares of pastures and is one of the largest global commercial producers of cattle, which are dependent on pastures (Silva et al., 2009a). Thus, pastures in Brazil are extremely important for the production of beef, and pastures occupy a broad extension the territory in the country. Pastures are considered the base of cattle feed, since they are a less costly means to produce animal protein for human consumption (Fernandes, Buzetti, Dupas, Teixeira Filho, & Andreotti, 2015). This low cost is possible because of climatic factors favoring the production of fodder in different locations and periods of the year. However, forage plants usually do not receive fertilization and over the years lose their developmental potential, reducing quality and productivity (Bennett, Buzetti, Silva, Bergamaschine, and Fabricio, 2008); pasture degradation then occurs after a few years (Silveira et al., 2010).

Several species are used in pasture formations in Brazil, and among them, Mombasa is widely used in breeding and rearing of cattle. The grass species *Panicum maximum* (syn. *Megathyrsus maximus*) presents one of the greatest known potentials for production of dry matter (DM) in subtropical and tropical environments, and can reach annual dry matter production of approximately 33 t ha^{-1} (Freitas et al., 2007). Proper management of soil fertility and knowledge of the nutritional requirements of this grass are extremely important for the practice of pasture management and result in higher productivity and availability of food for animals (Silva et al., 2009b; Barth Neto et al., 2010; Silveira et al., 2010; Pereira et al., 2012).

The use of fertilizer, particularly nitrogen, can significantly increase the production of fodder, allowing greater capacity and resulting in increased production of milk and meat per unit area. Furthermore, nitrogen fertilization may also improve production efficiency of grasses, which allows alternating the use of fodder and silage, the latter for use in the dry season. Food scarcity during the winter period, especially in the Cerrado region, has led producers to store food with higher nutritional value produced in more favorable conditions (spring and summer) in the form of silage for animal nutrition in the period when food is lacking (autumn and winter) (Costa, Andreotti, Bergamaschine, Lopes, & Lima, 2015). In this context, the preservation of green fodder in the form of silage is a strategy to cope with the pasture shortage problem in the dry season (Oliveira et al., 2014). Another important aspect, as discussed by Penteado et al. (2007), is that production potential for tropical grass silage increases with the intensification of the production system, warranting interest in additional research on the subject.

Currently, increased competitiveness in the livestock market in relation to agricultural land use and in seeking the best returns on the capital invested, complementary production technologies have been sought to provide benefits that can be integrated into the production system as a whole. Thus, the use of stored grass silage in the dry season from the summer production surplus has resulted in efficiency gains in pasture management and has minimized feeding costs for livestock due to a lower cost per ton of DM obtained with these silages (Coan et al., 2008).

Given the above, there is a need for viable alternatives to increase the efficiency and utilization of nitrogen fertilization, thereby allowing reduction of N use in the production system without decreasing production or quality of pasture, and to maximize dry matter production of forage during the year. However, there are few studies in the literature that show the economic effects of nitrogen fertilization using different sources and doses on the production of grass silage. The objective of this work was to evaluate the productivity and chemical composition of Mombasa Guinea grass dry matter in silage production, as well as the economic viability of this preservation technique, according to different sources and doses of N in the Northeast Paulista region.

Material and method

The experiment was conducted without irrigation in the region of Ilha Solteira, São Paulo State, Brazil, on the left bank of the Paraná river (20°21' S and 51°22' W). The study site has an altitude of 326 m in an area previously occupied by *P. maximum* cv. Mombasa under grazing (since 2006). The soil is classified as ultisol with sandy texture (Embrapa, 2013). Total precipitation during the experimental period was 1,320 mm, average air humidity was 70%, and average temperature was 25.3°C with average minimum and maximum temperatures ranging from 19.8 to 32.2°C. The climate type is Aw according to Koppen system, which is characterized as humid tropical with a rainy season in the summer and a dry season in the winter. Figure 1 shows the average weather data for each cut made.

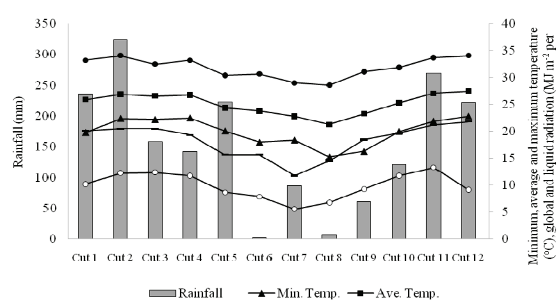

Figure 1. Climate data obtained from the weather station located at the study site in Ilha Solteira, São Paulo State, Brazil. Period December 2012 to January 2014.

Soil samples were collected at a depth of 0-20 cm before the cutting of grass in 2012 to determine the chemical characteristics of the soil, with the following results: P resin = 13 mg dm^{-3}, pH $CaCl_2$ = 5.2; K, Ca, Mg, Al + H, SB, and cation exchange capacity (CEC) = 2.2, 35.0, 7.0, 16.0, 44.2, and 60.2 $mmol_c$ dm^{-3}, respectively, organic matter (O.M.) = 25 g dm^{-3} and V = 73%.

We utilized a randomized block experimental design with ten treatments and four replicates and with two N sources: urea (45% of N) as the most commonly used nitrogen fertilizer and the type likely to be volatilized and ammonium nitrate (32% of N) as a comparative source. Five N doses were used for each N source (0, 50, 100, 150, and 200 kg ha^{-1}, totaling 0, 300, 600, 900, and 1,200 kg ha^{-1} for a period) in a 2 x 5 factorial scheme (two sources and five doses). Each plot area was 6.0 m^2 (3 x 2 m) with 2 m distance between plots.

Grass was cut at 25 cm above the soil at initial fertilization, and further growth for the evaluation of cuts was made on July 7, 2012. The other cuts were made from December 2012 to January 2014. At every third cut, 60 kg ha^{-1} of K_2O was applied. Due to the number of cuts (12) and for better interpretation of the data, the sections were divided into periods of the year: the dry season (4/20/2013, 5/25/2013, 6/28/2013, 8/03/2013, 9/26/2013, and 11/1/2013) and the rainy season (12/16/2012, 1/5/2013, 2/16/2013, 3/26/2013, 12/11/2013, and 1/18/2014).

Samples of the aerial portion of Mombasa Guinea grass were collected manually at 25 cm above soil in the center of the plot. Plots of 0.5 m^2 were delimited using a metallic square (1.0 x 0.5 m), and an iron frame was used to cut grass at intervals based on height, varying by approximately 90 to 100 cm. Overall, there was almost one cut per month, except for the first cut due to low rainfall that led to lower plant growth in that period. The harvested forage was packed in paper bags and subsequently dried in a forced-circulation oven at approximately 65°C for 72 hours. The samples were then weighed to quantify the DM (dry matter) produced in the representative area and ground in a Wiley Mill equipped with a screen with a 1 mm sieve for subsequent analysis.

After each cut, the N doses were topdress-applied to each plot. The DM of Mombasa Guinea grass was calculated based on the amount of green matter (kg m^{-2}), and the original amount of dry matter was obtained. Fiber content in neutral detergent (NDF) and acid detergent fiber (ADF) were measured following the methodologies of Casali et al. (2009) and Van Soest (1994). The nitrogen content (NT, %) was determined by the semimicro-Kjeldahl analytical method, and protein content (CP) was obtained by multiplying the content by 6.25 following Silva and Queiroz (2006).

Data were submitted to analysis of variance (F-test). We used a Tukey test for comparisons of means for N sources and regression analysis for N doses. Statistical analyses were performed using the SISVAR program (Ferreira, 2011).

After verification of bromatological and production results (e.g., high PMS and satisfactory bromatological values), an economic analysis was performed using an analytical structure based on the total operating cost (TOC) of production according to the Institute of Agricultural Economics (IEA) and following Matsunaga et al. (1976). It consisted of calculating the sum of operating expenses, including transactions, inputs (fertilizers, seeds, pesticides etc.), labor, machinery and irrigation, called the effective operational cost (EOC). In addition to the TOC, in this work, we considered other expenses and costs of interest (5% of EOC) (Matsunaga et al., 1976), resulting in a total operating cost (TOC) that was extrapolated to one hectare, which increased the compensation to the fixed capital, being considered 5% of the TOC; from the remuneration of the land, we obtained the total cost of production (CT) according to the methodology proposed by Martin, Serra, Oliveira, Ângelo, and Okawa (1998).

The total profit (PT) was calculated according to the total revenue obtained (RT) by subtracting the total cost of production (CT) in R$ ha^{-1}. We considered for basic calculations feed conversion values in kg of DM intake kg^{-1} LWG (weight gain) = 9; i.e., it is necessary to for an animal to eat 9 kg DM to gain 1 kg of live weight in animals showing initial live weight of 13 kg @ and an expected weight gain near 1 kg per day (adapted from Coan et al., 2008 and Difante et al., 2010) and with a price of @ = R$ 133.00, which is the mean value from the previous 3 years (IEA, 2016).

The data presented here were obtained under experimental conditions; however, to determine the economic factors, the values were extrapolated to real field conditions according to the practices typically employed by producers in the region. For Mombasa silage, a simulation of production costs was carried out on the basis of production data and bromatological results for the grass. The costs of mechanized operations were obtained from Agrianual (2015) and Anualpec (2015) and were adjusted to reflect the average rent values practiced in the region including the tractor driver and the cost of fuel and lubricants, as well as depreciation of machinery and equipment. The technical coefficients and unit values used were obtained from the technical and regional producers working with these crops and with similar levels of technology. For other expenses, we considered the average price spent in the study area adjusted to those prevailing in commercial crops in São Paulo State for the agricultural year of 2014/2015.

Result and discussion

In general, the nitrogen sources urea and ammonium nitrate did not differ in the levels of ADF, CP and accumulated DM regardless of the evaluation period, except for NDF content in the dry season with nitrate ammonium, which was lower compared to urea (Table 1). The results agree with those found by Silveira et at. (2015) working with the N sources ammonium nitrate, ammonium sulfate, urea, urea treated with Agrotain, Super N and ammonium sulfonitrate and under different N doses (0, 60, and 120 kg ha^{-1} per year) in bahiagrass (*Paspalum notatum*). Our results also differed from those of Fernandes et al. (2015) in a study with urea, ammonium sulfonitrate, ammonium nitrate, ammonium sulfate and sulfammo at doses of 0, 50, 100, 150, and 200 kg ha^{-1} in Mombasa Guinea grass, in which the authors found no differences between the sources in productivity and chemical composition.

The N doses influenced the NDF and CP levels in the dry and rainy seasons; however, ADF content was not affected by N dose regardless of the period (Table 1).

With regard to the NDF in the dry period, the value was fit to the second-degree equation with a minimum point at approximately 155 kg ha^{-1} (Figure 2A). In the rainy season, it fit decreasing linear function; i.e., N dose increments up to 200 kg ha^{-1} per cut reduced NDF content (Figure 2C). Bennett, Buzetti, Silva, Bergamaschine, and Fabricio (2008) also found that the NDF decreased with increasing N doses, and according to the authors higher doses of N applied at certain times, depending on environmental conditions, can change the NDF content of the forage, since the magnitude of the effect on NDF is related to climate and soil conditions, management of species used and achieved productivity. Further, according to Magalhães et al. (2012) and Martuscello et al. (2015), increased levels of applied N can increase the ratio between leaves and stems and cause competition for higher active photosynthetic rate and nutritional value since the leaves present lower fiber content and higher content of crude protein compared to the stem. Furthermore, according to Pereira et al. (2012), the possible increase in the specific leaf area with N fertilization is related to the lower leaf thickness at high doses of N, where under conditions of greater N inside the plant, leaf lignification tends to be lower. For ADF content, fodder with values approximately 40% or more have low consumption and digestibility. The results obtained in this study show that Mombasa grass as fodder has good composition of FDA, with less than 40% of dry matter irrespective of the dose and source of N.

Table 1. NDF, ADF, CP and accumulated DM of Mombasa guinea grass due to doses and sources of N per season. Ilha Solteira, São Paulo State, Brazil, 2012-2014.

			Dry season	
Doses of N	NDF	ADF	CP	Accumulated DM
---kg ha^{-1}---		---------% D.M.---------		---kg ha^{-1}---
0	68.25*	35.40^{ns}	11.53**	9,358**
50	67.42	34.83	12.70	10,518
100	67.21	35.12	13.35	11,423
150	65.19	33.29	14.74	11,988
200	67.22	35.55	14.14	11,780
Mean	67.06	34.84	13.29	11,013
C.V. (%)	0.98	2.75	7.19	12.69
Sources of N				
Urea	67.48 a	34.67 a	12.91 a	10,938 a
Ammonium nitrate	66.63 b	35.00 a	13.68 a	11,088 a
L.S.D. (5%)	0.66	0.97	0.97	906.5
			Rainy season	
	NDF	ADF	CP	Accumulated DM
Doses of N				
---kg ha^{-1}---		---------% D.M.---------		---kg ha^{-1}---
0	69.73*	39.46^{ns}	9.55**	21,948**
50	69.42	39.78	10.34	23,985
100	69.62	39.77	10.86	25,775
150	67.49	37.80	12.88	28,368
200	68.34	38.51	13.86	27,295
Mean	68.92	39.06	11.50	25,474
C.V. (%)	1.62	3.64	8.90	10.76
Sources of N				
Urea	69.08 a	38.84 a	11.06 a	25,150 a
Ammonium nitrate	68.76 a	39.29 a	11.94 a	25,798 a
L.S.D. (5%)	1.13	1.44	1.04	1,778.2

Means followed by the same letter in the column do not differ by Tukey test at 5% probability. ** Mean $p < 0.01$; Mean * $0.01 < p < 0.05$; ns: not significant.

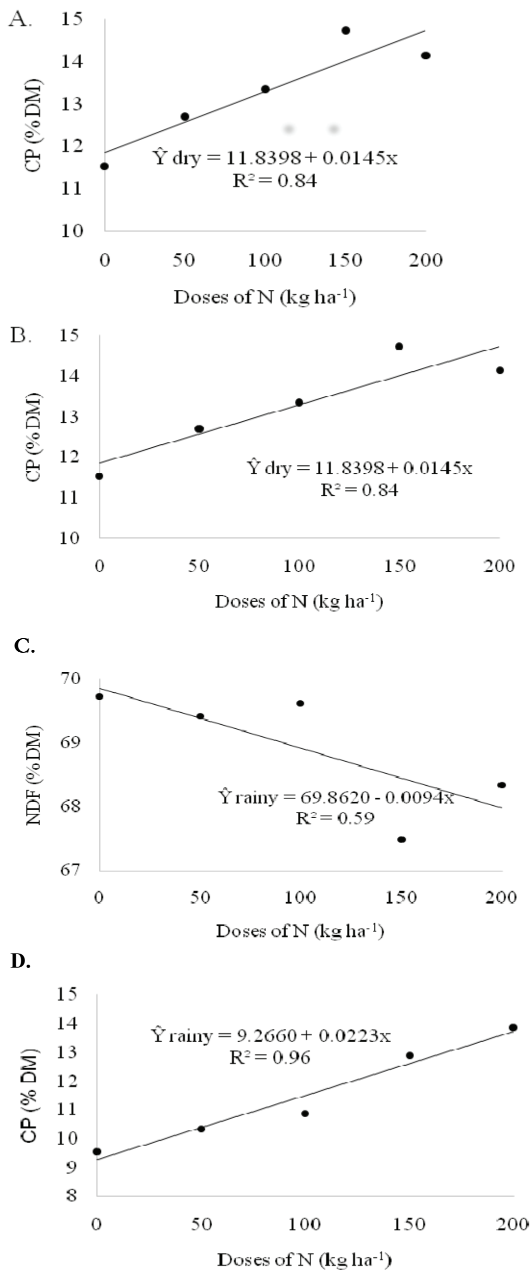

Figure 2. NDF of mombasa guinea grass according to N doses in the dry season (A); CP of mombasa guinea grass according to N doses in the dry season (B); NDF of mombasa guinea grass according to N doses in the rainy season (C); CP of mombasa guinea grass according to N doses in the rainy season (D). Ilha Solteira, São Paulo State, Brazil, 2012-2014.

Regarding the CP, in both the rainy and dry seasons, there was an adjustment to the increasing linear function, i.e., increased N doses led to an increase in CP content (Figure 2B and D). This corroborates the work of Silva et al. (2009b) in a study of N doses (0, 100, 300, and 500 kg ha^{-1} of N) in Mombasa Guinea grass showing that in the dry and rainy seasons, increased N resulted in increased CP content, with values ranging from 6.5 to 10.6%. Nitrogen fertilization increased the concentration of N in Mombasa, which is directly related to the increase in CP content. According to Van Soest (1994), CP content less than 7% in fodder reduces digestibility because of inadequate nitrogen levels for ruminal microorganisms, reducing their populations and consequently reducing the digestibility and intake of dry matter. Thus, higher levels of CP are necessary to meet the protein requirements of animals. Crude protein content in this study was above 7% and thus should not negatively affect rumen microorganism populations, preserving digestibility and dry matter intake.

The interaction between N dose and source was significant for DM accumulated in both the dry season and the rainy season (Tables 2 and 3). It was adjusted to an increasing linear function for dose for both urea and ammonium nitrate (Figure 3A and B).

Table 2. Interaction between doses and sources of N related to the productivity of dry matter accumulation of mombasa guinea grass in the dry season in Ilha Solteira region, São Paulo State, Brazil.

Sources	Doses of N (kg ha^{-1})				
	0	300	600	900	1,200
Urea**	9,820 a	10,540 a	10,745 a	12,025 a	11,560 a
A.N.**	8,895 a	10,495 a	12,100 a	11,950 a	12,000 a
L.S.D. (5%)			2,027		

Means followed by the same letter in the column do not differ by Tukey test at 5% probability. ** Significant p < 0.01, * significant 0.01 < p < 0.05, ns: not significant.

Table 3. Interaction between doses and sources of N related to the productivity of dry matter accumulation of mombasa guinea grass in the rainy season in Ilha Solteira region, São Paulo State, Brazil.

Sources	Doses of N (kg ha^{-1})				
	0	300	600	900	1,200
Urea**	21,835 a	23,585 a	24,215 a	28,075 a	28,040 a
A.N.**	22,060 a	24,385 a	27,335 a	28,660 a	26,550 a
L.S.D.(5%)			3,976		

Means followed by the same letter in the column do not differ by Tukey test at 5% probability. ** Significant p < 0.01, * significant 0.01 < p < 0.05, ns: not significant.

The increase in DM in the control (0 kg ha^{-1} of N) for the higher dose (1,200 kg ha^{-1} of N) in the dry and rainy seasons was 2,422 kg ha^{-1}, 5,347 kg ha^{-1}, and 1,425 kg ha^{-1}, representing 5.88 and 24.36%, respectively. On average, the DM in the rainy season was 131.31% higher than in the dry period, varying from 11,013 to 25,474 kg ha^{-1}, respectively, and bringing to light the problems related to lack of forage for cattle in the dry season, which is the main limiting factor for livestock in Central Brazil.

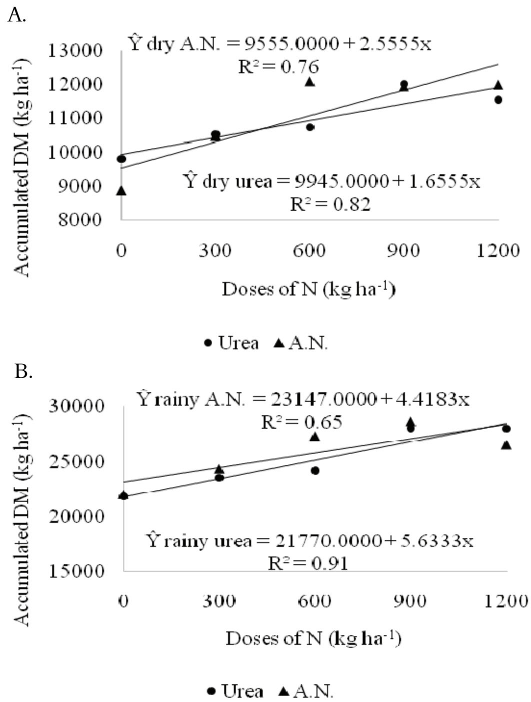

Figure 3. Breakdown of interaction between doses and sources of N in accumulated DM of mombasa guinea grass in the dry period (A); unfolding of the interaction between doses and sources of N in accumulated DM mombasa guinea grass in the rainy season (B).

The results for DM in the rainy season were higher than those found by Paziani et al. (2009) and were obtained by evaluating the DM of corn for silage, with an average yield of 18,690 kg ha^{-1}. These yields can be considered above average compared to the values obtained in practice, thus keeping high productive potential of green matter and silage dry matter per unit area, which is the advantage of using silage grass compared to corn and sorghum silage.

The DM produced due to the nitrogen fertilization was considered satisfactory to ensure stability of the pasture and animal production since the values were above 1,600 kg ha^{-1} by cutting, a value cited by Fernandes et al. (2015) as sufficient to ensure satisfactory forage consumption. However, this amount may vary according to the stocking dose used and period or season, which explains the magnitude of responses to nitrogen fertilization among different cuts. According to Paziani et al. (2009), the most desirable features in silage crop are high production of green and dry matter in both the silage point and in physiological maturity, and high concentrations of crude protein and energy factors that ensure greater digestibility of forage. Thus, the high yields obtained in this study are due to the technology adopted in these production systems, with proper fertilization to meet the requirements of Mombasa.

Considering the technical results (e.g., high DM, good NDF, ADF, and CP) combined with the durability, low risk of loss and greater flexibility in harvesting as well as the possibility of exclusive supply or as bulk for cattle complementary feed during seasonal food shortages, it is justifiable to analyze the economic feasibility of Mombasa Guinea grass silage production, mainly due to the need for livestock farming to become more competitive by reducing costs and increasing productivity.

Initial investment in terms of soil preparation, liming and forage deployment were not considered in this study, since these practices were not carried out in the undergrazed area with Mombasa already deployed. This contributed to the reduction of initial cost of deployment for silage. To evaluate the economic performance of silage production, the total and actual operating costs recorded in the experiment were extrapolated to one hectare.

Investments with additives to assist in lowering the pH and fermentation of the silage were not considered in this study, as these techniques are not adopted by producers of grass silage in the Ilha Solteira, São Paulo State region, mainly due to the increase in production costs and controversial results in relation to efficiency in improving the quality of silage grass surplus. However, it is noteworthy that this technique, when used rationally on specific areas such as those intended only for silage, may be a viable alternative compared to acquisition of foreign silage or the adoption of risk deferral. Use of the technique may also influence the fermentation process by favoring conservation and improving the nutritional value, reducing surface losses and the exposed layer of silage, increasing the useful lifetime, increasing the value energy, and improving fiber and dry matter digestibility, collectively resulting in improved animal performance (Ferreira Júnior, Paulino, Possenti, & Lucenas, 2009).

Table 4 shows that spending was highest on mechanized operations, followed by fertilizers, corresponding to 68.46 and 19.51% of the TOC, respectively. This result is in agreement with Costa et al. (2015) in a study of the cost of silage production in the Cerrado region in the 2010/2011 and 2011/2012 seasons, in which the authors applied urea at dose of 200 kg ha^{-1}, and also found higher detachment with mechanized operations, corresponding to more than 57% of the TOC. It is noteworthy that with increasing nitrogen doses and change in N source, there is a tendency toward increase in the percentage of spending in relation to the TOC of fertilizers.

Table 4. Total operating costs structure model of Mombasa guinea grass silage for the treatment control (zero kg ha^{-1} N in top-dressing, as urea form), per hectare. Ilha Solteira, São Paulo State, Brazil, 2012 until 2014.

Description	Specification[1]	Times	Coefficient	Unitary Value (R$)	Total Value (R$)
		A. Operations			
Hoeing	HM*	6.00	1.00	65.00	390.00
Top dressing	HM	6.00	0.30	65.00	117.00
Potassium fertilization	HM	2.00	0.30	65.00	39.00
Transport	HM	6.00	0.80	70.00	336.00
Compaction	HM	6.00	1.00	60.00	360.00
Subtotal A					1,242.00
		B. Agricultural input			
Potassium Chloride	T	2.00	0.10	1,770.00	354.00
Urea	T	6.00	0.00	1,780.00	0.00
Plastic canvas	m^2	1.00	0.50	160.00	80.00
Subtotal B					434.00
Effective operating costs (EOC)					1,676.00
Other expenses					83.80
Interest cost					54.47
Total operating cost (TOC)					1,814.27
Remuneration of fixed capital					90.71
Remuneration of land					850
Total cost (TC)					2,754.98

* Area with mombasa guineagrass already deployed. * HM = hour machine. 2014/2015 average exchange rate: R$ 2.97 = U$ 1.00.

Garcia et al. (2012), working with the corn crop submitted to different consortia with forage for silage in Selvíria region, MS, verified higher costs related to inputs with corn seeds (46.46%), followed by fertilization costs (39.01%), and higher operating costs of the center pivot sprinkler irrigation (45.28%) with yields ranging between 6,300 and 8,220 kg ha^{-1} of corn using urea as a source of nitrogen fertilizer at a dose of 100 kg ha^{-1}. This demonstrates the main technical advantage of the production of grass silages, with the reduction in spending on inputs and high production per area, making grasses a strategically interesting food as nutritional reserves due to lower cost compared to other additional bulky options. Additionally, Jobim, Sarti, Santos, Branco, and Cecato (2006), in a study of resulting animal performance and economic viability of elephant grass silage as a replacement for corn silage for dairy cows, concluded that elephant grass silages showed potential for production and chemical composition of milk equivalent to corn silage when given to cows in the intermediate period of lactation. The deficiencies of elephant grass silage compared to corn silage can be offset by the lower cost of production, showing that this culture has great potential for exploitation.

The costs of nitrogen fertilizer per period, season and cut with increasing doses of N ranged from 38.29 to 68.27% of the TOC for urea and 41.74 to 70.88% for ammonium nitrate. Regarding the COT and CT (Table 5), the highest values refer to the treatment using ammonium nitrate at a dose of 1200 kg ha^{-1} of N per period, 600 kg ha^{-1} per station or 200 kg ha^{-1} per cut. The lowest value for the TOC and CT corresponds to the treatments without nitrogen fertilization (0 kg ha^{-1}). However, it is worth noting that soil N reserves will be depleted, as occurs in the extraction of the nutrient, if this is not reset to the ground, jeopardizing the productivity of pastures over time. The TOC of treatments without nitrogen fertilization (dose 0 kg ha^{-1}) had the same values regardless of the source. This occurred because in the absence of nitrogen fertilizer, the relative cost is equal to zero for both sources.

The possibility of dry matter production and storage to feed, whether in the form of silage or hay, should consider possible improvements to chemical, physical and biological soil caused by fertilizer in addition to the possible improvement of nutritional value in the formed pasture for feeding of ruminants. Additionally, based on the technical results, consideration of the effect of nitrogen fertilization is essential to guarantee high DM with sufficient levels of crude protein and fiber, improving the quality and quantity of forage production in Mombasa.

Another important aspect relates to conserved forage acquisition costs, which can be higher compared to the production of silage grass remnants. Moreover, techniques used by farmers for deferral can be viable alternatives in this area, because rains and rotting will eventually occur, and there may also be a risk of fires. Typically, deferred pastures have high quantities of fodder but with low quality, and during the deferral period, much of the vegetative tillers (without inflorescences) develop on reproductive tillers (with inflorescences), and these are placed in the category of dead tillers. At this time, there is also a reduction in the amount of green leaf and an increase in the mass of dry leaves, dried stems and green stalks in the pasture (Santos, Fonseca, Gomes, Balbino, & Magalhães, 2010), in addition to problems with layering, which directly affect forage quality.

Table 5. Total operating costs and total cost of mombasa guinea grass silage production according to sources and doses of N. Ilha Solteira, São Paulo State, Brazil, 2012-2014.

Period				
	Urea		A.N.#	
Doses	TOC	TC	TOC	TC
kg ha^{-1}	-------------------(R$)--------------------			
0	1,814.27	2,754.98	1,814.27	2,754.98
300	3,098.84	4,103.78	3,309.94	4,325.44
600	4,383.40	5,452.57	4,805.61	5,895.89
900	5,667.97	6,801.37	6,301.28	7,466.34
1,200	6,952.54	8,150.16	7,796.94	9,036.79
Season				
	Urea		A.N.#	
Doses	TOC	TC	TOC	TC
kg ha^{-1}	-------------------(R$)--------------------			
0	907.14	1,802.49	907.14	1,802.49
150	1,549.43	2,476.89	1,654.97	2,587.72
300	2,191.70	3,151.29	2,402.80	3,372.94
450	2,833.99	3,825.68	3,150.64	4,158.17
600	3,476.27	4,500.08	3,898.47	4,943.40
Cut				
	Urea		A.N.#	
Doses	TOC	TC	TOC	TC
kg ha^{-1}	-------------------(R$)--------------------			
0	302.38	1,167.50	302.38	1,167.50
50	516.47	1,392.30	551.66	1,429.24
100	730.57	1,617.10	800.93	1,690.98
150	944.66	1,841.90	1,050.21	1,952.72
200	1,158.76	2,066.69	1,299.49	2,214.47

#Ammonium nitrate 2014/2015 average exchange rate: R$ 2.97 = U$ 1.00.

Table 6. Total profit production mombasa guinea grass silage according to sources and doses of N. Ilha Solteira, São Paulo State, Brazil, 2012-2014.

Total profit					
R$ ha^{-1}					
Doses of N (kg ha^{-1}) per period					
Sources	0	300	600	900	1,200
Urea	18,756.54	19,131.81	18,403.69	20,857.70	19,474.43
A.N.#	18,978.21	19,698.30	21,034.15	20,769.07	17,119.88
Doses of N (kg ha^{-1}) per season					
Sources	0	150	300	450	600
Ureia	9,378.27	9,565.91	9,201.85	10,428.85	9,737.22
A.N.#	9,489.10	9,849.15	10,517.07	10,384.53	8,559.94
Doses of N (kg ha^{-1}) per cut					
Sources	0	50	100	150	200
Ureia	3,126.09	3,188.64	3,067.28	3,476.28	3,245.74
A.N.#	3,163.00	3,283.05	3,505.69	3,461.51	2,853.31

#Ammonium nitrate.

Even with lower production costs in the absence of nitrogen fertilizer, management with nitrogen provided higher total profit from the production of silage. Although there were no significant differences between N sources for the technical parameters assessed, the use of ammonium nitrate at a dose of 600 kg ha^{-1} per period, 300 kg ha^{-1} per season, and 100 kg ha^{-1} per cut increased profitability compared to urea by R$ 176.45 (0.84%) and R$ 2,055.94 (9.77%) compared to the highest profit from urea (dose of 900, 450 and 150 kg ha^{-1} for a period, season and cut, respectively) and the control (without N) (Table 6, Figure 4).

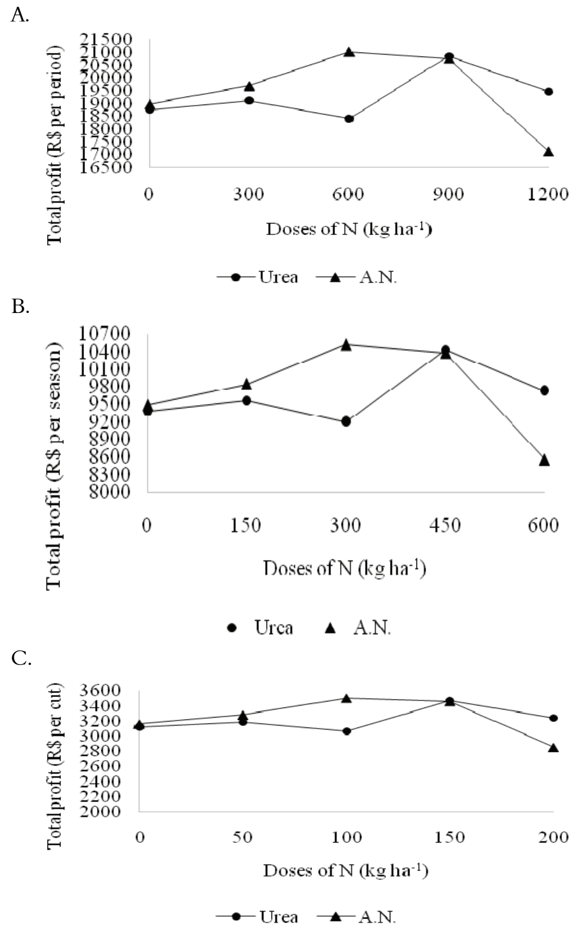

Figure 4. Total profit obtained on the basis of production mombasa guinea grass silage per period (A); Total profit on the production of mombasa silage per station (B), and total profit due to the production mombasa guinea grass silage cutting (C) 2014/2015 average exchange rate: R$ 2.97 = U$ 1.00.

According to Ferreira et al. (2009) and Gonçalves et al. (2010), the use of grass silage made with surplus production from summer in confinement systems in the dry season has allowed gains in efficiency in pasture management and minimization of feeding costs in confinement. This is due the lower cost per ton of DM obtained with these silages, corroborating the economic results obtained in the present work. In view of the greater competitiveness of livestock farming in relation to agriculture through land use, and aiming at better remuneration over invested capital, we have sought complementary production technologies that provide integrated benefits to the production system as a whole (Monteiro, Abreu, Cabral, Ribeiro, & Reis, 2011). Thus, as suggested by Vieira et al. (2010), the agronomic management of crop to obtain satisfactory nutritive value and with high-yielding pastures would justify the use of this forage as a preserved food, allied to the process of intensification of meat and milk production in pastures.

Looking at economies scaled for profit per area (R$ ha^{-1}), especially in places where the cost of land is high, silage becomes an interesting alternative due to the direct impact on productivity per hectare, where bulky foods with high capacity have the tendency to dilute costs of implementation, fertilizers and management in general.

Thus, although corn and sorghum crops are the most widely used for the production of silage, their production costs have been the limiting factor for use by farmers. This highlights the importance of studies concerning the feasibility, costs, and advantages of the production of silage grasses. In addition, the commonly used forage types are subject to seasonal production, resulting in considerable quantitative and qualitative deficiency of forage in the dry period in the Cerrado. Silage produced in the summer can thus serve as a high nutritional value food in the winter period.

Conclusion

Nitrogen doses positively influenced crude protein and dry matter yield of Mombasa Guinea grass and negatively influenced the fiber content in neutral detergent in both seasons up to a dose of 200 kg ha^{-1} by cutting. The nitrogen sources did not differ in technical evaluations.

The production of Mombasa silage can be economically viable due to the high productivity of dry matter and crude protein and low production costs in an established pasture. The lowest total cost and total operating cost were achieved in the absence of nitrogen fertilization; however, the proper management of nitrogen ensures high productivity and yield in cattle feed.

The use of ammonium nitrate source at a dose of 100 kg ha^{-1} by cutting provided higher total profit from silage Mombasa production.

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