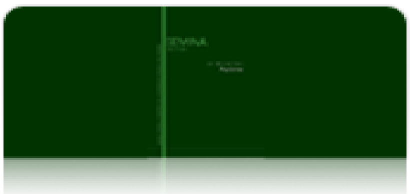

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Nutritional quality of massai grass fertilized with phosphorus and nitrogen and its influence on intake and weight gain of sheep under rotational grazing on quartzipsamment soil[1]

Qualidade nutricional do capim massai adubado com fósforo e nitrogênio e sua influência no consumo e ganho de peso de ovinos em pastejo rotacionado em neossolo quartzarênico

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Abstract

The effects of phosphate and nitrogen fertilization on aspects of forage composition and ruminal fermentation were separately evaluated pre- and post-grazing, in addition to the dry matter intake and weight gain of sheep grazing *Panicum maximum* cv. Massai under a rotational system on Quartzipsamment soil. The aim was to evaluate the effect of fertilization with different levels of phosphorous (50 and 200 kg P_2O_5/ha) and nitrogen (100 and 400 kg N/ha) compared to unfertilized control soil. The experiment was conducted at the School of Veterinary Medicine and Animal Science at Universidade Federal do Tocantins – UFT, in a randomized complete block design with four replicates in a factorial 2 × 2 design. The study area consisted of 32 paddocks (301 m²), each of which had previously been sown with *Panicum maximum* cv. Massai. The experimental area was managed under intermittent stocking with a variable stocking rate. Twenty-eight crossbreed sheep were used for grazing management. Evaluations were made before and after grazing, including forage evaluation and measurement of ruminal degradability and intake (using titanium dioxide as the external marker). Regarding the forage composition, a significant difference ($P < 0.05$) was observed between the control and fertilizer treatments for neutral detergent fiber (NDF), acid detergent fiber, crude protein, lignin and phosphorous content. Fertilization was found to alter the nutritional quality of *Panicum maximum* cv. Massai grass. Among the nutritional aspects evaluated, fertilization influenced NDF, grass digestibility and dry matter intake. The forage composition of Massai grass is improved by fertilization with nitrogen at 100 kg N/ha and phosphate up to 50 kg P_2O_5/ha, which represents a relevant management practice for increasing quantity and quality.

Key words: Nutrients. Pasture. Ruminal degradability. Titanium dioxide.

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Resumo

Objetivou-se avaliar os efeitos da adubação fosfatada e nitrogenada sobre aspectos bromatológicos e a fermentação ruminal da forrageira, no pré e pós pastejo separadamente, além do consumo de matéria seca e ganho de peso de ovinos em pastagem de capim *Panicum maximum* cv. Massai em sistema rotacionado em Neossolo Quartezarênico. O experimento foi conduzido na Escola de Medicina Veterinária e Zootecnia – UFT, com delineamento em blocos casualizados com quatro repetições, fatorial 2x2, utilizando P (50 e 200 kg ha^{-1} de P_2O_5) e N (100 e 400 kg ha^{-1} de N) e controle não adubado. A área estudada foi constituída de 32 piquetes cada (301 m^2), com pastagem já estabelecida de *P. maximum* cv. Massai. A área experimental foi manejada sob lotação intermitente, com taxa de lotação variável utilizou-se 28 ovinos sem raça definida, para fazer o manejo de altura de pasto. As avaliações foram feitas no pré e pós pastejo quanto a bromatologia, degradabilidade ruminal, e consumo, (utilizando dióxido de titânio como indicador externo de consumo). Para as frações FDN, FDA, PB, Lignina e P existentes na planta observou-se diferença ($p<0,05$) entre o tratamento controle e o adubado. As adubações empregadas alteram a qualidade nutricional do capim *P. maximum* cv. Massai. Dentre as variáveis nutricionais avaliados, as adubações influenciam os teores de FDN, a digestibilidade do capim e o consumo de matéria seca dos animais. Os parâmetros para o capim-massai são melhorados pela adubação nitrogenada em uma dose equivalente a 100 kg N kg ha^{-1} e fosfatada até 50 kg P_2O_5 kg ha^{-1}, constituindo prática de manejo relevante quando se busca ganho em quantidade e qualidade,

Palavras-chave: Degradabilidade ruminal. Dióxido de titânio. Nutrientes. Pastagem.

Introduction

Pastures are the main feed source for domestic ruminant production. This fact, combined with the extensive grazing areas occupied by these animals, contribute to making Brazil a leading country for ruminant production. As a result of the common use of this extensive system, production costs are reduced (EUCLIDES et al., 2010).

Maintenance of a satisfactory level of forage production, compatible with the edaphoclimatic conditions of the Cerrado ecosystem, has posed a challenge for guaranteeing the long-term productivity of these systems (RODRIGUES et al., 2012). The pasture consists of a complex ecosystem in which the biotic and abiotic factors interact, and consequently, the physical characteristics of the soil and the adopted management strategies directly influence the amount of nutrients available to the plant. Therefore, it is important to use forage that is adapted to the prevailing conditions in this region (PENA et al., 2009).

The Massai cultivar (*Panicum maximum* cv. Massai), derived from the cross-breeding of *P. maximum* and *P. infestum*, stands out for its high productivity, great leaf production and tiller capacity. In addition, it is well adapted to the Cerrado region, representing a promising alternative for ruminant production systems (MARTUSCELLO et al., 2006). However, due to the low fertility of Cerrado soils (latosols and quartz sands) and the intensification of ruminant grazing, it is important to use fertilizers for the purposes of maintenance, to prevent degradation or, if necessary, recovery and renewal of the pasture (MARTHA JÚNIOR; VILELA, 2007). Nitrogen is related to plant growth and tillering, and is one of the main nutrients associated with increased productivity. Phosphorus is a limiting factor for production in the Cerrado region due to the low availability of this element in the soil (AGUIAR, 2007). The inclusion of these nutrients, as well as other limiting factors, may alter the forage composition of the pasture.

Evaluation of specific types of forage for feed and their digestibility is essential for determining the optimum nutritional management system in order to maximize feed efficiency (CAMPOS et al., 2010). The nutritional factors of the pasture are predominantly altered by climatic and edaphic conditions, as these can modify the levels of neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (NELSON; MOSER, 1994). These fiber fractions determine the intake and digestibility of the feed by ruminal microorganisms (LANA, 2007).

In this study, the effects of phosphate and nitrogen fertilization on aspects of forage composition and ruminal fermentation were evaluated separately pre- and post-grazing, in addition to the dry matter (DM) intake and weight gain of sheep grazing *Panicum maximum* cv. Massai under a rotational system on Quartzipsamment soil.

Materials and Methods

The experiment was performed at the Livestock Unit of the School of Veterinary Medicine and Animal Science at Universidade Federal do Tocantins (UFT; Araguaína Campus), between the geographical latitude and longitude of 07°05’43’’S and 48°12’13’’W, respectively, at 226 m altitude. The experiment was conducted from 20 November to 20 February 2015, totaling 90 days. According to the Köppen (1948) classification, the climate in this region is Aw (tropical wet climate with well-defined dry and rainy seasons). During the experimental period, meteorological data were recorded at a meteorological station located 900 m from the experimental area (Table 1).

The soil of the experimental area is classified as Typic Quartzipsamment soil (EMBRAPA, 2013). The initial chemical characteristics of the soil, as determined by laboratory analysis performed at the School of Veterinary Medicine and Animal Science at Universidade Federal do Tocantins Soil Laboratory, are presented in Table 2.

Table 1. Maximum and minimum temperature, relative humidity and precipitation from December 2014 to February 2015.

Month	Maximum temperature (ºC)	Minimum temperature (ºC)	Humidity (%)	Precipitation (mm)
November	32.2	20.9	90	317.2
December	30.9	20.7	90	285
January	30.7	19.7	90	240
February	30.4	20.2	92	266.1

Instituto Nacional de Meteorologia (INMET, 2015).

Table 2. Chemical characteristics of soil samples from the experimental area collected from layers 0–5, 5–10 and 10–20 cm deep before the experiment.

Layers	pH	OM	P	K	Ca	Mg	H	H + Al	Al	SB	tCEC	BS	Al sat
	$CaCl_2$	(cmol dm^{-3})										(%)	(%)
0 to 5 cm	4.28	6.13	1.42	0.12	0.55	1.55	6.84	7.17	0.33	2.22	9.40	23.68	12.9
5 to 10 cm	4.58	6.23	1.42	0.14	0.65	1.45	6.84	7.19	0.33	2.21	9.40	23.66	13.0
10 to 20 cm	4.48	2.90	1.11	0.10	0.6	0.08	3.59	3.79	0.2	0.86	1.06	18.52	18.2

OM = organic matter; SB = summary of bases; tCEC = capacity of total cationic exchange.

The study area consisted of 32 paddocks, each with an area of 301 m², consisting of a previously established *Panicum maximum* cv. Massai pasture, sown in February 2008. After soil analysis and standardization of the area, phosphorus fertilization was carried out using superphosphate at two levels (50 and 200 kg P_2O_5/ha) and nitrogen fertilization was performed using urea at two levels (100 and 400 kg N/ha) in a 2 × 2 factorial arrangement, with an additional control treatment (without phosphate and nitrogen fertilization), with four replications of each treatment. Nitrogen application was divided equally over the three grazing cycles, while phosphate application was performed once at the beginning of the trial. In addition to these nutrients, potassium oxide was applied as potassium chloride (100 kg/ha), administered as recommended by Ribeiro et al. (1999) based on soil analysis, also divided into three equally spaced intervals. Potassium chloride was simultaneously applied with the nitrogen doses in the three cycles of the experimental period.

Intermittent stocking management was applied with a fixed period of 4 days and a variable stocking rate, which was carried out using the "put-and-take" method (MOTT; LUCAS, 1952) with trial and supplementary animals. Twenty-eight male and female crossbred sheep were used, all 6 month of age with a mean weight of 20 kg.

For assessment of the nutritional aspects of Massai grass such as forage composition and degradability, the vegetative material was collected and evaluated before and after grazing using the rotational system over three consecutive cycles. Each cycle consisted of 4 days of occupation followed by 16 days of rest for the treatments that received fertilization and 28 days for the control, during which the grass was cut close to the soil surface.

After cutting, the samples were weighed on a digital scale, then subsamples of 220 g were taken and stored in plastic bags. These samples were then identified and frozen following further separation into their constituents, including the leaves, stem and sheaths, and dead material. The samples were dried in an oven with forced air circulation at 55ºC for 72 h until they had reached a constant weight. Subsequently, the samples were ground using a 1.0-mm sieve in a Wiley-type mill. Ground samples were analyzed for DM, mineral matter (MM), organic matter (OM) and crude protein (CP) following standard protocols, as well as NDF, ADF (SILVA; QUEIROZ, 2002), lignin (VAN SOEST, 1994) and organic phosphorus according to the methodology of Brazilian Company of Agricultural Research (EMBRAPA, 2013).

The samples were submitted to gas production and degradability tests using an adaptation of the "Hohenheim Gas Test" technique developed by Menke et al. (1979), with graduated syringes used to measure gas production. Briefly, 0.2 g of each sample (diets) was incubated in 100 mL syringes containing 10 mL of inoculum and 20 mL of culture media, in addition to the inoculum of donor animals. The volume of gas produced was measured 3, 6, 9, 12, 24, 48, 72 and 96 h after inoculation.

The model of France et al. (1993) was fitted to the data, as expressed below:

$$Y = A\,\{1 - \exp^{[-b\,(t - L) - c\,x\,(\sqrt{t} - \sqrt{L})]}\}$$

The parameters regarding gas production kinetics were: cumulative gas production (mL); Y, incubation time; t, time (h); A, total gas (mL); T, lag time (h); and μ, fractional degradation rate (h^{-1}). The resulting equations were compared using the parallel test and identity test according to Regazzi and Silva (2004), with $P < 0.05$ indicating statistical significance. The effective degradability was obtained using the methodology described by France et al. (1993), given as:

$$ED = S_0\, e^{-kT}\,(1 - kI)/(S_0 + U_0)$$

where ED represents the effective degradability; k is the passage rate calculated for k = 0.02, 0.03, 0.04 and 0.05; S_0 represents the initially fermentable fraction; and U_0 represents the non-fermentable fraction, as follows:

$$I = \int\infty \exp - [(b + k)\,(t - T) + c(\sqrt{t} - \sqrt{T})]dt$$

Forage intake was evaluated according to the methodology of Moraes (2007) using titanium dioxide (TiO_2) as an external indicator. Titanium dioxide is insoluble in water and in diluted acids, in addition to being odorless and tasteless, and not absorbed by plants. Capsules containing 4 g of the marker were administered directly into the mouth of sheep with the aid of flexible ½ hoses. The adaptation period was composed of 7 days, with feces collected directly from the rectum over 5 days in order to avoid losses and contact with other materials. After collection, the samples were stored in identified plastic bags and dried in an oven with forced air circulation at 55ºC for 72 hours until a constant weight had been achieved, used to determine the dry weight. The samples were subsequently ground using a 1.0-mm sieve in a Wiley-type mill. The titanium analyses were performed according to the methodology described by Myers et al. (2004).

The experimental design consisted of a randomized block design with four blocks in 2 × 2 factorial arrangement, considering two levels of phosphorus and two levels of nitrogen, with an additional control treatment. The analyses were performed separately for pre- and post-grazing using Sisvar software (version 5.1).

The data were submitted to tests for normality (SHAPIRO; WILK, 1965) and homoscedasticity (COCHRAN, 1941). For data with a normal distribution and with homogeneous variances, ANOVA followed by an F-test in ANOVA was performed for the two levels of the two nutrients (phosphorus and nitrogen), and for comparison of these treatments with the control treatment. For variables with non-normal distributions, a logarithmic transformation was made (log (x + 1)).

The statistical model adopted was:

$$\mathbf{Y_{ijk} = \mu + P_i + N_j + PN_{ji} + C_l + B_k + e_{ijk}}$$

where μ is the general average; i is the phosphorous level (50 and 200 kg P_2O_5/ha); P_i is the effect of the phosphorus level i; j is the nitrogen level (100 and 400 kg N/ha); N_j is the effect of the nitrogen level j; PN_{ij} is the effect of the interaction between fertilization levels; C_l is the effect of the additional treatment (control); k is blocks 1, 2 and 3; B_k is the effect of block k; and e_{ijk} is the error.

Results and Discussion

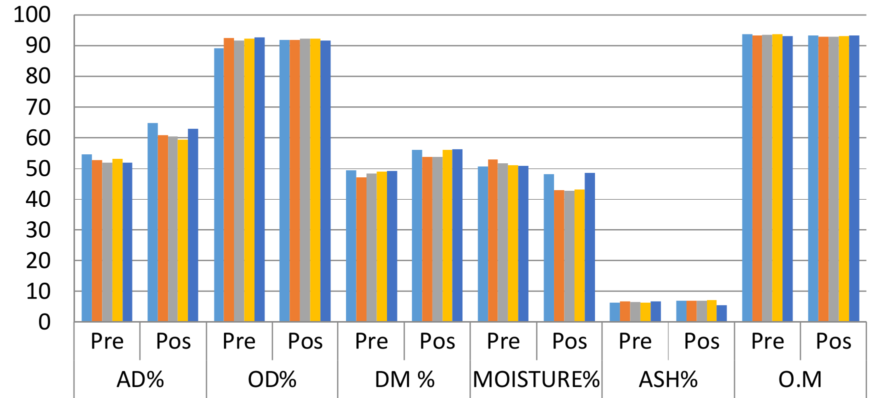
Forage composition analyses and quality of the Massai grass

In regard to forage evaluation during the three growth cycles (cycles 1, 2 and 3), there were no significant effects (P > 0.05) of nitrogen and phosphorus levels on dry matter, total dry matter, ash and organic matter content. These variables did not differ pre- and post-grazing (Figure 1), demonstrating that they were not altered by the experimental conditions. This result was not expected, as higher levels of nitrogen and phosphorus were expected to accelerate plant metabolism, resulting in an advanced physiological age, and consequently, greater dry matter content (RODRIGUES et al., 2012).

There was a significant difference (P < 0.05) between the control and other treatments for moisture content post-grazing (Figure 1), with the highest value obtained for the control treatment. This may be explained by the greater rest period (28 days) used for the control treatment than the other treatments. This longer period was implemented to offer the same conditions as the fertilized treatments.

For the plant CP, NDF, ADF, lignin and phosphate contents, there was a significant difference (P < 0.05) between the control treatment and the other treatments (Table 3). The highest values of CP were observed in treatments with 400 kg N/ha, which can probably be explained by a greater presence of free amino acids, the structure of which require nitrogen, as small peptides in the plant tissue would increase in response to greater nitrogen input in the soil (FREITAS et al., 2007). The minimum CP levels required to maintain the growth and development of microorganisms in the rumen has been reported to be 7% (VAN SOEST, 1994). Hence, all treatments reached a level of CP higher than the minimum requirements of ruminants, and consequently, the amount required by the ruminal microbiota responsible for degrading the fibrous fraction of the forage.

Figure 1. Characteristics of forage calculated on a dry matter basis pre- and post-grazing.



	AD% Pre	AD% Pos	OD% Pre	OD% Pos	DM % Pre	DM % Pos	MOISTURE% Pre	MOISTURE% Pos	ASH% Pre	ASH% Pos	O.M Pre	O.M Pos
Control	54,57	64,71	89,32	91,83	49,29	56,07	50,7	48,16	6,23	7	93,76	93,39
50 P2O5/100N	52,72	60,92	92,62	91,82	47,09	53,84	52,91	42,92	6,68	6,99	93,31	92,92
50 P2O5/400N	51,82	60,53	91,64	92,1	48,35	53,79	51,65	42,71	6,52	6,81	93,47	92,86
200P2O5/100N	53,32	59,38	92,43	92,21	48,9	56,08	51,09	43,28	6,32	7,15	93,67	93,19
200P2O5/400N	51,86	62,97	92,76	91,55	49,14	56,14	50,86	48,55	6,76	5,58	93,23	93,31

AD = pre-dry matters; DM, total dry matter; OM, organic matter; OD = dry matter; pre, pre-grazing; pos, post-grazing.

In relation to the NDF, fertilization modified the plant structure, and consequently, its nutritional quality, with the combination of 200 kg P_2O_5/ha and 400 kg N/ha showing the highest values for NDF. In terms of the result for treatment with 400 kg N/ha, higher levels of nitrogen applied at certain times of the year may alter the NDF forage content depending on the environmental conditions. This is supported by the results of Magalhães et al. (2015), who evaluated Marandu grass under irrigation and nitrogen fertilization (400 kg/ha) in a Dystrophic Yellow Latosol soil, obtaining 75% NDF. Another important factor is the management strategy used. The treatments with the highest nitrogen fertilization levels showed the highest values because the plant intensifies its cycle to increase aerial biomass and stem production, and consequently, senescence (GERON et al., 2012).

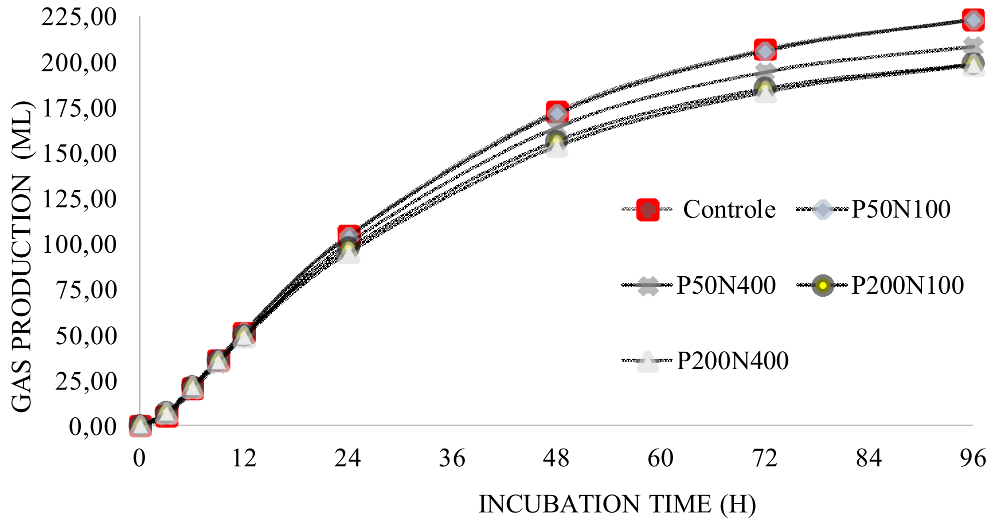
The average ADF level of the treatments that received fertilization was 44.22%. The ADF is an indicator of the digestibility and energetic value of the forage, where the lower the ADF, the higher the energy value of the plant (Figure 2). The values found for ADF in the present study were similar to those previously reported by Magalhães et al. (2007), who evaluated the effect of increasing nitrogen (0, 100, 200 and 300 kg/ha/year) and phosphorus (0.50 and 100 kg/ha/year) levels in *Brachiaria decumbens*.

Table 3. Forage evaluation of *Panicum maximum* cv. Massai submitted to nitrogen and phosphorous fertilization.

N	P_20_5			AVERAGES	P*				CV%
CP									
	0	50	200		P	N	P*N	CT*TM	
0	5.59*	-	-	-					
100	-	7.06Ab	8.86Aa	7.96	0.45	0.033	0.027	0.001	7.67
400	-	11.94Aa	10.88Aa	11.41					
AVERAGES	-	9.5	9.87	-					
NDF									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	77.73	-	-	-					
100	-	80.04Ba	79.79Ba	79.91	0.009	0.648	0.005	0.122	5.31
400	-	82.45Ba	82.7Aa	82.57					
AVERAGES		81.24	81.24	-					
ADF									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	42.11*	-	-	-					
100	-	45.39Aa	43.55Aa	44.47	0.728	0.372	0.007	0.012	4.4
400	-	42.86Aa	45.08Aa	43.97					
AVERAGES	-	44.12	44.31	-					
HEMICELLULOSE									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	37.88	-	-	-					
100	-	36.35	37.83	37.09a	0.125	0.343	0.769	0.844	11.46
400	-	37.08	39.16	38.12a					
AVERAGES	-	36.71A	38.49A	-					
CELLULOSE									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	7.24C	-	-	-					
100	-	7.66A	8.09A	7.87a	0.406	0.732	0.925	0.097	15.85
400	-	7.79	8.31	8.05a					
AVERAGES	-	7.72A	8.2A	-					
LIGNIN									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	5.32*	-	-	-					
100	-	4.33	3.62	3.97 a	0.492	0.387	0.294	0.052	42.18
400	-	3.55	3.70	3.62a					
AVERAGES	-	3.94A	3.66A	-					
PHOSPHORUS PL									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	0.086	-	-	-					
100	-	0.093	0.10	0.096a	0.072	0.141	0.741	0.342	29.3
400	-	0.086	0.09	0.08a					
AVERAGES	-	0.089A	0.095A	-					

* Significant difference between control and other treatments. CP, crude protein (% DM); NDF, neutral detergent fiber (% DM); ADF, acid detergent fiber; lignin in acid detergent (ADF); phosphorus PL present in the plant; phosphorus as P_2O_5 (kg/ha); N (kg/ha). P*N, interaction of phosphate and nitrogen fertilization; CT*TM, control treatment × all other treatments; P*, probability of type 1 error; CV%, coefficient of variation. Means followed by different capital letters in the rows and different lowercase letters in the columns differ by the Tukey test ($P < 0.05$).

Figure 2. Fermentation kinetics of Massai grass submitted to nitrogen and phosphorous fertilization.



Regarding lignin content (Table 4), higher levels were found in the treatment without fertilization when compared to the treatments with nitrogen and phosphorus fertilization. This may have occurred because lignin concentrations tend to increase as it forms part of the fibrous components with low digestibility. Maeda et al. (2007) found similar values during grazing cycles with other domestic ruminants.

Table 4. Parameters of the *in vitro* ruminal fermentation of Massai grass at different fertilization levels, using the France model and effective degradability.

France parameters	Fertilization level				
	Control	$50P_20_5$ –100N	$50P_20_5$/400N	$200P_20_5$ – 100N	200 P_20_5 – 400N
A*	238.0100	239.4000	219.9123	210.3420	212.6540
T* (h:min)	1:43	1:31	1:38	1:12	1:25
μ*	0.02787	0.02699	0.02956	0.02915	0.02733
ED** (2%)	50.1731	50.2291	47.5313	43.7149	43.3218
ED (3%)	48.8289	48.9833	46.3006	42.7664	42.2836
ED (4%)	47.5160	47.7637	45.0974	41.8343	41.2663
ED (5%)	46.2338	46.5697	43.9210	40.9185	40.2692

A, total gas (mL); T; lag time (h); μ, fractional degradation rate (h^{-1}); ED = Effective degradability.

Rumen fermentation and intake

The ruminal fermentation of Massai grass in sheep during the three growth cycles (cycle 1, 2 and 3) showed significant effects ($P < 0.05$) of the nitrogen and phosphorus levels on ruminal degradability, gas production, lag time and intake (grams of unit metabolic size).

Figure 2 shows that the control treatments and treatment with 50 kg P_2O_5/ha and 100 kg N/ha were more efficient in terms of forage degradation, indicating that the higher concentrations of phosphorous and nitrogen reduced degradation as the stem digestibility is lower than that of the leaves. The leaf:stem ratio is influenced by factors related to management of the forage, such as the grazing cycles, rest period (CÂNDIDO et al., 2005) and nitrogen and phosphate fertilization. Therefore, the gradual reduction in leaf:stem ratio with an increasing rest period and over successive grazing cycles occurs due to the continuous elongation of the stems, and the preference of the animals to consume leaves instead of the stem. The treatments with the lowest forage production presented the greatest degradability, evidencing the association between NDF and digestibility of the grass.

In relation to lag times, the treatments that received higher fertilization levels showed the shortest lag times. This is expected as higher concentrations of fertilizers modify the plant characteristics (Tables 3 and 6), making available a higher amount of soluble compounds. It can be deduced from Table 4, which shows a reduced lag time, that a reduction in effective degradation, possibly due to less retention time in the rumen, reduces the possibility for the rumen microbiota to act on the forage, which may result in reduced animal performance. These results are in agreement with those found by Valente et al. (2010).

The effective degradability of the Massai grass is within the expected range for tropical grasses (40.5–56.1%). This is similar to that observed in a study by Bamikole et al. (2004) which evaluated the dry matter digestibility of *Panicum maximum*.

There was a significant difference ($P < 0.05$) between the control and the fertilized treatments for total digestible dry matter (DDM) (Table 5), where the treatments that received fertilization obtained the highest TDM production, which is reflected in the total DDM. However, Difante et al. (2011) emphasized that pastures with higher proportions of stems and dead material influence the grazing capacity and the voluntary intake of forage, compromising the use efficiency of the grass produced.

Table 5. Total digestible dry matter content of Massai grass.

TDDM (kg/ha)									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	2817.1*	-	-	-					
100	-	3452.6	3426.6	3439.6a	0.313	0.813	0.429	<0.001	6.41
400	-	3569.7	3362.6	3466.2a					
AVERAGES	-	3511.15A	3394.6A	-					

* Significant difference between control and other treatments. TDDM, total digestible dry matter (kg/ha); P_2O_5 (kg/ha); N (kg/ha). P*N interaction of phosphate and nitrogen fertilization; CT*TM, control treatment × all other treatments; P*, probability of type 1 error; CV%, coefficient of variation. Means followed by different capital letters in the rows and different lowercase letters in the columns differ by the Tukey test ($P > 0.05$).

There was no significant difference between treatments in relation to forage intake and intake relative to body weight (Table 6). For the intake expressed as grams per kilogram of metabolic weight, the treatments that received fertilization obtained the greatest values. This variable is the best expression of animal intake (VAN SOEST, 1994).

Table 6. Massai grass intake relative to the fertilization level.

FORAGE INTAKE (kg)									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	0.894	-	-	-					
100	-	0.986	0.953	0.969a	0.188	0.973	0.546	0.192	11.04
400	-	1.011	0.925	0.968a					
AVERAGES	-	0.99A	0.93A	-					
INTAKE RELATIVE TO BW									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	3.617	-	-	-					
100	-	4.123	3.917	4.02a	0.009	0.073	0.233	0.123	7.84
400	-	4.040	3.527	3.78a					
AVERAGES	-	4.08A	3.72B	-					
INTAKE ($g.UMS^{-1}$)									
N	P_20_5			AVERAGES	P*				CV%
	0	50	200		P	N	P*N	CT*TM	
0	80500*	-	-	-					
100	-	9083	9000	9041.5 a	0.002	0.06	0.134	0.021	11.95
400	-	8683	7983	8333 a					
AVERAGES	-	8883A	8491.5B	-					

* Significant difference between control and other treatments. BW, body weight; UMS, unit metabolic size (g/ha); individual intake (kg/day); intake relative to BW (kg/ha); P_2O_5 (kg/ha); N (kg/ha); P*N, interaction of phosphate and nitrogen fertilization; CT*TM, control treatment × all other treatments; P*, probability of type 1 error; CV%, coefficient of variation. Means followed by different capital letters in the rows and different lowercase letters in the columns differ by the Tukey test (P > 0.05).

Conclusions

The forage composition of Massai grass is modified by nitrogen and phosphate fertilization at high levels, demonstrating the responsiveness of this grass to intensive management. Therefore, this grass represents another forage option for exploitation in systems of intensive production under rotational grazing.

The aspects of Massai grass are most improved by nitrogen fertilization at 100 kg N/ha and phosphate fertilization at 50 kg P_2O_5/ha, constituting a relevant management practice to increase quantity and quality.

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