PRODUCTIVITY AND NUTRITIONAL VALUE OF PAREDÃO GRASS UNDER DOSES OF POTASSIUM FERTILIZATION AND RESIDUE HEIGHTS

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ABSTRACT

The choice of forage is one of the essential factors to consider in pasture areas, as well as whether it is responsive to fertilization to facilitate management, as is the case with *Panicum maximum (syn. Megathyrsus maximus).* With this in mind, the aim was to evaluate the productivity and nutritional value of Paredão grass using doses of potassium fertilizer and residue heights in an experiment conducted in a greenhouse with a randomized block design, 5x3 factorial scheme, with five doses of potassium fertilization (0, 30, 60, 90 and 120 kg of K_2O ha^{-1}) corresponding to 0, 0.24, 0.48, 0.72 and 0.96 g of KCl /vessel, and three residue heights (5, 15 and 30 cm). Vases with a capacity of 9 dm^{-3} were used filled with soil characterized as Cambissolo, collected from the 0-20 cm depth. Data was collected every 30 days by measuring plant height and counting the number of leaves and tillers to determine dry mass, crude protein, and neutral and acid detergent fiber. A residue height of 30 cm promotes greater plant height, crude protein, and NDF content, which favors forage quality. Increasing doses of potassium resulted in lower crude protein content. We recommend fertilizing Paredão grass with doses of 88.62 kg of K_2O ha^{-1} (7.69% CP).
Keywords: crude protein, defoliation; forage; *Panicum maximum*

PRODUTIVIDADE E VALOR NUTRITIVO DE CAPIM PAREDÃO SOB DOSES DE ADUBAÇÃO POTÁSSICA E ALTURAS DE RESÍDUO

RESUMO

A escolha da forrageira é um dos fatores importantes a se considerar nas áreas de pastagens, além de que seja responsiva a adubação para facilitar o manejo como é o caso de *Panicum maximum (syn. Megathyrsus maximus).* Com esse intuito, objetivou-se avaliar a produtividade e o valor nutritivo de capim Paredão sobre doses de adubação potássica e alturas de resíduo em experimento conduzido em casa de vegetação com delineamento experimental em blocos casualizados, esquema fatorial 5x3, sendo cinco doses de adubação potássica (0; 30; 60; 90 e 120 kg de K_2O ha^{-1}) que corresponderam a 0; 0,24; 0,48; 0,72 e 0,96 g de KCl /vaso, e três alturas de resíduo (5; 15 e 30 cm). Foram utilizados vasos com capacidade de 9 $dm^{3,}$ preenchidos com solo caracterizado como Cambissolo, coletado na camada de 0-20 cm de profundidade. As avaliações foram realizadas a cada 30 dias, determinando a altura de planta, número de folhas, número de perfilhos, massa seca, proteína bruta, fibra em detergente neutro e ácido. A altura de resíduo de 30 cm promove maior altura de planta, teor de proteína bruta e FDN, o que favorece a qualidade da forragem. Doses crescentes de potássio proporcionaram menor teor de proteína bruta. Recomenda-se a adubação do capim Paredão com doses de 88,62 kg de K_2O ha^{-1} (7,69% de PB).
Palavras-chave: desfolhação; forragem; proteína bruta; *Panicum maximum*

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INTRODUCTION

Brazil is the most considerable potassium (K) importer and the most critical nutrient. In 2022, it imported 40% of its K from Russia and Belarus, with a 36% share of the global supply. Countries such as Canada, China, Nigeria, and Israel have increased the supply of fertilizers in Brazil, with China and Canada being the most prominent exporters from January to April 2022, exporting around 1.7 million and 1.1 million tons, respectively (RABORESEARCH, FOOD & AGRIBUSINESS, 2022).

The annual increase highlights the growing need to use fertilizers in pasture areas to increase productivity and the producer's income (ANDA, 2021).

Nitrogen, potassium, and phosphate fertilization in pastures is essential to replenish the soil with the nutrients that the plants absorb and are exported by the animals and those that have been leached or lost. Fertilizing forage plants also promotes a more significant accumulation of green mass per hectare (SANTOS et al., 2016).

Potassium contributes to the physiological and photosynthetic processes that occur in plants, such as altering the growth and productivity of crops. It also acts to regulate the opening and closing of stomata, limiting water loss in the plant. It also participates in numerous biochemical processes such as carbohydrate metabolism (synthesis, translocation, and storage), protein synthesis, neutralization of organic acids, and pH regulation (TAIZ et al., 2017).

In addition to fertilization, it is important to pay attention to the height of the residue and the choice of forage with high productivity per area and responsiveness to fertilization. Among these characteristics are the genera *Pennisetum, Cynodon, Megathyrsus, and Urochloa* (SOUSA SILVA et al., 2019), and *Megathyrsus* stands out as a highly demanding forage that is responsive to fertilization. It is a grass with a cespitose growth habit with excellent regrowth vigor and high forage production.

Of this genus, the best-known and most widely used forage is *M. maximus* cv. Mombaça. In view of its persistent use, other cultivars have emerged, such as *M. maximus* cv. MG-12 Paredão. In order to learn about fertilizer management strategies for this new cultivar, the aim was to evaluate the productivity and nutritional value of Paredão grass under different doses of potassium fertilizer and residue heights.

MATERIAL AND METHODS

Location and experimental design

The experiment was carried out in a greenhouse at the Faculty of Agronomy and Zootechnics (UFMT), Cuiabá campus. *Megathyrsus maximus* Paredão grass was used.

The experimental design was in randomized blocks, in a 5x3 factorial scheme: five doses of potassium fertilizer, using potassium chloride as a source ((0, 30, 60, 90, and 120 kg of K_2O ha^{-1}) and three cutting heights (5, 15 and 30 cm), totaling 60 plots (pots). The pots were arranged in four blocks of 15 pots, containing the five treatments and the three heights.

Soil collection and characterization

The soil sample was collected from the 0 to 20 cm depth layer at the UFMT Experimental Farm, located in the municipality of Santo Antônio do Leverger - MT, characterized as Cambissolo according to the Brazilian Soil Classification System (SANTOS et al., 2018). The soil sample was air-dried, sieved, and then analyzed chemically and granulometrically according to the methodology of Teixeira et al. (2017) (Table 1).

Table 1- Chemical and granulometric characteristics of the soil at a depth of 0-20 cm

Ca	Mg	Al	H+Al	SB	T	V
		cmolcdm3				%
1.08	1.02	0.01	1.43	2.11	3.53	59.64
pH CaCl2	**K**	**P**	**Clay**	**Silt**		**Sand**
	mg dm3			g/kg		
5.44	2.19	5.71	540	91		369

pH = acidity, P = phosphorus, K = potassium, Ca = calcium, Mg = magnesium, H+Al = hydrogen plus aluminum, SB = sum of bases, T = cation exchange capacity, V = base saturation.

Setting up and carrying out the experiment

The post-analysis soil sample was transferred to pots with a capacity of 9 dm^3, as the soil's base saturation was at a high level according to the fertility classification of Souza and Lobado (2004) and based on the requirements of Mombaça grass (VILELA et al., 2007), it was not necessary to apply lime. The seeds were sown directly into the pot. $^{-1}$Phosphate fertilization was then applied, with 20 mg dm^3 of P_2O_5 in the form of simple superphosphate (18% P_2O_5, 16% Ca, and 8% S), corresponding to 90 kg ha^{-1}.

Irrigation was carried out daily by weighing the pots. Thinning was carried out 15 days after emergence (DAE), leaving the five most vigorous plants in each pot and maintaining humidity at around 60% of field capacity. After six days of thinning, a uniform cut was made at a height of 20 cm.

Nitrogen and potassium fertilization was carried out after the uniformization cut, using ammonium sulfate ($(NH_4)_2SO_4$) (21% ammonium and 24% sulphur) as the source, using 150 mg dm^{-3} of N/vessel corresponding to 150 kg N ha^{-1}.

The respective doses of potassium were applied at 0, 30, 60, 90, and 120 kg ha^{-1}, which corresponded to 0, 0.24, 0.48, 0.72 and 0.96 g of KCl $vase^{-1}$, using KCL fertilizer (58% K_2O) as the source. The pots were then irrigated. Three cuts were made at 30-day intervals, the first two at 5, 15, and 30 cm from the base of the plant, in order to provide regrowth, but the last cut was made close to the ground.

Morphological composition and productivity

The following morphological variables were measured at each cutting: plant height in each pot, number of leaves per pot, number of tillers per pot, and dry mass yield. Plant height was measured using a graduated ruler, taking into account the distance from the base to the apex and carried out every 30 days before cutting.

The leaves, tillers, and stalks contained in the experimental unit were counted manually after each cut at the respective heights, in which the green mass was weighed first, and the leaves and tillers were separated after weighing.

The green mass of the aerial part was obtained by weighing it on an analytical balance. The green mass was placed in a forced-air oven at 55˚C to dry until it reached a constant mass, and then the dry mass was obtained by weighing it on an analytical balance.

Bromatological composition

The total nitrogen (TN) content was determined using the Kjeldahl method to obtain the crude protein (CP) content. The TN content was multiplied by the conversion factor of 6.25, considering that most proteins contain 16% TN in their molecules (SILVA & QUEIROZ, 2002). The method described by Van Soest (1994) was used for the NDF and ADF contents.

Statistical analysis of data

The data was submitted to analysis of variance and regression for the quantitative factors (potassium doses) and analysis of variance and test of means (Tukey at 5%) for the qualitative factors (cutting height), using the SISVAR statistical program (FERREIRA, 2015).

RESULTS AND DISCUSSION

Plant height, number of tillers, leaves, and dry mass as a function of residue height

Cutting height had a significant effect on plant height and dry mass. The 30 cm cutting height provided the most critical plant height. On the other hand, at the 5 cm residue height, the dry mass of the aerial part was greater (Table 2). According to Rodrigues et al. (2008), this growth is due to increased photosynthetic efficiency and potassium acting on nitrogen metabolism in the plant's meristematic growth, thus growing biomass production (SOUZA et al., 2007).

Table 2. Plant height, number of tillers (NT), leaves (NL), and dry mass (DM) of Paredão grass as a function of residue height.

Variables	Residue heights			CV (%)	Pr >F
	5	15	30		
Plant height (cm)	82.00 b	85.00 ab	91.00 a	12.04	0.0285**
NT (pot)	25.83	25.59	23.93	18.13	0.4712ns
NL (leaves pot)$^{-1}$	101.65	95.05	89.03	17.83	0.0762ns
DM (g pot)$^{-1}$	15.39 a	13.33 b	10.71 c	8.29	0.0000**

Means followed by the same lowercase letter in the columns do not differ (P>0.05) by the Tukey test. CV: Coefficient of Variation. **: Significant at the 1% probability level by the F test.

The height of the residue is a very important variable to consider, as lower residue heights induce the removal of apical meristems, which makes it difficult to maintain the remaining leaf area and growth points, hindering the regrowth of the forage plant (COSTA et al., 2016). In contrast, the high height allows for a greater accumulation of thatch and dead material, which is detrimental to animal performance (Author). Because of these responses, it is important to observe the height of the residue for each forage plant, always using the management ruler.

Even though the Paredão grass, at a height of 5 cm, did not reach a similar height to the 30 cm cut, the plant still reached an average of 9 cm less in its attempt to survive than the 30 cm cut. According to Costa et al. (2016), it is not advisable to keep the cutting height at 5 cm in the field since this removes the apical meristem and causes the plant to develop new leaves that are continually grazed, making future regeneration more challenging.

Plant height, number of tillers, leaves, and dry mass as a function of potassium fertilizer doses

Potassium doses had a significant linear effect (P <0.01) for dry mass. There was no adjustment for the other variables, with average values of 24.93 and 92.25 for several tillers and several leaves, respectively (Table 3).

Table 3. Plant height, number of tillers (NP), leaves (NL) and dry mass (MS) of Paredão grass as a function of potassium fertilization doses.

Variables	Potassium doses (kg ha-1)				
	0	30	60	90	120
Plant height (cm)	83.00	84.00	87.00	82.00	92.00
NT (tillers pot $)^{-1}$	22.83	24.77	23.94	28.22	24.91
NL (leaves pot $)^{-1}$	93.52	94.16	91.64	98.22	98.75
DM (g pot $)^{-1}$	9.89	13.06	13.28	13.95	15.53
	EQUATION			**R^2**	**CV (%)**
Plant height (cm)	$\bar{Y}$= 86.00			-	12.04
NT (tillers pot $)^{-1}$	$\bar{Y}$= 24.93			-	18.13
NL (leaves pot $)^{-1}$	$\bar{Y}$= 95.26			-	17.83
DM (g pot $)^{-1}$	$\hat{Y}$= 10.3192+0.0666X**			0,9	8.29

CV: Coefficient of Variation. **: Significant at the 1% probability level by the F test.

In the study by Motta et al. (2023), potassium fertilization significantly influenced forage mass, tiller density, and residue mass, regardless of the dose of nitrogen, and had an effect on both residues mass and forage mass. According to these authors, the absence of potassium can harm the development of the cultivars of *Megathyrsus maximus* cv Mombaça and Zuri.

Dry mass production increased from 10.31 to 18.31 g kg-1 with each kg of K_2O ha-1 applied. Similar results were obtained by Costa et al. (2012), evaluating doses of potassium chloride (0, 15, 30, 45, and 60 mg kg-1 of soil) in Mombasa grass with an increase in dry mass and a decrease in PB and phosphorus levels as the doses of fertilization increased. Potassium fertilization interferes with plant development, which means that combining nitrogen and potassium with phosphate fertilization increases the production and quality of the forage (FARIA et al., 2015).

Coutinho et al. (2014) observed significant increases in dry mass production when Tifton 85 grass was subjected to potassium fertilization due to the drop in concentrations of other macronutrients. However, with the increase in potassium doses, there was a dilution effect; since potassium influences the plant's ability to regrow, and cutting results in a decline in soluble carbohydrates, the plant, in an attempt to restore its leaf area, produced leaves with greater leaf area, increasing dry mass production.

Cruz et al. (2021) evaluated doses of KCl in *Urochloa brizantha* cv. Paiaguás grass observed that at the highest doses of KCl in the first two cuts, there were no differences in the number of tillers. The highest number of tillers in the highest dose of KCl occurred only in the third cut. There was an increase in dry mass as the doses increased. This increase may be due to the increase in leaf area.

The bromatological composition as a function of residue height

There was a significant effect on the levels of CP and NDF. Cutting at a height of 30 cm resulted in higher levels of CP and NDF. On the other hand, slashing at 5 cm did not result in a higher dry mass of the aerial part (Table 4).

The height of the residue influences the content of CP and NDF, as plants subjected to severe defoliation suffer damage to the formation of new leaves. This intense defoliation eliminates a large amount of leaf area, leading to a more significant reduction in photosynthetic capacity, which slows down regrowth and can influence the fiber and protein content of the forage (DIAS et al., 2007).

Table 4. Bromatological composition of Paredão grass as a function of residue height

Content (%)	Residue heights			CV (%)	Pr >F
	5	15	30		
CP	8.01 b	8.91 a	9.41 a	10.85	0.0002**
NDF	71.32 b	71.76 b	73.04 a	2.10	0.0025**
ADF	53.19	51.97	52.81	7.02	0.2007ns

Means followed by the same lowercase letter in the columns do not differ (P>0.05) by the Tukey test. CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber CV: Coefficient of Variation. **: Significant at the 1% probability level by the F test.

According to Costa et al. (2017), the higher proportion of NDF in the 30 cm height (73.04%) is due to the residual height, which is one of the factors that directly influence the bromatological composition of the forage. The higher residual height, due to the less aggressive cutting, provided more elevated levels of fibrous components and plant protein because, as shown in Table 2, the 30 cm height (91 cm) had the highest plant height and contained higher proportions of structural components of the stalk fraction, resulting in higher fiber content.

The NDF contents were similar to those obtained by Schnellmann et al. (2020). These authors evaluated two cutting heights (15 and 30 cm), three cutting frequencies (30, 45, and 90 days), and two evaluation times (90 and 180 days) and observed that missing height and evaluation time had a significant influence ($p<0.01$) on the NDF content. In addition, the cutting height of 30 cm led to increases in the dry mass of the aerial part and the number of stalks and leaves.

A study by Van Soest (1991) found similar values of NDF and ADF, in which the content found in the forage *Megathyrsus maximus* cv. Colonião was 77.5 and 50.00 of NDF and ADF, respectively.

Euclides et al. (1992), when studying some cultivars of *Megathyrsus maximus*, pointed out that NDF values between 75 and 80% are common in older grasses, considering it rare for them to be below 55% and expected for them to be above 65%. In the present study, we thought this value was average for NDF values.

CP, NDF, and ADF as a function of potassium fertilization doses

Regarding the CP content (Table 5), there was a quadratic effect of the potassium doses, and in this study, we obtained the minimum point (7.69% CP) at a dose of 88.62 kg K_2O ha-1. All the potassium doses met the minimum requirement of 7% CP, as Valadares et al. (1997) recommended, as lower levels can reduce intake and hinder rumen fermentation. The lower CP content is due to the higher proportion of thatch in the forage.

Table 5. Bromatological composition of grass. Paredão grass as a function of potassium fertilization doses.

Variables	Potassium doses (kg $^{ha-1}$)				
	0	30	60	90	120
CP (%)	11.30	7.97	8.40	8.37	7.81
NDF (%)	71.73	71.92	71.46	72.43	72.67
ADF (%)	53.09	54.20	50.77	53.33	51.90
	EQUATION			**R^2**	**CV (%)**
CP (%)	$\hat{Y}=9.2453-0.0709X^{**}+0.0004X^{2**}$			0.75	10.85
NDF (%)	$\bar{Y}= 72.04$			-	2.10

ADF (%)	$\bar{Y}$= 52.66	-	7.02

CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber CV: Coefficient of Variation.
**: Significant at the 1% probability level by the F test.

Although the CP content had a significant linear effect (P <0.01) as a function of the potassium doses, the CP content decreased as the doses increased. There was no adjustment for the other variables, with average values of 73.04% and 52.06% for the NDF and ADF, contents respectively.

The evaluation of the aerial part (leaves and tillers) of the grass probably caused the high ADF content. Assessing plant structures (leaves and tillers) together results in an increase in the ADF content, according to Rego et al. (2003).

Interaction between potassium doses and residue height on dry mass

There was an interaction between the doses of potassium and the height of residue for the dry mass productivity variable. As the doses of potassium increased, the dry mass increased at all cutting heights, with an increase of 0.047, 0.042, and 0.005 g/vessel per kg of K_2O ha^{-1} applied at 5, 15, and 30 cm residue heights, respectively (Table 6).

Table 6- Dry mass productivity (g pot^{-1}) of potassium doses and residue heights in the grass *Megathyrsus maximus* cv. Paredão.

Height	Potassium doses (kg $^{ha-1}$)				
cm	0	30	60	90	120
5	10.99 a	15.92 a	15.77 a	16.52 a	17.75 a
15	10.11 ab	13.20 b	13.06 b	14.37 b	15.90 a
30	8.56 b	10.06 c	11.01 c	16.52 c	12.94 b
EQUATION					R^2
$\hat{Y}$= 12.5715+0.0470X**					0.75
$\hat{Y}$= 10.7810+0.0424X**					0.90
$\hat{Y}$= 8.7810+0.0057X**					0.92
CV (%): 8.29					

[1]Means followed by the same letter in the columns do not differ (P>0.05) by the Tukey test.
**: Significant at the 1% probability level by the F test.

Sbrissia and Silva (2008) evaluated different heights (10, 20, 30, and 40 cm) in *Urochloa brizantha* cv. Marandu grass pointed out that the height choice depends on seasonal canopy size adjustments. In winter and early spring, the height of 20 cm provided more excellent forage production. In late spring and summer, maintaining heights above 30 cm increased leaf area. These same authors point out that greater leaf area is due to competitive ability based on tolerance to grazing, and lower leaf area helps with resistance to stresses such as water deficit or cold. In the present experiment, the Paredão grass showed the same behavior, increasing its leaf area to resist the pressure when cut.

The results were also similar to those obtained by Macedo et al. (2021), in which plants subjected to higher cutting or grazing intensities increased their leaf angle, which is negatively correlated with plant height. The increase in the angle of the leaf and the decrease in size represent a mechanism used for protection, changing the position of the leaves to a more prostrate shape, which is characterized as phenotypic plasticity.

CONCLUSION

A residue height of 30 cm promotes greater plant height, crude protein, and NDF content, which favors forage quality. Increasing doses of potassium resulted in lower crude protein content. Doses of 88.62 kg of K_2O ha^{-1} (7.69% CP) are recommended for Paredão grass.

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