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Fertilization of nitrogen and potassium in Marandu grass

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Abstract. Nitrogen and potassium are the nutrients most extracted by forage grasses, in which identify the appropriate dose is necessary for a efficient fertilization response. making it essential to identify the appropriate doses for efficient fertilization. Therefore, this study aimed to determine the maximum nitrogen dose to be fertilizedfor Marandu grass and to assess whether potassium supplementation increases the efficiency of nitrogen fertilization. The experiment was conducted at the Experimental Farm of the Federal University of Mato Grosso, which is located in the municipality of Santo Antônio do Leverger. A completely randomized design was used, with 10 treatments arranged in a 5×2 factorial scheme, with 3 replications. The treatments consisted of five nitrogen doses (0, 25, 50, 75, and 100 kg N ha^{-1}) and two potassium doses (0 and 25 kg K_2O ha^{-1}) applied after each regrowth cycle. The fertilizers used were ammonium sulfate and potassium chloride. The variables analyzed were forage accumulation, percentage of leaf blades, stem + sheath, tiller population density, ground cover, forage participation, and biomass of invasive plants. Nitrogen fertilization enhanced forage accumulation, altered the morphological composition, and increased tillering. In contrast, potassium fertilization promoted only an increase in forage accumulation. Forage accumulation and growth rate increased with nitrogen application up to 50 kg ha^{-1} per regrowth cycle, which also led to higher tiller population density. When potassium (K_2O) was applied at 25 kg ha^{-1}, forage accumulation increased by 10%, 12%, and 18% in combination with nitrogen doses of 0, 25, and 50 kg ha^{-1}, respectively, compared to treatments without potassium. However, an economic viability analysis is recommended to ensure the rational use of potassium inputs. Therefore, the recommended nitrogen dose per defoliation cycle for Marandu grass is 50 kg ha^{-1}, and potassium fertilization clearly enhances the efficiency of nitrogen fertilization.
Keywords: *Brachiariabrizantha*, forage accumulation, maintenance fertilization, replacement fertilization

Introduction

The longevity and productivity of pastures are directly related to several factors, in which the appropriate choice of forage species stands out. Therefore, the most cultivated forage grasses in Brazil belong to the genus *Brachiaria* (Landau et al., 2020) because of their ability to adapt to the most diverse types of soils and climates.

Due to its wide adaptability, marandu grass is often cultivated in soils with low natural fertility, which are not able to adequately meet the nutritional demand of forages. The lack of nutrients associated with inadequate management, such as the absence of maintenance fertilization and the high stocking rate, results in low forage production and, consequently, in pasture degradation.

In more advanced stages, pasture degradation can lead to soil degradation, as it is exposed and susceptible to erosion. According to Dias-Filho (2023), pasture degradation is characterized by reduced plant vigor, decreased productivity, and decreased carrying capacity and nutritional value of the forage, which are factors that directly impact animal performance.

One of the strategies to recover pastures or slow the degradation process is to restore soil fertility. Nitrogen is the nutrient that most strongly promotes changes in the growth of grasses. The nitrogen dose is a determinant of the number of tillers and the production of dry mass of the leaf blades (Wasselai et al., 2020). In addition, this nutrient contributes to the increase in protein content in forage (Silva and Silveira, 2023).

Table 1. Chemical and particle size characterization of the soil of the experimental area with *U. brizantha*cv. Marandu

pH	P	K	Ca+Mg	H+Al	CTC	V	m	Sand	Silte	Clay
CaCl2	mg dm^{-3}		CMOCC $^{DM-3}$			%		g $^{kg-1}$		
4,5	9,4	51	2,2	5,1	7,4	31	17	748	58	194

Thus, nitrogen is a fundamental macronutrient for the productive maintenance of pasture and, therefore, must be applied through fertilization, since the nitrogen made available by the mineralization of organic matter is not enough to meet the demand for grasses with high productive potential (Silva et al., 2024).

Another important macronutrient in forage production is potassium, which, along with nitrogen, is the second most abundant nutrients extracted by forages (Muniz, 2020). Although potassium does not form structural compounds, this nutrient is involved in essential physiological processes, such as osmotic regulation, the opening and closing of stomata, and the synthesis and stability of carbohydrates and proteins. This nutrient also positively influences dry matter production and tiller production, as evidenced by Bet (2021).

It is evidenced that there is a proportional increase in potassium extraction when the nitrogen supply is increased (Yin et al., 2023), in which synergism between these nutrients is likely to occur. In addition, there are few recent field studies on potassium fertilization in pastures (Nascimento et al., 2021; Philp et al., 2021; Fernandes et al., 2022). Therefore, the objectives of this study were to verify whether potassium supply increases the efficiency of nitrogen fertilization and to identify the individual effects of nitrogen and potassium fertilization on the development of marandu grass.

Material and methods

The experiment was conducted at the experimental farm of the Federal University of Mato Grosso, located in the municipality of Santo Antônio do Leverger. The experimental design was completely randomized, with a factorial 5 × 2arrangement, with ten treatments, and three replications. The treatments consisted of application of five doses of nitrogen (0, 25, 50, 75 and 100 kg ha^{-1}) and two doses of potassium (0 and 25 kg ha^{-1}), which were applied after each regrowthcycle of marandu grass (*Brachiaria brizantha* cv. Marandu; Sin. *Urochloa brizantha* cv. Marandu). The study was carried out in two successive rainy seasons: from October 2017 to May 2018 and from October 2018 to May 2019.

For the chemical and granulometric analysis of the soil, 20 samples distributed throughout the experimental area were collected and composited for chemical and granulometric characterization (Table 1).

The experimental trial was implemented in an area of 960 m^2 with marandu grass established in 2010.In October 2017, the grass was cut to standardize the grass, maintaining a residual height of 20 cm above ground level, followed by the application of lime (ENP: 81%) and phosphate fertilization according to Martha Junior et al. (2007). The treatments with nitrogen and potassium fertilization were applied immediately. The fertilizers used were monoammonium phosphate, ammonium sulfate and potassium chloride, which are sources of phosphorus, nitrogen and potassium, respectively.

After each evaluation, the entire residue height of the plot was standardized with the aid of a manual mechanical grass cutter, and the treatments were reapplied. In both years, on the first and last cutting of each treatment, the condition of pasture degradation was evaluated measuring the percentages of forage participation and soil cover, according to the methodology of Campbell and Arnold (1973) by means of a 1 m² (1.0 × 1.0 m) frame, measured at three random points per experimental unit. In the last evaluation of the forage mass, the tiller density was quantified, determined by counting all the tillers contained in a square of 0.09 m² (30 cm × 30 cm).

When the forage canopy of each treatment reached the pre-harvest height of 40 cm, the quantification of the forage mass and the evaluation of the tiller population density were carried out. Forage collection was carried out with respect to the recommended post-grazing height for marandu grass, according to Euclides et al. (2014). The forage mass was estimated from the collection of the biomass present in three frames of 1.0 m² per experimental unit.

The harvested forage biomass was subsequently weighed and subjected to botanical (forage and invasive plants) and morphological (leaf blades, stem + sheath and dead material) separation. The material was subsequently placed in paper bags and dried in oven with air circulation at 55 ± 5 °C for 72 hours, after which the dry mass was weighed.Forage accumulation was obtained by adding the forage mass of all harvests during the rainy season.

The individual effects of nitrogen and potassium fertilization and the interactions between the factors were evaluated via analysis of variance. The effect of nitrogen fertilization was evaluated via the F test to identify the regression models (linear and quadratic). The effect of potassium fertilization was analyzed via Tukey's test. For all tests, a level of 5% significance was adopted.

Results and Discussion

There was no interaction between nitrogen and potassium for any of the variables evaluated (*P > 0.05)*. Nitrogen had an isolated effect on all the variables analyzed (*P* < 0.0001). Potassium fertilizationincreased only the forage mass (Table 2).

Nitrogen fertilization promoted an increase in forage accumulationup to a dose of 50 kg ha$^{-1;}$ thus, at higher doses, no significant increase was observed (Figure 1). According to Lima et al. (2021), nitrogen increases the forage mass, the appearance of leaf blades and stems, and consequently tillers. The absence of an increase in forage accumulation with doses greater than 50 kg ha^{-1} of nitrogen may be related to the leaching of nutrients (PRIMAVESI et al., 2006) or to luxury consumption, characterized by the accumulation of nitrogen in the leaves without a corresponding increase in productivity (SALES et al., 2020).

Table 1. Summary of the analysis of variance for the effect of nitrogen (N), potassium (K) fertilization and interaction between the factors (N*K)

Variable	N	K	N*K	EPM
Forage accumulation	<0.0001	<0.0001	0,2141	343,64
Leaf blades	<0.0001	0,6270	0,9330	0,92
Stem + sheath	<0.0001	0,6525	0,8590	0,60
Tiller population density	<0.0001	0,7356	0,6153	37,89
Ground cover	<0.0001	0,2860	0,2455	1,43
Forage participation	<0.0001	0,0790	0,2922	1,85
Invasive plant mass	<0.0001	0,8558	0,7121	106,50

EPM: standard error of the average

In addition to increasing the forage accumulation to a dose of 50 kg ha^{-1}, nitrogen fertilization also promoted an increase in the number of tillers, greater ground cover, greater participation of forage and absence of invasive plant mass (Table 2).The increase in tillering resulted in a denser ground cover, contributing to protection against erosive processes and making it difficult to establish undesirable species.This effect of weed suppression through nitrogen fertilization was demonstrated by Sales et al. (2020) and Mekdad et al. (2021).

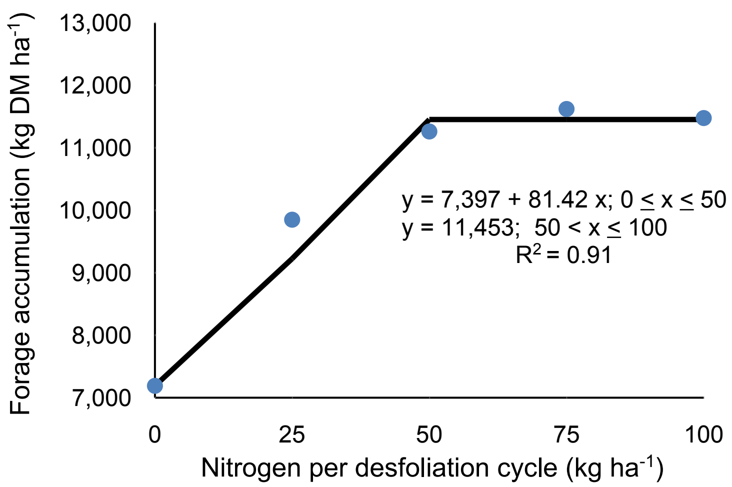

Figure 1. Forage mass of marandu grass fertilized with various nitrogen doses and potassium.

In the absence of potassium, the application of 25 kg ha^{-1} of nitrogen resulted in the presence of weeds. However, when this same dose of nitrogen was combined with potassium fertilization, no weeds were observed, indicating the importance of potassium in combination with nitrogen.

Similar to the forage accumulation, an increase in tillering was observed up to the nitrogen dose, per regrowth cycle, of 50 kg ha^{-1}, the same dose that extinguished the presence of invasive plants. To avoid the degradation of Marandu pastures, nitrogen doses greater than 25 kg ha^{-1} should be used per defoliation cycle, as soil cover and forage participation above 95% were obtained.

When fertilized with potassium at a dose of 25 kg ha^{-1}, at each regrowth cycle, the forage accumulation was greater than in the absence of potassium fertilization. However, potassium does not influence tillering, since its influence on tillering is more indirect, as evidenced by Nascimento (2021). Potassium is important for the flow of water in plants and controls the loss of water from leaves through transpiration. When a plant is deficient in this nutrient, photosynthesis decreases, and respiration increases, which reduces the supply of carbohydrates to the plant, making it difficult to efficiently incorporate nitrogen (Luz, 2023).

Table 2. Forage mass, morphological composition and invasive species of Marandu grass fertilized with nitrogen and potassium.

K2O	N (kg ha^{-1})						*P value*		
(kg ha^{-1})	0	25	50	75	100	Average	L	LP	Q
Forage accumulation(kg DM ha^{-1})									
0	6,774	8,876	10,388	9,945	10,717	9,340B			
25	7,482	9,948	11,915	12,878	12,045	10,854A			
Average	7,190	9,849	11,261	11,621	11,476		<0.001	<0.001	<0.001
Leaf blades (%)									
0	26	33	33	32	33	31 A			
25	28	34	33	33	33	32 A			
Average	27	33.619	33	33	33		<0.001	<0.001	<0.001
Stem+Sheath (%)									
0	14	16	17	17	17	16 A			
25	13	17	17	18	17	17 A			
Average	13	16	17	17	17		<0.001	<0.001	0,007
Tiller density (n° m^{-2})									
0	558	570	808	901	892	746A			
25	460	625	846	945	912	757 A			
Average	502	601	830	926	903		<0.001	<0.001	0,010
Ground cover (%)									
0	88	94	97	99	100	94 A			
25	82	95	100	99	95	96 A			
Average	85	95	99	99	97		<0.001	<0.001	<0.001
Forage participation (%)									
0	68	95	97	100	100	92 A			
25	78	98	100	100	99	95 A			
Average	74	96	99	100	100		<0.001	<0.001	<0.001
Invasive (kg DM ha-^{1})									
0	1.018	175	0	0	0	238 A			
25	1.282	0	0	0	0	256 A			
Average	1.150	87,5	0	0	0		<0.001	<0.001	<0.001

Thus, both nitrogen and potassium influence the development of Marandu grass, with nitrogen being the nutrient with the greatest impact, as it positively affected all the variables analyzed. Although potassium fertilization also contributes to the increase in forage accumulation, it is important to consider its economic viability, since potassium represents a significant additional cost in terms of fertilization. In situations of recovery of degraded pastures, especially when there are financial constraints, prioritizing the use of nitrogen is recommended. This is because in addition to increasing forage production, nitrogenfertilization improves ground cover, increases the participation of forage in the area and reduces the presence of weeds.

Conclusions

Nitrogen and potassium fertilizers increase the mass of marandu grass. It is recommended that the dose of nitrogen applied is up to 50 kg ha^{-1} at each regrowth cycle. A potassium dose of 25 kg ha-1 can also be fertilized for each regrowth cycle. When selecting between nitrogen and potassium fertilization for pasture recovery, priority should be given to nitrogen, as it plays a more critical role in stimulating forage regrowth and increasing forage accumulation.

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