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What is the maximum nitrogen in marandu palisadegrass fertilization?

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Abstract

The absence of nutrient replacement, especially nitrogen (N), is one of the main causes of grazing system underutilization and tropical climate pasture degradation. Therefore, N is a very important nutrient in the pasture maintenance; however, it is necessary to know the maximum limit to be used of this nutrient, since fertilization increases production cost. Thus, the objective of this study was to identify the N dose that provides the highest production of marandu palisadegrass (*Brachiaria brizantha* cv. Marandu), and the fertilization effect on pasture degradation process and forage nutritive value. Treatments consisted in the application of : 0 (control), 25, 50, 75 and 100 kg N ha^{-1} $cycle^{-1}$ of regrowth. The evaluations were carried out during the summers (November to April) of 2015/2016 and 2016/2017. The highest dry matter yield (DMY) and forage accumulation rate (FAR) occurred between doses of 50 and 75 kg ha^{-1} $cycle^{-1}$, with no change in productive potential at higher doses. The reduction in mineral content and the increase in crude protein (CP) are the main changes in the nutritional value of marandu palisadegrass, with no pronounced effect on in vitro dry matter digestibility (IVDMD), indigestible neutral detergent fiber (iNDF) and potentially digestible dry matter proportions of CP in the cell wall (CP_{CW}) and in cellular content (CP_{CC}).The productive effect of nitrogen fertilization under marandu palisadegrass is the increase in DMY and FAR. Thus, the use of nitrogen fertilizers in pasture systems with marandu palisadegrass has a greater impact on the area gain than the individual gain, assuming these systems, the use of nitrogen doses of 50 to 75 kg ha^{-1} $cycle^{-1}$.

KEYWORDS

ammonium sulfate, chemical composition, maintenance fertilization, tillering, *Urochloa brizantha*

1 | INTRODUCTION

In central region of Brazil, the Cerrado predominates, a biome with areas of low natural fertility and exploration in an extractive way, without the necessary replacement of the nutrients extracted, which results in a system with high levels of pasture degradation. It is estimated that about 60% of the Brazilian pasture in the Cerrado biome is in some degradation stage, due to inadequate management practices ranging from the implantation of the livestock system to the inadequate maintenance of forage production (Euclides et al., 2010). The lack of nutrient replenishment, mainly N, and high stocking rates are the main causes of tropical climate pasture underutilization and degradation (Boddey et al., 2004). Under these conditions, it is observed reductions in forage production, leading to the lower support capacity of the pastures, thus damaging the productivity of grazing animals (Campos et al., 2016; Pontes et al., 2017). Moreover, nitrogen (N) scarcity reduces plant coverage, which favors the emergence of invasive plants (Sunding, Le Jeune, & Seastedt, 2004), which compete with forage grasses.

Thus, nitrogen fertilization for well-managed forages is an important strategy in the animal production system in pastures, as it increases forage accumulation, in response to increased leaf elongation rate, leaf area index and population density of tillers (Paciullo et al., 2017; Silva et al., 2016; Teixeira et al., 2014; Yasuoka et al., 2018). Therefore, nitrogen fertilization is a way of restoring the productivity of degraded pastures.

Another positive aspect in the nitrogen fertilization is the change in the forage nutritive value, with an expressive increase in the crude protein (CP) content in fertilized forage. However, the efficiency of nitrogen fertilization on the increase in the nutritive value of forage species can be reduced with the increase in N application (Bernardi, Silva, & Baretta, 2018). In the case of xaraes grass (*Brachiaria brizantha* Jacq. cv. Xaraés), it was observed that the nitrogen fertilization provides greater changes in the CP content than in the in vitro dry matter digestibility coefficients and in the levels of neutral detergent insoluble fiber (NDF; Campos et al., 2016). In addition to variation in CP content, nitrogen fertilization provides changes in the levels of fast and slow digestion protein fractions (Johnson, Reiling, Mislevy, & Hall, 2001).

Considering the above, it is evident that the addition of N in pastures provides an increase in forage accumulation and changes in growth dynamics and forage nutritive value. However, it must be considered that there is an increase in the cost of production, demanding knowledge about the maximum biological response limit of the forage. Besides that, the use of nitrogen fertilization erroneously, more that required for maximum forage growth, may result in increased nitrate (Chakwizira et al., 2015), a compound toxic to animals and which can be leached into ground and surface water (Jankowski et al., 2018), causing major environmental problems.

Through this knowledge, it will be possible to carry out economic studies of the grazing system which use marandu palisadegrass, which is the main forage present in Brazilian pastures, since it is considered the largest monoculture in the world (Jank, Barrios, Valle, Simeão, & Alves, 2014).Therefore, the objective of this study was to identify the N dose that provides the highest production of marandu palisadegrass, and the fertilization effect on the pasture degradation process and forage nutritive value.

2 | MATERIAL AND METHODS

2.1 | Experimental area

The experiment was carried out at the Experimental Farm of the Federal University of Mato Grosso, in the city of Santo Antônio do Leverger, Mato Grosso, Brazil (15°51'08.6 "S, 56°04'15.2" W, altitude of 141 meters). The experimental period covered the two-year summer (November to April): 2015/2016 (summer 1) and 2016/2017 (summer 2). The climatological variables were collected at the Padre Ricardo Remeter Meteorological Station, located 1,000 meters from the experimental area (Figure 1). Water balance (Thornthwaite & Mather, 1955) was calculated considering an available water capacity of 40 mm. The climate of the region, according to Köppen classification, is Aw type, with period of rain (October to March) and dry period (April to September) well defined.

The experiment was implemented in an area of 960 m^2 with marandu palisadegrass established in the year 2010. After the implantation, the pasture was never fertilized, which favored a degradation process.

The soil of the experimental area was classified as Cambisol Haplic (Santos et al., 2018). Soil sampling was performed in August 2015, at 0 to 10 cm layers for chemical and granulometric characterization. The averages of the chemical and granulometric analysis were as follows: pH ($CaCl_{2t}$) = 5.4; phosphorus = 7.0 mg/dm^3; potassium = 68.3 mg/dm^3; calcium = 2.15 cmol/dm^3; magnesium = 0.83 cmol/dm^3; H + Al =2.38 cmol/dm^3; sum of bases = 3.2 cmol/dm^3; cation exchange

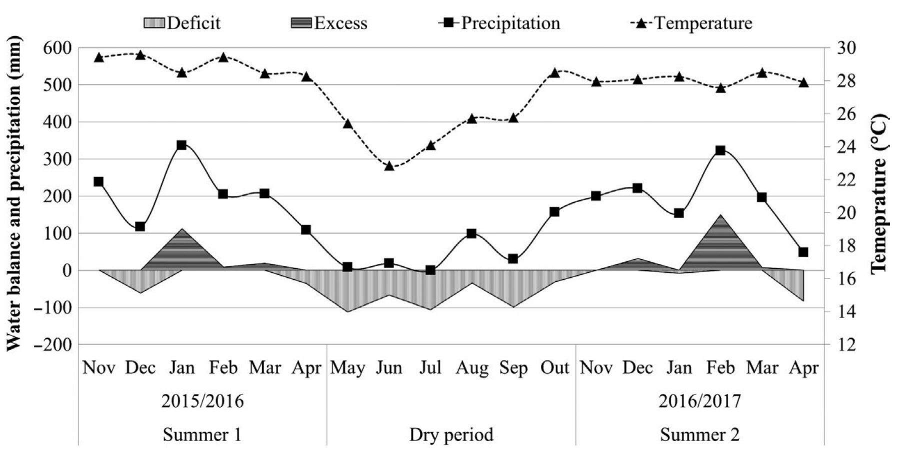

FIGURE 1 Water balance (Thornthwaite & Mather, 1955) calculated considering an available water capacity of 40 mm, precipitation (mm) and temperature (°C) in the experimental area (November 2015 to April 2017)

capacity = 5.5 cmol/dm^3; base saturation = 57.0%; sand = 740 g/kg; silt = 59 g/kg; and clay = 201 g/kg.

In November 2015, the mechanized cut of marandu palisadegrass was performed, considering a 20 cm residue height. After the standardization, maintenance fertilization was carried out, according to the recommendations of Martha Júnior, Vilela, and Sousa (2007). In summers 1 and 2, the doses of phosphorus (P_2O_5) and potassium (K_2O) used were 30 and 60 kg/ha, in the form of simple superphosphate and potassium chloride, respectively. After the uniformization and maintenance fertilization, the experimental period was started with the application of nitrogen in the form of ammonium sulfate.

2.2 | Experimental design and treatments

The experiment was conducted in a completely randomized design with five treatments (N doses) and seven replicates, totaling 35 experimental units of 20 m^2.

The treatments consisted in the application of N doses in the marandu palisadegrass at each regrowth cycle: 0 (control), 25, 50, 75 and 100 kg ha^{-1} cycle^{-1}. In the control treatment, three regrowth cycles were performed in each evaluation year. In summer 1, five regrowth cycles were performed for all treatments, corresponding to the application of 125, 250, 375 and 500 kg N/ha. In summer 2, four regrowth cycles were performed for the treatment 25 kg ha^{-1} cycle^{-1} and for the other five cycles, corresponding to the application of 100, 250, 375 and 500 kg N/ha.

2.3 | Measurements

After application of the treatments, canopy height was measured with a graduated ruler, every 3 days. When forage reached the precut height of 40 cm, the evaluations were carried out. After the samples were collected, the plots were standardized with use of a manual scrubber, at the same residue height of 20 cm. Then, the plant material from standardization was removed and N fertilization was carried out.

Dry matter yield (DMY) was estimated by destructive sampling at each regrowth cycle. When canopy height reached 40 cm, three samples in each plot were collected at 20 cm (residue height), using a metal frame of 1 m^2 (1.0 × 1.0 m). DMY was obtained by summing the forage mass of all regrowth cycles. The forage accumulation rate (FAR) was estimated by the ratio of the DMY to the regrowth interval.

In order to characterize the pasture and the presence of invasive plants was realized in a subsample (300 g) of the forage mass, a botanical (marandu grass and invasive plants) and morphological (leaf blade and stem + sheath) separation and then taken to a forced circulation oven at 55 ± 5°C for 72 hr for assessment of dry matter. The presence of dead material in the forage mass was not observed.

Another subsample (500 g) was packed in paper bags and dried in a forced ventilation oven at 55 ± 5°C for 72 hr to obtain dry matter (DM). After drying, the material was weighed, milled in 1- and 2-mm sieve in Willey mill and then stored. A composite sample of all evaluations performed in summer 1 and summer 2 was used for chemical analysis. Dry matter (DM), crude protein (CP) and mineral matter (MM) contents were determined according to Silva and Queiroz (2002); neutral detergent fiber (NDF; Mertens, 2002) and indigestible neutral detergent fiber (iNDF), according to Valente et al. (2011), quantified by in situ incubation procedures with Ankon® bags (ANKOM Technology, F57) for 288 hr in samples processed at 2 mm. IVDMD was determined as described by Tilley and Terry (1963). Potentially digestible dry matter (DMpd) was estimated according to the following equation (Paulino, Detmann, & Valadares Filho, 2008): DMpd = 0.98 (100 − NDFap) + (NDFap − iNDF), where NDFap is the NDF corrected for ash and protein.

In order to evaluate CP fractions, CP contents in cell wall (CP_{CW}) and cell contents (CP_{CC}) were quantified. Ground samples were submitted for analysis of neutral detergent insoluble protein (NDIP; Silva & Queiroz, 2002), which was designated CP in cell wall (CP_{CW}). Fast digestion fractions, being nonprotein nitrogen (NPN) and true protein not associated with cell wall, were quantified by the difference between CP and NDIP, which was designated CP in cellular content (CP_{CC}).

To evaluate tiller density (TD), a metal frame of 0.09 m^2 (0.30 × 0.30) was used, which was allocated at three representative points of average canopy condition for counting the number of tillers.

In the last evaluation (May) of each year, using a 1-m^2 (1.0 × 1.0 m) frame, the mean pasture score was evaluated. The evaluations were performed by assigning grades from 0% to 100% for plant coverage (Campbell & Arnold, 1973).

2.4 | Statistical analysis

Data were submitted to variance analysis, considering nitrogen fertilization effect, in a repeated measure in time. If the effect of nitrogen fertilization was significant, a regression analysis was performed, treating the linear and quadratic effects. For DMY, FAR, TD and leaf blade and stem + sheath proportion, the linear response plateau (LRP) test was used. In all tests, 5% probability was adopted, according to the model:

$$Y_{ij} = \mu + A_i + e_{ij}$$

Y_{ij} = expected response; μ = average/constant, associated with the experiment; A_i = treatment effect (N dose): i, normally distributed; e_{ij} = treatment error (N dose): i, in repetition and j, normally and independently distributed.

3 | RESULTS

There was LRP effect of N doses on DMY, FAR and TD in the 2 years (Table 1, p < .001). In summer 1, the highest DMY and FAR of

TABLE 1 Dry matter yield (DMY), forage accumulation rate (FAR), tiller density (TD) and leaf blade and stem + sheath proportion of marandu palisadegrass fertilized with nitrogen (N) doses

	N doses (kg ha^{-1} cycle^{-1})					*p*-value			
	0	25	50	75	100	L	Q	LRP	*SEM*
DMY, kg/ha									
Summer 1	8,308	10,118	12,623	14,646	14,375	<.001	.001	<.001	474.66
Summer 2	6,927	10,026	13,900	14,272	13,576	<.001	<.001	<.001	427.32
FAR, kg ha^{-1} day^{-1}									
Summer 1	50.45	56.59	79.98	84.34	83.20	<.001	<.001	<.001	2.52
Summer 2	42.00	56.96	81.61	82.15	78.46	<.001	<.001	<.001	1.77
TD, tiller m^{-2}									
Summer 1	661	903	975	1,108	1,144	<.001	.046	<.001	45.20
Summer 2	673	994	1,014	1,218	1,058	<.001	<.001	<.001	36.57
Leaf blade, g/kg									
Summer 1	490	670	680	700	710	<.001	<.001	.579	20.18
Summer 2	620	630	630	630	640	.254	.882	.575	6.36
Stem + sheath, g/kg									
Summer 1	510	330	320	300	290	<.001	<.001	.579	21.74
Summer 2	380	370	370	370	360	.254	.882	.575	6.36

Abbreviations: L, linear; LRP, linear response plateau; Q, quadratic; *SEM*, standard error of the mean.

TABLE 2 Parameterization of dry matter yield (DMY), forage accumulation rate (FAR), tiller density (TD) and plant coverage of marandu palisadegrass fertilized with nitrogen (N) doses according to *linear response plateau*

	Linear phase		Plateau		
Variables	Intercept	Inclination	N doses	Estimate	R^2
DMY, kg/ha					
Summer 1	8,149.10	17.24	75	14,516.01	0.97
Summer 2	7,049.60	27.73	50	13,916.57	0.98
FAR, kg ha^{-1} day^{-1}					
Summer 1	49.88	0.0991	75	83.77	0.95
Summer 2	42.00	0.1496	50	80.79	0.99
TD, tiller m^{-2}					
Summer 1	672.66	2.57	25	1,071.18	0.94
Summer 2	661.02	1.93	25	1,033.56	0.90
Plant coverage, %					
Summer 1	56.71	0.1269	50	92.65	0.91
Summer 2	76.60	0.0421	75	96.88	0.88

marandu palisadegrass occurred at the N dose of 75 kg ha^{-1} cycle^{-1}, while in summer 2, they increased up to 50 kg ha^{-1} cycle^{-1} (Table 2). For TD, in summer 1 and summer 2, the plateau occurred at a dose of 25 kg ha^{-1} cycle^{-1} ($p < .001$; Table 2).

Nitrogen fertilization affected the proportion of leaf blade and stem + sheath only in the first year of evaluation ($p < .001$; Table 1). The leaf blade ratio increased linearly in summer 1, while there was a decrease in the proportion of stem + sheath as there was a higher supply of N to the grass.

With the increase in N doses, there was increase in plant coverage in summer 1 and summer 2 (Table 3). Doses of N greater than 25 kg ha^{-1} cycle^{-1} guarantee plant coverage higher than 80%.

In summer 1, the mass of invasive plants (*Alysicarpus vaginalis*) reduced with increasing nitrogen supply (Table 3). In contrast, in summer 2 no invasive plant mass was observed in any of the treatments, including the control treatment.

Nitrogen fertilization altered the MM, CP and NDF contents ($p < .001$; Table 4). With increasing doses of N, a reduction in MM and NDF and increase in CP content were observed for the two years of evaluation. The levels of iNDF and DMpd were not influenced by nitrogen fertilization ($p > .05$).

In summer 2, there was a linear reduction in relation to the supply of N for IVDMD (Table 4). The N supply increased CP_{CW} and CP_{CC} fractions in DM ($p < .001$; Table 5); however, there was no change in

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TABLE 3 Mass of invasive plants and plant coverage of marandu palisadegrass fertilized with nitrogen (N) doses

	N doses (kg ha^{-1} cycle^{-1})					*p*-value			
	0	25	50	75	100	L	Q	LRP	*SEM*
Invasive plants, kg DM/ha									
Summer 1	600	101	138	0	0	<.001	<.001	.725	89.29
Summer 2	–	–	–	–	–	–	–	–	–
Plant coverage, %									
Summer 1	57	88	88	97	98	<.001	<.001	.002	2.42
Summer 2	77	84	82	95	99	<.001	.406	<.001	2.41

Abbreviations: L, linear; LRP, linear response plateau; Q, quadratic; *SEM*, standard error of the mean.

TABLE 4 Mineral matter (MM), crude protein (CP), neutral detergent fiber (NDF), indigestible neutral detergent fiber (iNDF), potentially digestible dry matter (DMpd) and in vitro dry matter digestibility (IVDMD) of marandu palisadegrass fertilized with nitrogen (N) doses

	N doses (kg ha^{-1} cycle^{-1})					*p*-value		
	0	25	50	75	100	L	Q	*SEM*
g/kg of DM								
MM								
Summer 1	92.0	83.8	80.1	81.3	78.7	<.001	.009	1.53
Summer 2	98.0	86.8	82.5	70.9	73.2	<.001	.002	1.57
CP								
Summer 1	70.5	88.1	103.6	125.3	150.4	<.001	.013	2.15
Summer 2	68.7	77.9	96.2	123.2	142.4	<.001	.423	9.45
NDF								
Summer 1	655.3	661.8	654.5	637.7	629.4	<.001	.005	3.43
Summer 2	678.4	701.5	675.5	647.0	656.6	.002	.388	9.08
iNDF								
Summer 1	217.7	206.2	227.2	214.3	212.5	.910	.549	6.40
Summer 2	225.6	239.6	221.8	223.8	242.2	.497	.347	8.01
DMpd								
Summer 1	775.3	787.0	765.8	778.3	780.0	.969	.570	6.40
Summer 2	767.9	754.4	771.6	769.0	750.8	.450	.336	8.00
g/kg								
IVDMD								
Summer 1	728.8	718.7	714.4	714.4	718.4	.118	.088	4.77
Summer 2	584.0	590.4	564.9	546.9	561.5	<.001	.204	4.79

Abbreviations: L, linear; Q, quadratic; *SEM*, standard error of the mean.

the proportions of CP_{CW} and CP_{CC} in relation to the total CP content ($p > .05$).

4 | DISCUSSION

In summer 1, the plateau for DMY occurred in a higher dose of N (75 kg ha^{-1} cycle^{-1}) than in summer 2 (50 kg ha^{-1} cycle^{-1}), since it was a pasture at the beginning of degradation process, and it is possible that there is a greater requirement for reestablishment of the root system. Nitrogen supply through fertilization shows an increase in root mass and nitrogen content in roots of degraded grass (Faria et al., 2018; Silveira, Oliveira, Bonfim-Silva, & Monteiro, 2011). According to Martha Júnior et al. (2007), the maximum N dose of 60 kg ha^{-1} cycle^{-1} should be used, which is similar to the average of the evaluated 2-year plateaus (75 and 50 kg ha^{-1} cycle^{-1}), and demonstrates the necessity of splitting in larger doses, in order to minimize the leaching of N.

In cases of high pasture degradation with annual productivity between 2000 and 3,000 kg DMY ha^{-1}, the N doses required in the first year of recovery should be lower than those observed in this study, assuming doses of 50 kg ha^{-1} cycle^{-1} only in the second year of recovery (Oliveira, Trivelin, Oliveira, & Corsi, 2005).

Beyond the increase in DMY, nitrogen fertilization increased FAR, which accelerates the reestablishment of post-regrowth forage, preventing the appearance of invasive plants and delaying the forage degradation process. In addition, under grazing conditions

TABLE 5 Crude protein content in cell wall (CP_{CW}) and cellular content (CP_{CC}) of marandu palisadegrass fertilized with nitrogen (N) doses

	N doses (kg ha^{-1} cycle^{-1})					*p*-value		
	0	25	50	75	100	L	Q	*SEM*
g/kg of DM								
CP_{CW}								
Summer 1	23.8	23.4	40.0	40.2	67.4	<.001	.013	3.04
Summer 2	14.5	17.5	18.4	23.0	35.5	<.001	.025	2.39
CP_{CC}								
Summer 1	46.7	55.7	63.6	85.1	83.1	<.001	.473	3.11
Summer 2	54.2	60.9	67.5	100.3	106.9	<.001	.549	9.94
g/kg of CP								
CP_{CW}								
Summer 1	339.1	368.6	388.2	320.5	446.7	.061	.304	27.11
Summer 2	205.8	225.2	283.5	211.7	264.7	.495	.728	32.68
CP_{CC}								
Summer 1	660.9	631.4	611.8	679.5	553.3	.061	.304	27.11
Summer 2	794.2	774.8	716.5	788.3	735.3	.495	.728	32.65

Abbreviations: L, linear; Q, quadratic; *SEM*, standard error of the mean.

the increase in FAR allows a rapid return of the animals to the picket in systems in intermittent stocking (Gimenes et al., 2011).

It was observed in summer 1 and summer 2, plateau of the TD at the dose of N of 25 kg ha^{-1} cycle^{-1} (Table 2). The doses that stabilized tillering were lower than the doses that provided plateau for DMY (75 and 50 kg ha^{-1} cycle^{-1}). The increase in TD as a function of N supply corroborates with the influence of N on tillering (Paciullo et al., 2017), as well as in the recovery of degraded pastures, since continuous emission of leaves and tillers is relevant for the perennial pasture (Pereira et al., 2015).

N increases elongation and leaf appearance (Borges et al., 2017; Gatti, Ayala Torales, Cipriotti, & Golluscio, 2017; Pereira et al., 2015), favoring the rapid forage regrowth, which can quickly prevent the luminosity to reach basal buds, limiting tillering, since red wavelength (625–740 nm) is important for tiller emission process (Casal, Sanchez, & Gibson, 1990; Williamson, Wilson, & Hartnett, 2012). Thus, in N plant shortage (doses lower than 25 kg ha^{-1} cycle^{-1}), tillering is limited by nutritional deficiency, and in cases of high fertilizer application, tillering may be limited by light deficiency, which makes it imperative to adopt an adequate management of grazing.

The increase in the plant coverage, mainly by the increase in TD, decreased the mass of invasive plants (Table 2). Thus, the N effect was observed to retard pasture degradation, as well as to the recovery of degraded pastures, since the increase in the plant coverage minimizes the appearance of invasive plants and the emergence of erosion and soil compaction contributing to increase in vigor and better pasture condition (Faria et al., 2018). Moreover, in summer 2, it was observed that even in the treatment without nitrogen fertilization, there was more plant coverage than in summer 1, which also reaffirms the need for adequate management, since over the two years the heights were respected of pre- and post-regrowth.

Nitrogen fertilization increased CP levels of marandu palisadegrass, being the bromatological variable more affected by N supply. Conversely, comparing the highest N dose (100 kg ha^{-1} cycle^{-1}) and the absence of fertilization, a reduction of 3.48% in the NDF, a smaller amplitude than the one observed for the change in the CP content, shows that nitrogen fertilization has less influence on the fiber content. There was a reduction in mineral content as N increased in fertilization. The main explanation is associated with the increase in forage mass, which results in dilution effect of all absorbed nutrients (Soares et al., 2009). Even with a reduction in NDF content and an increase in CP content, no effect of nitrogen fertilization on IVDMD was observed in summer 1 and a little expressive effect on summer 2 (Table 4). As the IVDMD depends on the availability of forage CP and energy, and the nitrogen fertilization provides the increase in CP and does not alter the energy content, an imbalance occurs between CP and energy.

Nitrogen fertilization did not change iNDF and DMpd content (Table 4). It is known that the more mature the forage grass, the greater the cell wall thickening, which results in an increase in NDF levels (Santos et al., 2009) and therefore reduction in DMpd. Thus, forage maturity has a greater potential for cell wall alteration than nitrogen fertilization, which was also demonstrated by the non-alteration of NDF and the lowest NDF change compared with CP. Therefore, with the use of fertilization, greater caution should be exercised in the grazing management, since N accelerates the development of forage grass (Lemaire, Da Silva, Agnusdei, Wade, & Hodgson, 2009; Silva et al., 2016; Yasuoka et al., 2018), which results in smaller regrowth intervals, due to the greater DMY.

The N supply to marandu palisadegrass increased CP_{CW} and CP_{CC} levels in DM (Table 5). Similar results were observed by Dupas et al. (2016); however, other studies mention that nitrogen fertilization in tropical forage grass increases the proportion of CP_{CW} (Silva et al., 2009), which is a fraction of CP from slow and incomplete digestion. In contrast, in temperate grasses the nitrogen supply increases the proportion of CP_{CC} (Gierus, Pötsch, & Weichselbaum, 2016; Johnson et al., 2001), which is CP of rapid and higher digestion. This is why nitrogen fertilization in temperate grasses increases the average daily gain of animals (Pontes et al., 2018; Hernández Garay et al., 2004), while in tropical forage grasses there is a significant increase in the stocking rate (Cecato et al., 2017), which results in an increase in gain per area.

5 | CONCLUSION

Nitrogen fertilization has a pronounced effect on forage yield, mainly on DMY, which has a direct impact on the stocking rate, the main characteristic related to animal performance by area. In relation to nutritional characteristics, the greatest effect occurs on the CP content, without entailing a high change in the IVDMD. Therefore, the use of nitrogen fertilizers in pasture systems with marandu palisadegrass has a greater impact on the area gain than the individual gain, assuming nitrogen fertilizer of 50–75 kg ha^{-1} cycle^{-1} was applied in the system.

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