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4 **Nitrogen fertilization of Marandu palisade grass**
5 **under different periods of deferment**
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11 **ABSTRACT**
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The goal with this study was to evaluate the morphological characteristics, nutritive value and the forage dry matter (DM) accumulation of *Brachiaria brizanthacv.* Marandu in different stages of deferment under nitrogen fertilization levels. The experimental design was a randomized block in split-plot, with three replicates. Plot treatments corresponded to two levels of fertilization (with and without). Split-plot treatments corresponded to four deferment periods (March, April, May, June). Plant height and forage DM accumulation increased ($P = .05$), while the leaves percentage decreased according to the deferral months. Regarding the fertilization, the percentage of leaves was lower ($P = .05$) with nitrogen use. The DM content was higher ($P = .05$) in pastures deferred for a longer time. The neutral detergent fiber (NDF) content increased due to fertilization and greater deferral period. The crude protein (CP) level decreased as the deferral periods increased. Nitrogen fertilization proved to be viable for the production of good quality forage. The reduction in the deferment period produces forage with better morphological composition and nutritive value.

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14 **Keywords:** Crude Protein; percentage of leaves; plant height.

15
16 **1. INTRODUCTION**
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18 Cattle production in grazing systems is one of the most economical and profitable
19 alternatives, since it is rationally explored. However, in tropical regions, the availability of
20 forage is not regular throughout the year, due to climatic variation, which limits the
21 productive potential of the forage and cause the seasonality of the animal production [1].

22 One of the management strategies used to reduce the forage deficit during the dry season is
23 the pasture deferment, which aims to reserve the excess of forage produced at the end of
24 the summer, to be used during the dry season [2]. The forage plants most indicated to this
25 practice present low accumulation of stalks and good retention of green leaves, which
26 results in smaller reductions in nutritive value over time, highlighting grasses of the
27 *Brachiaria* genus [3].

28 A greater efficiency with this strategy can be obtained with the use of nitrogen fertilizers,
29 since nitrogen (N) has a positive effect on dry matter production, specifically on leaf
30 percentage and nutritional value [4]. Applying N at the end of the summer season, can be an
31 alternative to compensate the deleterious effect of the deferment period, becoming
32 fundamental in the pasture production process, since the N from the organic matter
33 mineralization may not be enough to meet the forage demand.

34 However, the pasture deferment promotes longer rest periods, which added to the
35 environmental conditions, result in important changes, especially in the pasture structure.
36 The evaluation of the structural and nutritional composition of the deferred pasture is
37 important, since it is determinant for the growth dynamics and competition in the plant
38 community, as to the grazing animals ingestion behavior[5].

39 The goal was to evaluate the morphological characteristics, nutritive value and forage
40 accumulation of *Brachiaria brizantha* cv. Marandu under different periods of deferment with
41 nitrogen input, in order to determine the most appropriate deferral strategy for the Mato
42 Grosso Cerrado region.

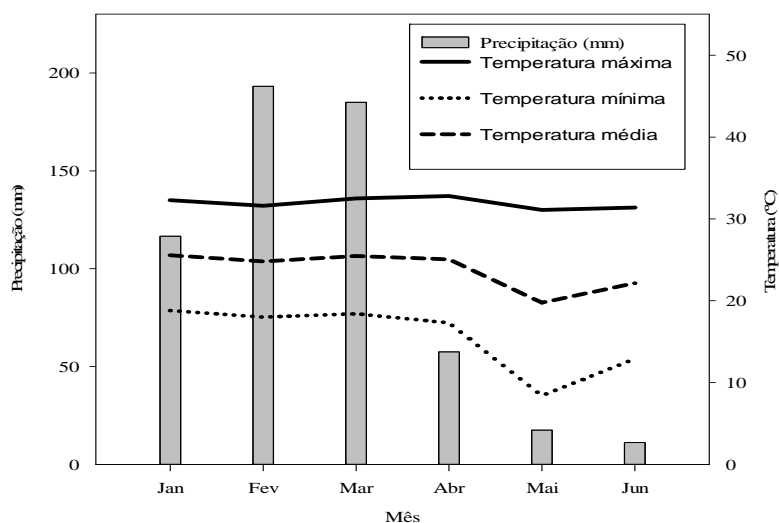
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44 2. MATERIAL AND METHODS

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46 The trial was carried out in the Campo Verde-MT, located at 15° 48 ' South and 55° 26' West
47 of Greenwich, average altitude of 745 m. The climate, according to the classification of
48 Köppen, is Aw type, characterized by two well-defined seasons: dry (April to September) and
49 rainy (October to March). The average annual rainfall was 2007 mm and the maximum and
50 minimum temperatures were 24.7 and 19.6 °C, respectively. The soil of the experimental
51 area is an Oxisol of medium texture with flat relief.

52 At the experiment beginning, soil were sampled in the 0 to 20 cm layer, and the results of
53 which were: pH (CaCl₂) = 5.4; Organic matter = 24.1 g dm⁻³; P = 4.9 mg dm⁻³; K = 170 cmolc
54 dm⁻³; Ca = 1.0 cmolc dm⁻³; Mg = 0.7 cmolc dm⁻³; H + Al = 4.2 cmolc dm⁻³; Sum of basis = 2.1
55 cmolc dm⁻³; Cation exchange capacity = 6.3 cmolc dm⁻³; Base saturations (%) = 33.8; Sand
56 = 733 g kg⁻¹; Silt = 66 g kg⁻¹; Clay = 201 g kg⁻¹. According to the results of the soil analysis
57 and the recommendations [6], it was applied 250 kg ha⁻¹ of limestone filler; 167 kg ha⁻¹ of
58 single superphosphate; 750 kg ha⁻¹ of ammonium sulphate. There was no need to apply
59 potassium fertilizers. During the evaluation period, the climatic data were monitored in the
60 experimental area (Figure 1).



61

62 **Fig. 1. Monthly averages of precipitation, maximum, minimum, mean temperature and**
 63 **monthly water balance during the experimental period.**

64 The experimental design was a randomized block in split-plot, with three replicates. Plot
 65 treatments corresponded to two levels of fertilization (with and without). Split-plot treatments
 66 corresponded to four deferment periods (March, April, May, June). The deferment beginning
 67 of the marandu palisade grass was carried out in February. The total area of the plot and the
 68 split-plot was 16.0 m² and 4.0 m², respectively.

69 The evaluated characteristics were: dry matter yield (kg DM ha⁻¹), percentage of leaves (%),
 70 plant height (cm), content of crude protein (CP), neutral detergent fiber (NDF), total
 71 digestible nutrients (TDN) and in vitro dry matter digestibility (IVDMD). At the implementation
 72 day, a uniformity cut was performed at 10 cm of the soil, using a costal mower, followed by
 73 the application of the fertilizers in single dose. For treatments determination, the use period
 74 of pastures deferred in Campo Verde-MT region was taken into account.

75 The forage samples were collected before the animals entrance. At the respective cutting
 76 dates, the plants heights were measured using a graduated ruler, from the soil level up to
 77 the insertion of the last leaf, into ten representative tillers of each split-plot. The same
 78 sampling was done to determine the leaves percentage, separating the live material of the
 79 dead material and the leaf blade were. The forage cuts of the marandu palisadegrass to
 80 determine the green mass yield were made at 20 cm of the soil level, with the harvesting of
 81 all the biomass cut. The green mass was weighed at sight on a 1.0 g weighing scale. The
 82 leaf and forage samples were packed in perforated, weighted and identified paper bags.

83 To determine the dry matter (DM) content, the samples were pre-dried in a forced circulation
 84 oven at 55 °C for 72 hours. Afterwards, the material was weighed and ground using a
 85 stationary mill with a sieve of 1.00 mm. Then, samples (3 g) of this material were taken to an
 86 oven at 105°C for determination of DM (final drying) [7]. The dry matter yield (kg DM ha⁻¹)
 87 was obtained by multiplying the green mass yield estimates by the respective DM content.

88 In the forage samples, the neutral detergent fiber (NDF) and crude protein (CP) contents
 89 were determined according [8]. Equations adapted from [9] were used for the determination
 90 of total digestible nutrients (TDN) and in vitro digestibility of dry matter (IVDMD),

91 respectively: $TDN = 83.79 - 0.4171 \times NDF$ ($R^2 = 0.82$; $P = .01$); $IVDDM = (TDN - 6.12) / 0.851$
 92 ($R^2 = 0.72$, $P = .01$). Data were submitted to analysis of variance and the means were
 93 compared by the Scott Knot test, adopting 5% of significance level, according to the
 94 methodology described by [10], using SAEG software.

95

96 3. RESULTS AND DISCUSSION

97

98 The marandu palisade grass had lower plant height only in March, regardless of whether or
 99 not nitrogen fertilization was used ($P = .05$) (Table 1). For the other months of deferment,
 100 higher plant height was observed with N application, and there was no difference between
 101 deferment of May and June ($P = .05$).

102 As for the forage mass ($kg DM ha^{-1}$), using or not nitrogen fertilization, the months of May
 103 and June presented higher values ($P = .05$). Like for the plant height, nitrogen fertilization
 104 provided higher forage mass ($kg DM ha^{-1}$) than without application in all periods ($P = .05$),
 105 being more significant in the months of May and June. However, deferred pasture had a
 106 significant reduction in the leaves percentage in longer deferment ($P = .05$). In April, it was
 107 observed a significant reduction of leaves percentage with the application of N, which was
 108 not observed for other months ($P = .05$).

109

110 **Table 1. Plant height, forage mass and percentage of leaves of marandu**
 111 **palisadegrass according to the periods of use and nitrogen fertilization, Campo**
 112 **Verde-MT.**

Nitrogen fertilization	Period of use				CV (%)
	March	April	May	June	
Plant height (cm)					
Without	17.00 aC	27.33 bB	40.33 bA	41.33 bA	(a)= 7.00
With	22.67 aC	78.00 aB	110.00 aA	110.00 aA	(b)= 10.02
Forage mass (kg MS/ha⁻¹)					
Without	653.90 aB	1.433.19 bB	2.450.96 bA	3.141.64 bA	(a)= 24.89
With	1.305.94 aC	4.416.62 aB	12.220.98 aA	11.593.52 aA	(b)= 16.88
Percentage of leaves (%)					
Without	100.00 aA	67.04 aB	51.76 aC	49.81 aC	(a)= 2.79
With	100.00 aA	45.75 bB	44.67 aB	43.66 aB	(b)= 6.41

113 Means followed by the same letter, lowercase in the column and upper case in the row, do
 114 not differ by the Scott-Knott test up to 5% probability. CV: Coefficient of variance.

115 The authors [11] and [12] also found, in deferred pastures of *Brachiaria* sp., an increase in
 116 height due to the stem elongation rate, which developed larger tillers, especially when N was
 117 applied. Tiller competition for light is a relevant factor at the forage height, especially over
 118 time, since variations in the leaf area index and light interception cause changes in the
 119 canopy light environment and in tillering of the deferred pasture [13]. Thus, deferment time
 120 and nitrogen fertilization should be carried out carefully due to a direct influence on forage
 121 accumulation, since such strategies may alter the final forage quality, by the higher
 122 percentage of stem and the reduction of the leaf blades number [14].

123 The forage mass at the two study conditions was above $2000 kg DM ha^{-1}$ [15], which is
 124 considered the minimum limit to not restrict the animal intake in the pasture, however, the
 125 fertilization provided an increase of 199.71, 308.16, 496.59 and 369.02, respectively to the
 126 evaluated periods, which confirms that N acts directly in the cell division, accelerating the
 127 forage growth rates [16]. The forage mass accumulated in N treatments were higher than
 128 observed by [17] ($7,665 kg of DM ha^{-1}$) and [14] ($7,997 kg of DM ha^{-1}$) in pastures of

129 *Brachiaria decumbens* cv. Basilisk with application of N, deferred respectively in 116 and 95
 130 days. These results can be explained by the climatic variations and the period in which the
 131 trials were developed. Regarding the experiment, the rainfall occurred in March, together
 132 with the high temperatures during the period, may have increased the N use by plants.

133 The pasture deferment for a shorter period generated little amount of forage. On the other
 134 hand, it has a high percentage of leaves, a fact that can be attributed to the effect of
 135 compensation between forage mass and the development of basal buds in new tillers,
 136 accentuated mainly by the N application [18]. Without the addition of N, the forage mass
 137 increased from 653.90 to 3,141.64 kg DM ha⁻¹, and with the N application, the value of
 138 1,305.94 increased to 12,220.98 kg DM ha⁻¹. Contradictory effect was obtained by [19] that
 139 found similar mass of leaves from the deferral beginning to the quantity obtained at the end
 140 of the analyzed period. The author [20] verified that the green leaf blade in *B. decumbens*
 141 pastures decreased from 1,638 to 891 kg DM ha⁻¹ during the pasture period use in autumn
 142 due to the increase in stem length and maintenance of the live leaves number in the
 143 vegetative tillers. More attention must be paid to the grass quality for animal grazing,
 144 considering that the green leaf blade is the morphological component with the best nutritive
 145 value [21].

146 The DM content of marandu palisade grass increased during the deferment periods (P =
 147 .05), with higher value for June, with or without the use of N. Regarding nitrogen fertilization,
 148 March and April presented initially higher DM content (P = .05), but the final period of use
 149 (June) the previous result reversed, in which nitrogen fertilization resulted in higher DM
 150 content (P = .05) (Table 2).

151 The CP levels of the marandu palisade grass were higher in the deferral of March
 152 independently of the nitrogen fertilization use (P = .05). However, the remaining months in
 153 deferral presented significantly reduced values. The NDF content presented an increase (P
 154 = .05) as a function to the deferment period with nitrogen fertilization.

155 **Table 2. Contents of dry matter (DM), crude protein (CP) and neutral detergent fiber**
 156 **(NDF) in the forage of marandu palisade grass according to the use periods and**
 157 **nitrogen fertilization, Campo Verde-MT**

Nitrogen fertilization	Period of use				CV (%)
	March	April	May	June	
Dry matter content – DM (%)					
Without	24.51 aB	20.96 aB	22.59 aB	30.44 bA	CV (a)= 17.76
With	17.57 bC	16.35 bC	26.38 aB	35.91 aA	CV(b)= 10.06
Crude protein content - CP (% MS)					
Without	7.92 aA	7.92 aA	6.45 aB	5.95 aC	CV (a)= 2.04
With	8.29 aA	7.71 aB	6.27 aC	5.73 aD	CV(b)= 6.27
Neutral detergent fiber content - NDF (%)					
Without	74.17 aB	76.01 aA	73.78 aB	77.22 aA	CV (a)= 1.43
With	67.89 bC	75.01 aB	73.77 aB	77.92 aA	CV(b)= 1.74

158 Means followed by the same letter, lowercase in the column and upper case in the row, do
 159 not differ by the Scott-Knott test upto 5% probability. CV: Coefficient of variance.

160 The values obtained in the treatment with N possibly occurred because the fertilization
 161 added to the rains that occurred in March extended the vegetative phase of the marandu
 162 palisadegrass, and with this they maintained the dry matter content low, comparing to
 163 the treatment without nitrogen fertilization. From the moment that the plant started the
 164 maturation process, the greater participation of reproductive structures resulted in an

165 increase in DM contents, and this phenomenon may also have been potentiated by N and by
 166 the water deficit. According to [22], nitrogen fertilization provides an increase in the
 167 production of plant reproductive structures, reflecting the reduction of the
 168 leaf:stem/reproductive structure ratio, and consequently increasing the DM content of the
 169 whole plant.

170 Higher CP content was observed in the initial period of use (March). Thus, it can be
 171 observed that the CP content was positively associated with the percentage of leaves, and
 172 negatively with the NDF contents. From the month of May (60 days of deferment) the CP
 173 content was lower than 7%, becoming a limiting factor in the analysed forage [23].

174 Decreases in CP contents, during the deferment period, were also observed for deferred *B.*
 175 *decumbens* pastures in February and March [24]. Due to maturation of plant tissues, the
 176 concentration of potentially digestible components, including soluble carbohydrates, protein,
 177 minerals and other cellular contents, tends to decrease. In contrast, indigestible fractions
 178 that limit intake and animal performance have a greater presence [25].

179 Deferred pasture for long periods usually presents a higher mass of dead forage, a fraction
 180 that is more fibrous and with lower nutritional value, as a result from senescence. However,
 181 at the treatments without the use of nitrogen fertilization, an unexpected result was obtained,
 182 since it was expected increase in NDF during the periods of use, as the percentage of
 183 leaves decreased, and the participation of stems increased. The author [24] verified that
 184 stem length correlated negatively with CP percentages, and positively with NDF contents.

185 The mean value of NDF for the treatment without the use of N during March was 74.17,
 186 which was greater ($P = .05$) than treatments that N was used, with value of 67.89 %.
 187 [26]found a NDF decrease with increasing N doses throughout the year, possibly because
 188 this nutrient stimulates the growth of new tissues, with high protein content and lower levels
 189 of structural carbohydrates and lignin. However, nitrogen fertilization in high doses, together
 190 with favorable climatic conditions, can accelerate plant maturity and senescence, limiting the
 191 beneficial effect of nitrogen fertilization on NDF values, since the percentage of cell wall in
 192 the dry matter is inversely correlated with CP values.

193 It was observed that NDT and IVDDM of marandu palisade grass in March were higher with
 194 N application ($P=.05$), with respective values of 55.47% and 57.99%. However, there was a
 195 significant reduction of the same characteristics with the use of N in the last period of
 196 deferral use (Table 3).

197 **Table 3. Estimation of total digestible nutrients (TDN) and in vitro digestibility of dry**
 198 **matter fiber (IVDDM) in the forage of marandu palisade grass as a function of the use**
 199 **periods and nitrogen fertilization, Campo Verde-MT**

Nitrogen fertilization	Period os use				CV (%)
	March	April	May	June	
Total digestible nutrients – TDN (%)					
Without	52.85 bA	52.09 aA	52.51 aA	51.58 aA	CV (a)= 0.84
With	55.47 aA	53.01 aB	53.02 aB	51.29 aC	CV(b)= 1.02
In vitro digestibility of dry matter - IVDDM (% DM)					
Without	54.91 bA	54.01 aA	54.51 aA	53.42 aA	CV (a)= 0.96
With	57.99 aA	55.11 aB	55.11 aB	53.07 aC	CV(b)= 1.16

200 Means followed by the same letter, lowercase in the column and upper case in the row, do
 201 not differ by the Scott-Knott test upto 5% probability. CV: Coefficient of variance.

202 According to the advance in the deferment periods evaluated, there was a decrease in green
203 leaf blades and an increase in fibrous material in the forage mass, so the NDT and IVDDM
204 values, as well as the CP, decreased due to the increase of the fibrous components that
205 interfere in digestibility and nutritional value, and limit animal intake [27]. The plant
206 maturation increases the fibrous constituents (NDF, ADF and lignin) that have a negative
207 correlation with digestibility and intake [28].

208 Regarding to nitrogen, during the experiment, a change in the pasture structure was noticed,
209 which causes the reduction of NDT and IVDDM, similar to [4], that evaluated the nutritive
210 value of Massai guineagrass submitted to 121 days deferment and N doses, and verified
211 that the favorable environmental condition together with nitrogen fertilization, accelerated
212 plant senescence and increased reproductive tillers, which limited the beneficial effect of
213 fertilization on the cell wall components.

214 Based on the results obtained from the forage morphological and chemical composition of
215 the simulated grazing samples, it is proposed not to prolong the use of marandu palisade
216 grass deferred pastures if the goal is to obtain high animal performance. Otherwise, if the
217 goal is a more discrete weight gains or just weight maintenance, the pasture could be used
218 for a longer period. Another technique to prevent the animals from consuming lower quality
219 forage is to carry out deferment in a partial way, thus using deferred areas at different times
220 during the dry season.

221

222 **4. CONCLUSION**

223

224 1. Nitrogen fertilization is a viable strategy to produce good quality forage of marandu
225 palisade grass to be used in the dry season.

226 2. The reduction in the deferment period of marandu palisade grass produces forage with
227 better morphological composition and nutritive value.

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