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What is the productive potential of digit grass in response to nitrogen fertilization?

Qual é o potencial produtivo do capim faixa-branca em resposta à fertilização nitrogenada?

P. T. N. Fontes[1*]; D. B. O. Santos[2]; J. L. Fagundes[2]; A. A. Backes[2]; B. M. L. Souza[2]; L. P. S. Santos[2]; M. E. R. Santos[3]

[1] *Departamento de Engenharia Agronômica/Laboratório de Ecofsiologia e Pós-colheita, Universidade Federal de Sergipe, 49100-000, São Cristóvão-Sergipe, Brasil*

[2] *Departamento de Zootecnia/ Laboratório de Forragicultura, Universidade Federal de Sergipe, 49100-000, São Cristóvão-Sergipe, Brasil*

[3] *Escola de Medicina Veterinária, Universidade Federal de Uberlândia, 38410-337, Uberlândia-Minas Gerais, Brasil*

**pryankafontes@yahoo.com.br*

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The digit grass is a highly cultivated species in Northeast Brazil, especially in Sergipe and Alagoas. However, research related to the management of fertilization of this specie is incipient. This experiment was carried out to examine the productive potential of digit grass and its morphological changes in response to nitrogen fertilization. The experimental period was from August 2014 to July 2015. Treatments consisted of five levels of nitrogen fertilization (0, 50, 100, 300 and 600 kg ha^{-1}) arranged in a randomized-block design with four replicates. Urea was used as a source of nitrogen. Height, light interception (LI), leaf area index (LAI), total tiller density (TTD), basal tiller density (BTD) and total (TDM), leaf (LDM) and stem dry matter (SDM) accumulations were influenced ($P<0.05$) by the nitrogen doses, fitting a positive quadratic equation. Nitrogen fertilization did not influence ($P>0.05$) dead material accumulation rate or aerial tiller density. Overall, the increasing nitrogen doses culminated in increased canopy height, LI and LAI as a result of the increase in TTD and BTD, which in turn elevated TDM, LDM and SDM. The herbage yield potential of digit grass can be increased with the application of 478 kg N ha^{-1}, enabling its use as an alternative in intensive animal production systems.
Keywords: *Digitaria eriantha*, intensive production, nitrogen.

O capim faixa-branca é uma espécie bastante cultivada no Nordeste brasileiro, especialmente em Sergipe e Alagoas. No entanto, pesquisas relacionadas ao manejo da adubação desta espécie são incipientes. Objetivou-se com este experimento avaliar o potencial produtivo do capim faixa branca e suas modificações morfológicas, em função da adubação nitrogenada. O período experimental se deu entre agosto de 2014 e julho de 2015. Os tratamentos consistiram-se de cinco níveis de adubação nitrogenada (0, 50, 100, 300 e 600 kg ha^{-1}), dispostos em um delineamento experimental de blocos casualizados, com quatro repetições. Utilizou-se a ureia como fonte de nitrogênio. A altura, interceptação luminosa (IL), índice de área foliar (IAF), densidade populacional de perfilhos totais (DPT) e basais (DPB), o acúmulo de matéria seca total (MST), folhas (MSF) e de colmo (MSC) foram influenciadas ($P<0,05$) pelas doses de nitrogênio ajustando-se a uma equação quadrática positiva. A adubação nitrogenada não influenciou ($P>0,05$) a taxa de acúmulo de material morto e a densidade populacional de perfilhos aéreos (DPA). De maneira geral, a elevação na quantidade de nitrogênio aplicada resultou no aumento dos valores de altura do relvado, IL e IAF decorrentes do incremento na DPT e DPB que, por sua vez, elevou a produção de MST, MSF e MSC. O capim faixa-branca possui potencial de aumento de produção de forragem com aplicação de 478 kg de N ha^{-1} tornando-se uma alternativa para o uso em sistemas intensivos de produção animal.
Palavras-chave: *Digitaria eriantha*, produção intensiva; nitrogênio.

1. INTRODUTION

The rising global temperature has increased the need for cultivating species adapted to regions with high temperatures and water deficits. In this scenario, digit grass (*Digitaria erianta* Steud cv. Survenola) is an alternative for such regions. This forage species, which is commonly grown in the Brazilian states of Sergipe and Alagoas [1], has characteristics such as dew-water absorption ability which allow its development in the pasture systems found in the northeastern region of Brazil [2].

Recent studies have investigated herbage accumulation and tillering dynamics in digit grass subjected to defoliation frequencies [3, 4] as well as the chemical characteristics of this species when irrigated [5]. Digit grass also has the ability to thrive in soils of low natural fertility, making it responsive to fertilization in intensive grazing systems. However, information about the morphological and productive responses of this species when subjected to intensive nitrogen fertilization management is still incipient. Thus, the productive potential of digit grass in response to nitrogen fertilization is not known.

The fertilization of pastures, especially nitrogen, is essential for the maintenance of forage plants in the system, as the high extraction of nutrients by plants, as well as the inefficiency of recycling these nutrients by animal waste can compromise the recovery of pastures and, consequently, lead to degradation of pasture [6, 7]. In addition, losses due to denitrification, volatilization and leaching compete with the amount of nitrogen that is absorbed by the plants, making the N requirement for pasture maintenance higher and, as a consequence, increase the cost of fertilization, especially in intensive systems. grazing [7].

Several studies have demonstrated the positive effects of nitrogen on the growth and development of forage plants [8, 9]. In this respect, nitrogen is an important chemical element in that it stimulates cell division and elongation [10]. Because it is a component of chlorophyll in plants, nitrogen also stimulates an increase in leaf elongation and appearance rates [11], contributing to increasing tissue and tiller turnover in the pasture [12]. This has a positive impact on the amount of herbage produced per unit area [12] and, consequently, on animal productivity [13]. According to Oliveira et al. (2015) [14] information on fertilization, especially nitrogen, is very important for forage plants to be able to express their productive potential. Additionally, the information on pasture fertilization management is based on the empiricism of rural producers, who, in part, lack results based on scientific research [15].

Therefore, the present study proposes to examine the productive potential of digit grass as well as its morphological changes in response to nitrogen fertilization.

2. MATERIAL AND METHODS

The experiment was conducted at the Laboratory of Foraging Practices of the Federal University of Sergipe, located in São Cristóvão, SE, Brazil (11º22' S; 37º12' W; 47 m), from July 2014 to June 2015. The soil of the experimental area is classified as a Quartzipsamment of sandy texture and flat relief. At the beginning of the experiment, the 0-20-cm depth soil layer was analyzed and the following chemical characteristics were revealed: pH in H_2O = 6.65; P = 307 mg dm^{-3} (Melich 1); K = 110 mg dm^{-3} (Melich 1); Ca = 2.38 cmolc dm^{-3}; Mg = 2.08 cmolc dm^{-3}; H+Al = 0.86 cmolc dm^{-3}; sum of exchangeable bases = 4.79 cmolc dm^{-3}; cation-exchange capacity (pH 7.0) = 5.65 cmolc dm^{-3}; and organic matter = 11.9 g dm^{-3}. According to the Köppen classification, the climate of the region is a tropical Awa type [16]. The climatic conditions during the experimental period were monitored by a meteorological station, 5.6 km from the experimental unit (Table 1).

Digit grass (*Digitaria erianta* Steud cv. Survenola) was implemented on 06/11/2013 via seedlings, in 2.25 m^2 experimental plots. The grass was irrigated daily and defoliated monthly so that the plant would adapt to the defoliation management from defoliation to the start of the experiment. The soil moisture level was monitored daily by tensiometers, aiming at maintaining 50% soil field capacity via irrigation throughout the experimental period. A uniformity cut was performed in July 2014 at 10 cm above soil level in the experimental plots, which was followed by the application of treatments.

Table 1: Monthly means of maximum, minimum and average temperatures, precipitation and insolation from July 2014 to June 2015.

Year	Month	Precipitation (mm)	Temperature (ºC)			Average insolation (h)
			Maximum	Minimum	Average	
2014	July	116.30	28.67	22.31	25.71	6.38
	August	62.90	28.99	22.36	25.74	7.83
	September	38.20	29.29	22.67	25.96	8.25
	October	35.70	30.26	23.29	26.69	8.55
	November	44.30	30.38	23.32	26.85	8.84
	December	9.00	31.14	23.91	27.37	7.91
2015	January	25.50	31.25	24.49	27.81	9.65
	February	38.40	31.23	24.40	27.79	7.89
	March	44.40	31.21	24.05	27.80	8.54
	April	91.60	31.48	24.17	27.90	8.04
	May	282.10	30.28	23.41	26.85	6.63
	June	149.40	29.32	22.77	25.95	6.54

Source: Meteorological station of SEMARH Sergipe.

Treatments consisted of five nitrogen fertilization doses (0, 50, 100, 300 and 600 kg ha^{-1} year^{-1}), using urea. The experiment was set up as a randomized-block design with four replicates, totaling 20 experimental plots. Nitrogen fertilization was split into ten applications, which were performed after each harvest of the plants in the plots. Those harvests took place at every 36 days, at 10 cm above soil surface, totaling 10 harvests throughout the experimental period.

Canopy height was measured using a centimeter-graduated ruler. The measurements were performed before the harvests, at five random points per plot. Light interception (LI) and leaf area index (LAI) were measured also prior to the harvests, using a forage canopy analyzer (SUNSCAN, Delta-T Devices, Cambridge, England). The equipment read the canopy at three points chosen at random in each plot, following the methodology described by Fagundes et al. (1999) [17].

To determine the forage accumulation and morphological-composition rates, herbage samples were collected using a rectangular 0.70-m^2 metal frame that was allocated at random in each experimental plot before the harvests. Herbage was harvested at 10 cm above soil level. The herbage samples were subsequently packed in labeled plastic bags. In the laboratory, each sample was weighed and subdivided into two subsamples. The first was weighed, stored in paper bags, labeled, dried in a forced-air oven at 65ºC for 72 h and then weighed again. The second subsample was fractioned into green leaf blades, green stems (stem + leaf sheath) and dead material (dead leaves + dead stems). After separation, all the morphological components were stored in labeled paper bags and dried in a forced-air oven at 65 ºC for 72 h to determine the weight of dry samples. These evaluations made it possible to calculate total herbage accumulation (kg DM ha^{-1} year^{-1}) and the accumulation of the morphological components of digit grass at each harvest.

To determine the total, leaf, stem and dead material accumulation rates (kg DM ha^{-1} day^{-1}), the herbage accumulation of all the harvests was summed and the result was divided by the number of experimental days. Nitrogen utilization efficiency was determined by subtracting the DM yield of the unfertilized treatment from the total DM yield of the fertilized treatments and dividing this difference by the nitrogen increment value of each treatment, which generated the amount of DM produced per kilogram of urea.

Basal, aerial and total tiller densities were determined by counting the number of live tillers within a 0.25-m^2 frame, which was allocated at random in each experimental plot. The number of tillers was counted after the plants in the plots were harvested.

Data were subjected to analysis of variance using the PROC ANOVA procedure of SAS statistical software (Statistical Analysis System) version 8.0 for Windows, considering a 5% probability of type-I error. When a significant effect was detected, the response variables were subjected to regression analysis by the PROC REG procedure. The following statistical model was used for all analyzed variables: $Y_{ij} = \mu + B_i + N_j + e_{ij}$, where i = 1, 2, 3 or 4 blocks (random variable); j = 1, 2, 3, 4 or 5 nitrogen doses (fixed variable); Y_{ij} = observation of block i, where nitrogen dose j was applied; μ = constant inherent to all observations; B_i = effect of block i; N_j = effect of nitrogen dose j; and e_{ij} = experimental error.

3. RESULTS AND DISCUSSION

Canopy height was influenced by nitrogen fertilization ($P<0.05$), fitting a quadratic model (Figure 1) that indicated a maximum point of 37 cm achieved at the nitrogen (N) dose of 473 kg ha^{-1}. The total (TDM), leaf (LDM) and stem (SDM) dry matter accumulations of digit grass also rose quadratically ($P<0.05$), with maximum values of 97.62 kg DM ha^{-1} day^{-1} (TDM) achieved at 478 kg N ha^{-1}, 59.03 kg DM ha^{-1} day^{-1} (LDM) at 446 kg N ha^{-1} and 28.60 kg DM ha^{-1} day^{-1} (SDM) at 503 kg N ha^{-1} (Figure 2). Dead material accumulation rate, in turn, did not vary with N fertilization, averaging 7 kg DM ha^{-1} day^{-1}.

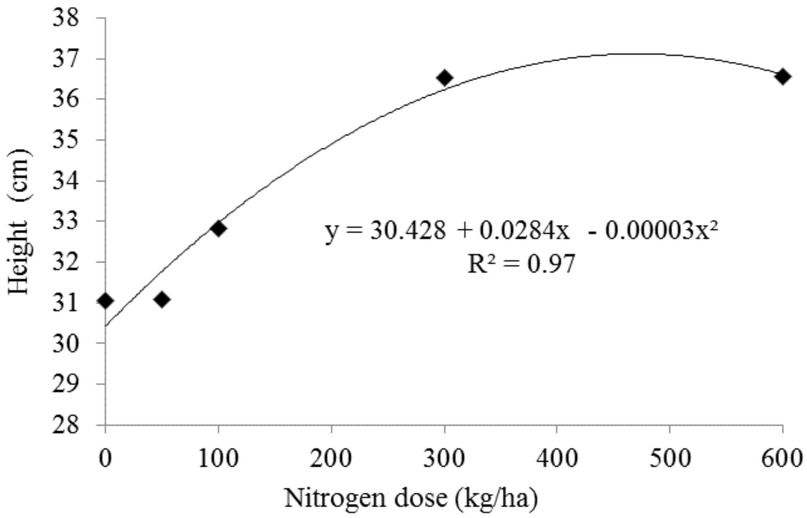

Figure 1: Pre-harvest height of digit grass fertilized with nitrogen and harvested at every 36 days.

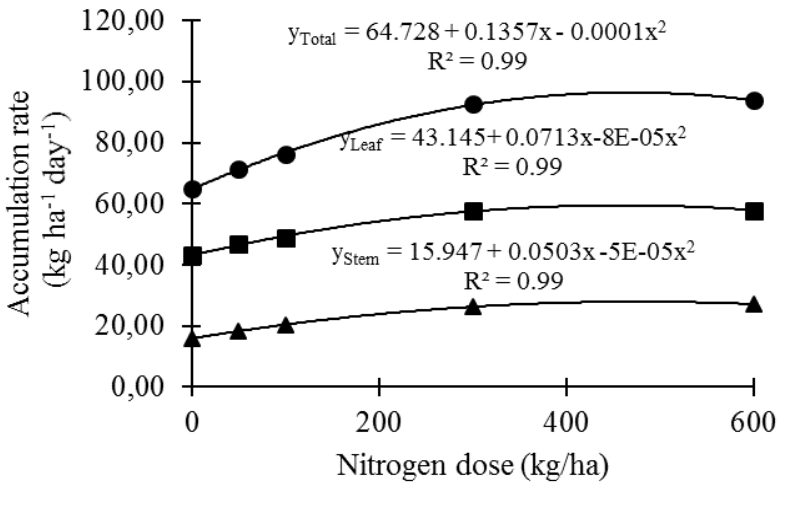

Figure 2: Total, (●), leaf (■) and stem (▲) dry matter accumulation rates of digit grass fertilized with nitrogen and harvested at every 36 days.

Nitrogen (N) is an important mineral in that it stimulates cell division and elongation in a plant [11], consequently accelerating leaf and stem growth [10]. This certainly increased canopy height (Figure 1) and TDM, LDM and SDM (Figure 2). The same response patterns were also observed in Brachiaria grass [12]; Tanzania, Mombaça and Mulato grasses [18]; and elephant grass [19]. According to Oliveira et al. (2015) [14], the growth stimulus forage plants when subjected to nitrogen fertilization prove that the use of N allows the use of shorter rest periods or an increase in the grazing frequency.

It is noteworthy that N application also increased stem accumulation rate up to the N dose of 503 kg ha^{-1}. Stem production in tropical pastures should be controlled, since this organ has low nutritive value [20]; limited accessibility to the animal, as it is located in the lower part of the canopy [8, 21]; and greater resistance to shearing, compared to the leaf [22], which requires greater effort from the animal upon biting.

Light interception (LI) by the canopy was influenced by N fertilization ($P<0.05$), fitting a quadratic model, with a maximum of 96.5% achieved at 476 kg N ha^{-1} (Figure 3). The LAI of digit grass was also influenced by N fertilization ($P<0.05$) and also fitted a quadratic model, with a maximum point of 5.0 at the N dose of 480 kg ha^{-1} (Figure 4). Because the high, LI and LAI of the canopy are highly and positively correlated [20], it is natural for those traits to exhibit the same response pattern to N fertilization (Figures 1, 3 and 4).

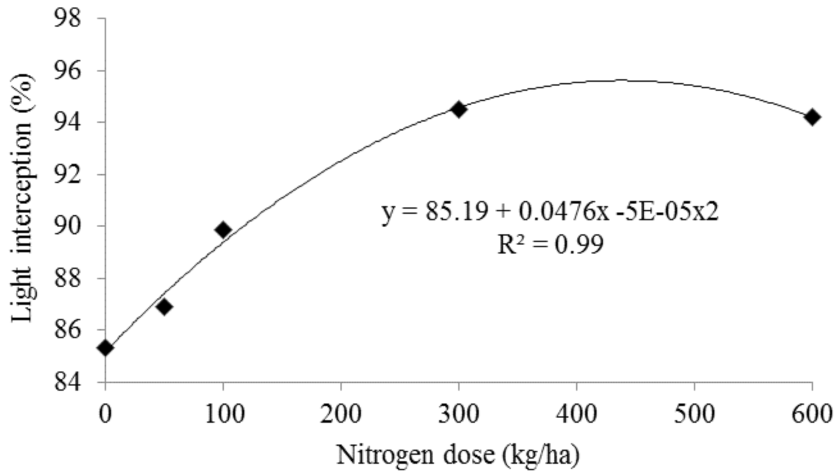

Figure 3: Light interception (%) pre-harvest of digit grass fertilized with nitrogen and harvested at every 36 days.

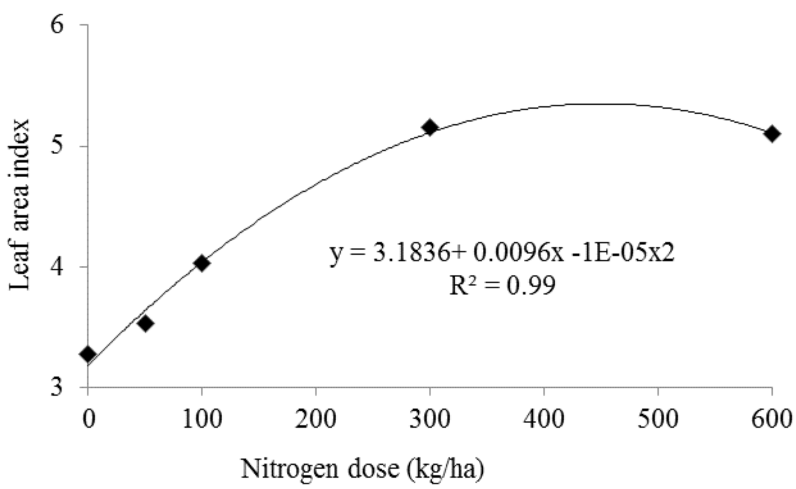

Figure 4: Leaf area index pre-harvest of digit grass fertilized with nitrogen and harvested at every 36 days.

A more favorable environment for the growth of the forage plant allows it to be harvested earlier. Consequently, the fertilized pasture should be managed with a shorter rest period, as compared to non-fertilized pastures [23]. However, this was not true in the present study, where a fixed rest period (36 days) between the harvests was adopted. As a result, interspecific competition for light increased in the canopies under higher N doses, a condition that intensifies stem elongation. In fact, the growth of a tropical pasture is initiated basically by accumulation of leaves, and from the moment the canopy intercepts 95% of the light, its regrowth pattern is altered, with a reduction in leaf accumulation and a marked increase in accumulation of stems and senescing leaves [24]. In the current experiment, light interception was higher than 95% in the canopies fertilized with N doses higher than 476 kg ha^{-1}, which indicates that competition for light was already high, in those canopies. Oliveira et al. (2015) [14] when evaluating digital grass subjected to different doses of N, they observed that the LI varied between 92.95% and 95.80% when applying 200 kg N ha^{-1} $year^{-1}$ e 800 kg N ha^{-1} $year^{-1}$, respectively. For the authors, the pasture is considered developed by intercepting 90% to 95% of the light and in this condition there is an increase in the rate of leaf expansion and tillering.

Basal (BTD) and total (TTD) tiller densities in digit grass responded ($P<0.05$) quadratically to N fertilization (Figure 5). Based on the equations, the maximum values for BTD (547 tillers m^{-2}) and TTD (661 tillers m^{-2}) occurred at 450 and 428 kg N ha^{-1}, respectively. On the other hand, aerial tiller density was not influenced ($P>0.05$) by N fertilization, averaging 119 tillers m^{-2}. Nitrogen also increased the number of basal and total tillers in the digit grass canopies (Figure 5) due to its positive effect in activating basal and axillary buds for the development of new tillers [9, 25, 26].

However, N doses greater than 450 and 428 kg ha^{-1} reduced BTD and TTD, respectively (Figure 5), which was possibly due to the increased interspecific competition for light among the tillers in that condition. In this respect, Sousa et al. [4] evaluated digit grass under different defoliation frequencies and found that, when subjected to a low frequency (55 cm), the forage plant reduced its basal-tiller appearance rate and number per tussock.

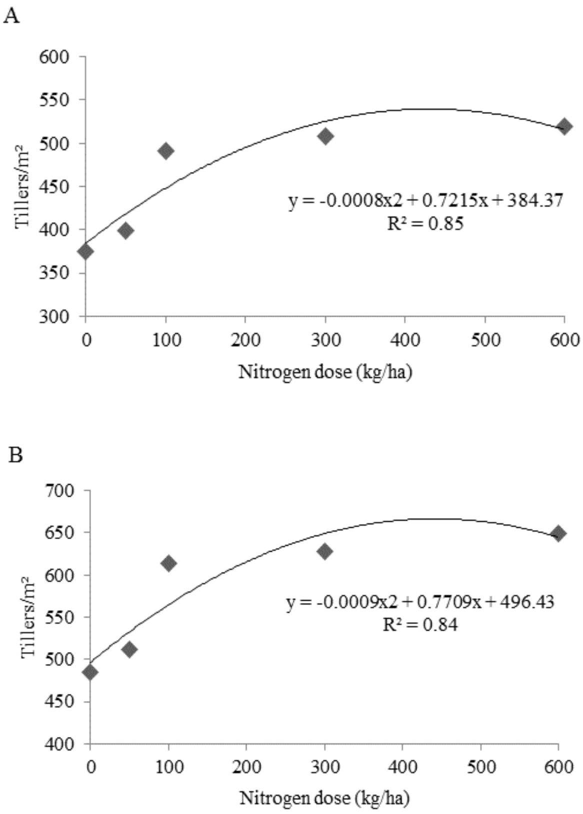

Figure 5: Basal (A) and total (B) tiller density of digit grass fertilized with nitrogen and harvested at every 36 days.

The increased number of basal and total tillers (Figure 5) as well as increased stimulus to tiller elongation (Figure 1) caused by the application of high N doses on digit grass resulted in an increase in LAI (Figure 4), which, in turn, increased light interception by the canopy (Figure 3). This may explain the increased total herbage accumulation of digit grass with the application of up to 478 kg N ha^{-1} (Figure 2). Although this forage grass is adapted to low-fertility soils, it increased its herbage production following the application of high N doses, suggesting that this plant has great flexibility of use and can thus be cultivated in soils with distinct fertility gradients.

Nitrogen utilization efficiency (NUE) decreased with the increasing N fertilization levels (Table 2). This variable is related to the degree of nutrient recovery by the crop, considering possible losses from leaching and volatilization [14]. Fagundes et al. (2005) [27] observed that there was a linear reduction in NUE when evaluating increasing doses of nitrogen fertilization in *Brachiaria decumbens*. Unlike Castanagra et al. (2011) [18] that when assessing three forage species (*Panicum maximum* cvs. Tânzania and Mombaça and *Brachiaria* sp. cv. Mulato) reported that there was a quadratic response to the application of 0, 40, 80 e 160 kg ha^{-1}. According to the authors, forage plants may respond differently to NUE [18].

In this context, the use of elevated N doses increases the possibility of losses of this nutrient through leaching and volatilization, which may explain the reduction in NUE. Indeed, when higher N levels are applied, the plant is not able to absorb all the nutrient provided, which results in increased losses of the nutrient to the environment [28]. Furthermore, it is possible that the digit grass reached its maximum N utilization capacity. It is also likely that NUE decreased with higher N doses, since some other nutrient essential to plant growth became the limiting factor.

Table 2: Nitrogen utilization efficiency of digit grass fertilized with nitrogen and harvested at every 36 days.

Nitrogen dose (kg ha^{-1})	**Total biomass yield (kg DM ha^{-1})**	**Nitrogen utilization efficiency (kg DM kg N^{-1})**
0	23,356	0
50	25,684	46.6
100	27,472	41.2
300	33,343	33.3
600	33,789	17.4

4. CONCLUSION

The digit grass proved to be responsive to nitrogen fertilization, reflecting the increase in plant height, dry matter production, leaf blades and stem. Consequently, the increase in canopy height contributed to greater light interception and the leaf area index. In addition, the use of nitrogen fertilization stimulated the tillering of digit grass. Thus, we conclude that the herbage yield potential of digit grass can be increased with the application of up to 478 kg N ha^{-1}, enabling the use of this forage resource in intensive pasture-based animal production systems.

5. ACKNOWLENGMENTS

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