

**Nitrogen fertilization in *Brachiaria decumbens* Stapf grass under degraded soil condition**

**Adubação nitrogenada em capim *Brachiaria decumbens* Stapf sob condição de solo degradado**

**Fertilización con nitrógeno en pasto *Brachiaria decumbens* Stapf en condiciones de suelo degradado**

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## Abstract

Chemically degraded soils are found all over the world. Fertilization is an essential agronomic technique for recovering fertility and productivity in these areas. In this context, the objective was to recover the productive capacity of a degraded Red Yellow Argisol, grown with *Brachiaria decumbens* Stapf, in the presence of mineral fertilization with increasing amounts of nitrogen, evaluating the production of plant mass, plant height, tillering and water consumption. The experiment was conducted in a screened shelter and humidity control, according to a completely randomized experimental design. The treatments were organized in a factorial scheme, 6 treatments (without fertilization, 0, 30, 60, 90, 120 of nitrogen; 80 and 50, phosphorus and potassium for all treatments in g vase<sup>-1</sup>, respectively) corresponding to the amount of fertilizer applied in Kg ha<sup>-1</sup>, 4 cuts (performed every 30 days, starting 45 days after planting) and 5 repetitions. When fertilizing with 120 Kg ha<sup>-1</sup> of nitrogen, it was obtained increase in fresh (655%) and dry (685%) mass when compared to the phytomasses of the treatment without fertilization, there was also an increase in the number of effective tillers and plant height, as the amounts of nitrogen applied increased in the soil. The maximum amount of nitrogen to be applied to the soil, in order to produce phytomass of *B. decumbens* in the condition of chemical degradation of the soil, obtained in the work was 120 Kg ha<sup>-1</sup>. In addition, the work allowed us to conclude that fertilization is an inexpensive and very important technique to recover the productive capacity of forage in the micro region of Brejo Paraibano, Northeast Brazil.

**Keywords:** Argisol; Mineral fertilization; Phytomass; Semiarid.

## Resumo

Solos quimicamente degradados são encontrados em todo o mundo. A adubação é uma técnica agrônômica essencial para recuperação da fertilidade e produtividade dessas áreas. Nesse contexto, objetivou-se avaliar a produção de fitomassa, altura de planta e perfilhamento de *Brachiaria decumbens* Stapf, na presença de adubação mineral com quantidades crescentes de nitrogênio em Argissolo Vermelho Amarelo degradado. O experimento foi conduzido em abrigo telado e controle de umidade, conforme delineamento experimental inteiramente casualizado. Os tratamentos foram organizados em esquema fatorial, 6 tratamentos (sem fertilização, 0, 30, 60, 90, 120 de nitrogênio; 80 e 50, fósforo e potássio para todos os tratamentos em g vaso<sup>-1</sup>, respectivamente) correspondendo à quantidade de fertilizante aplicado em Kg ha<sup>-1</sup>, 4 cortes (realizados a cada 30 dias, a partir de 45 dias após o plantio) e 5 repetições. Ao adubar com 120 Kg ha<sup>-1</sup> de nitrogênio, obteve-se aumento na massa fresca

(655%) e seca (685%) quando comparada às fitomassas do tratamento sem adubação, observou-se ainda aumento no número de perfilhos efetivos e altura de plantas, à medida que elevaram-se as quantidades de nitrogênio aplicadas no solo. A quantidade máxima de nitrogênio a ser aplicada ao solo, visando produção de fitomassa de *B. decumbens* na condição de degradação química do solo, obtida no trabalho foi 120 Kg ha<sup>-1</sup>. Ademais, o trabalho permitiu concluir que a adubação é uma técnica menos onerosa e muito importante para a recuperação da capacidade produtiva de forragem na microrregião do Brejo Paraibano, Nordeste do Brasil.

**Palavras-chave:** Adubação mineral; Argissolo; Fitomassa; Semiárido.

### Resumen

Los suelos químicamente degradados se encuentran en todo el mundo. La fertilización es una técnica agronómica fundamental para recuperar la fertilidad y la productividad en estas áreas. En este contexto, el objetivo fue evaluar la producción de fitomasa, altura de planta y macollamiento de *Brachiaria decumbens* Stapf, en presencia de fertilización mineral con cantidades crecientes de nitrógeno en Argisol Rojo Amarillo degradado. El experimento se realizó en un refugio con mosquitero y control de humedad, de acuerdo con un diseño completamente al azar. El experimento se realizó en un refugio con mosquitero y control de humedad, de acuerdo con un diseño completamente al azar. Los tratamientos se organizaron en un esquema factorial, 6 tratamientos (sin fertilización, 0, 30, 60, 90, 120 de nitrógeno; 80 y 50, fósforo y potasio para todos los tratamientos en g jarrón<sup>-1</sup>, respectivamente) correspondientes a la cantidad de fertilizante aplicado en Kg ha<sup>-1</sup>, 4 cortes (realizados cada 30 días, comenzando 45 días después de la siembra) y 5 repeticiones. Al fertilizar con 120 kg ha<sup>-1</sup> de nitrógeno, se obtuvo un aumento de masa fresca (655%) y seca (685%) al comparar con fitomasas de tratamiento sin fertilización, también se observó un aumento en el número de macollos efectivos y altura de plantas, a medida que aumentaba la cantidad de nitrógeno aplicado al suelo. La cantidad máxima de nitrógeno a aplicar al suelo, con el fin de producir fitomasa de *B. decumbens* en la condición de degradación química del suelo, obtenida en el trabajo fue de 120 Kg ha<sup>-1</sup>. Además, el trabajo concluyó que la fertilización es una técnica menos costosa y muy importante para la recuperación de la capacidad de producción de forrajes en la microrregión Brejo Paraibano, noreste de Brasil.

**Palabras clave:** Argisol; Fertilización mineral; Fitomasa; Semiárido.

## 1. Introduction

Brazil stands out for the size of its bovine herd. In the year 2018 it obtained the first place in the world ranking, with a herd of approximately 214,69 million head, for this, the country had a forage support of 162.19 million hectares of pastures (Abiec, 2019), of these, 111,77 million hectares are cultivated pastures and 46,74 million hectares of natural pastures (Ibge, 2017). The intensive exploitation of agricultural areas, is generally associated with the degradation of ecosystems, causing a reduction in biodiversity, soil fertility and intensification of erosion processes in relation to the conditions found under original vegetation. In this sense, there is a need to adopt sustainable management techniques to maintain productivity and mitigate environmental problems (Terra et al., 2019).

In the Brejo Paraibano region, Northeast Brazil, Santos et al. (2010) found that the substitution of native forest for livestock led to a generalized impoverishment of the soil, particularly in relation to the levels of calcium, magnesium and potassium in Argisol Red Yellow. In this way, soil correction and fertilization are less costly and efficient factors for the recovery of degraded areas (Santini et al., 2015). The application of fertilizers enables the supply of nutrients to maintain metabolism and the best development of pasture, nitrogen fertilization in particular is essential to increase biomass production, mainly related to pasture recovery (Silva et al., 2013).

Among macronutrients, nitrogen is the most limiting factor for pasture productivity, due to the fact that it actively participates in the synthesis of organic compounds that form the structure of the plant, such as amines, amides, vitamins, pigments, amino acids, proteins and nucleic acids (Malavolta, 1980). Among these, proteins, a polymer of amino acids, represent the main form of organic nitrogen present in plants, protein molecules have 16% nitrogen, representing about 1 to 5% of the plant's biomass (Costa et al., 2020).

The positive effect on primary forage productivity is optimized by the correlation between the amount of nitrogen and carbon fixation, improving photosynthetic efficiency and carbon allocation to the shoots, causing an increase in the photosynthetic area (Taiz et al., 2017; Silva, 2018; Costa et al., 2020). Furthermore, the knowledge of the influence of fertilization on structural characteristics of pasture in degraded soil, is relevant to its proper management, resulting in ingestive behavior, consequently, in the performance of the animal in the grazing area (Silva et al., 2013).

The genus *Brachiaria* is one of the tropical forages with the largest cultivated area in the world, lately it has had a great expansion in Brazil. The forage stands out for presenting advantageous characteristics compared to other genera: great adaptability to acidic soils with low fertility and high dry matter yield (Silva et al., 2012). In addition, it has extraordinary drought tolerance, remaining green during the drought period, still resisting cold (except for frosts), fire, trampling and tolerating excessive humidity (Pupo, 1981).

In this context, the objective was to recover the productive capacity of a degraded Red Yellow Argisol, grown with *Brachiaria decumbens* Stapf, in the presence of mineral fertilization with increasing amounts of nitrogen, evaluating the production of plant mass, plant height, tillering and water consumption.

## **2. Methodology**

### **Soil collection and climate**

The soil collection took place at the Frecheiro property, in the municipality of Areia, in the region of the Brejo Paraibano, Northeast Brazil. The topography of the analyzed area is mostly made up of rugged terrain, represented by relief ranging from strong undulating to mountainous, with a steep slope measuring approximately 45%. The soil was classified as Red Yellow Argisol according to the criteria of the Brazilian Soil Classification System - SiBCS (Embrapa, 2018), which is used predominantly with pastures. According to the Köppen-Geiger climate classification (Alvares et al., 2013), the region has an As' climate, which is characterized by being hot and humid, with autumn - winter rains and a dry period between the months of September and February. Average annual rainfall of 1.400 mm and average annual temperature ranging between 23 and 25 °C.

### **Conducting the experiment**

The experiment was conducted in a screened shelter belonging to the Department of Phytotechnics and Environmental Sciences (DFCA) of the Federal University of Paraíba (UFPB). The soil was dried in the shade for 48 hours and sieved through a 2 mm mesh sieve (TFSA). After drying, it was characterized in the chemical analysis laboratory of the Department of Soils and Rural Engineering - CCA - UFPB (Table 1), following methodologies contained in Embrapa (2017).

**Table 1.** Chemical characterization of Red Yellow Argisol, collected at a depth of 20 cm.

Chemical Analysis											
pH	P	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	Al <sup>3+</sup>	H <sup>+</sup> +Al <sup>3+</sup>	CEC	BSP	M.O	
--- mg Kg <sup>-1</sup> ---		----- cmol <sub>c</sub> Kg <sup>-1</sup> -----							%	g Kg <sup>-1</sup>	
4,52	1,08	35,96	0,45	0,55	0,20	0,80	3,80	5,09	21,41	164,5	

MO - Organic matter; CEC - Cation exchange capacity:  $(Ca^{2+} + Mg^{2+} + K^{+} + Na^{+}) + (H+Al^{3+})$ ; BSP - Base saturation percentage:  $(Ca^{2+} + Mg^{2+} + K^{+} + Na^{+}) / CEC \times 100$ . Source: Authors.

The soil after drying was deposited in plastic vases, with a capacity of 8,0 kg of dry soil. The treatments were organized in a factorial scheme, 6 treatments (without fertilization, 0, 30, 60, 90, 120 of nitrogen; 80 and 50, phosphorus and potassium for all treatments in g vase<sup>-1</sup>, respectively) corresponding to the amount of fertilizer applied in Kg ha<sup>-1</sup> based on Oleynik (1987), 4 cuts (performed every 30 days, starting 45 days after planting) - standardization cut and 5 repetitions. The sources of mineral fertilizers used were ammonium sulfate (45% N), simple superphosphate (20% P<sub>2</sub>O<sub>5</sub>) potassium chloride (60% K<sub>2</sub>O).

The forage used was *Brachiaria decumbens* Stapf, the seeds were acquired in a commercial house, with 60% purity and germination level, were sown in the amount of 20 seeds vase<sup>-1</sup>, to guarantee a satisfactory stand of three plants per vase, thinning, was performed fifteen days after planting (DAP). The vase were irrigated, every three days, in order to maintain 80% of the field capacity, aiming to change the amount of water lost from the system through evapotranspiration.

### Agronomic variables

In each cutting season, the following traits were determined:

- Total fresh mass of the aerial part of the plants, cut at five centimeters from the soil surface, measuring the mass in the field to avoid loss of mass due to dehydration;
  - Total dry mass, conditioning the material vegetable in paper bags and taken to dry in an oven with forced air circulation at 65 °C for a minimum of 72 hours until it reaches constant mass, then the dough is removed from the paper bag;
- ]
- Height of plants cut measured from the base of the plant in relation to the last stem node;

- Total number of tillers, counting only vegetatively active tillers, as recommended Hodgson (1990), since they are important because they are modular units of the growth of forage grasses;
- Water consumption or evapotranspiration of the culture ( $ET_c$ ), was quantified every three days, represented by the amount of water applied to the vase to reach the initial corresponding mass of the vase + soil + water (80% of the field capacity ). The amount of water replenished in the vase every three days until the end of the experiment, which represented the water consumption of the soil-plant system.

### **Statistical analysis**

The data were subjected to analysis of variance ( $P < 0.05$ ), after finding the significance, polynomial regression models were constructed ( $P < 0.05$ ). Statistical analyzes were performed using the STATISTICA 9.0<sup>®</sup> software.

### **3. Results and Discussion**

The productive variables evaluated: fresh mass, dry mass, plant height and number of effective tillers differed by the analysis of variance  $F$ - test ( $P < 0.05$ ). In addition, there was a significant interaction between treatments and cuts (Table 2).

**Table 2.** Analysis of variance of grass productive variables *B. decumbens*.

Sources of variation	dF	FM		DM		H		TN	
		Calculated <i>F</i>	<i>P</i> Value	Calculated <i>F</i>	<i>P</i> Value	Calculated <i>F</i>	<i>P</i> Value	Calculated <i>F</i>	<i>P</i> Value
<b>Treatment</b>	3	73,92*	0	69,41*	0	372,41*	0	72,30*	0
<b>Cut</b>	5	273,72*	0	210,95*	0	47,63*	0	45,37*	0
<b>Treatment/ Cut</b>	15	19,39*	0	15,09*	0	24,45*	0	1,80*	0,04
<b>Residue</b>	96								
<b>CV (%)</b>		22,71		24,15		14,98		18,27	

FM - Fresh Mass; DM - Dry Mass; H - Height; TN - Tiler Number; dF - Degree of Freedom; CV - Coefficient of variance. \* significant by *F*- test ( $P < 0.05$ ). Source: Authors.

### Fresh and dry mass

The treatment without fertilization did not show fresh and dry phytomass production (Figures 1 and 2), respectively, in the first cut performed 45 days after planting, it is explained by the fact that *B. decumbens* grass does not have enough height to be cut of its aerial phytomass, with the aerial part being cut only after the second cut, at 75 (DAP).

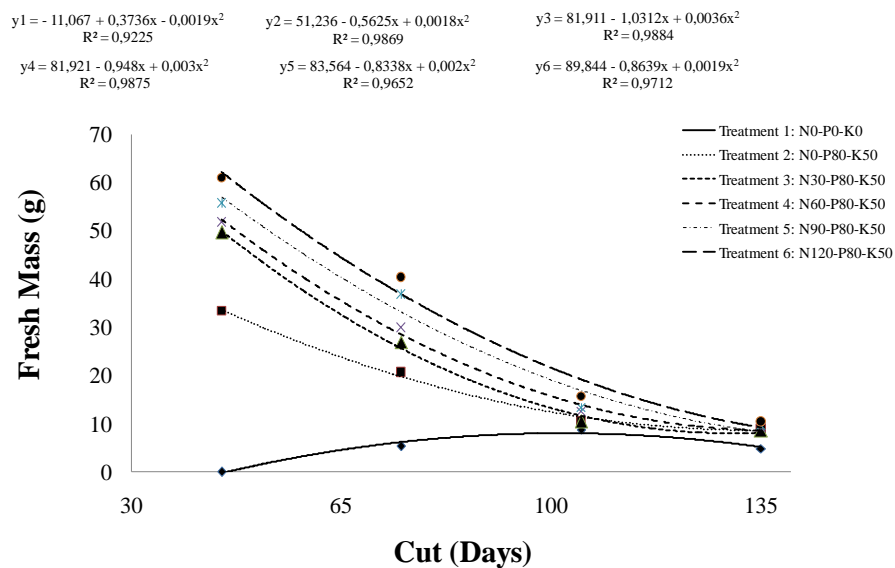
In the second cut 75 (DAP), treatment 6 (120 kg ha<sup>-1</sup> of N) produced 40,33 and 8,09 g vase<sup>-1</sup>, respectively (Figures 1 and 2), increment of fresh mass (655%) and dry (685%) when compared to the phytomasses of the treatment without fertilization, this increase in the forage phytomass is explained by the greater stimulus of cell division and expansion (Gastal & Lemaire, 2002), allowing the growth of plants and consequently an increase in phytomasses.



Machado et al. (2017) when working with nitrogen fertilization (400 kg ha<sup>-1</sup> year<sup>-1</sup>), in condition of medium soil fertility, with Brachiaria (*Urochloa decumbens* Stapf), obtained an increase of 51,53% in dry mass, a percentage lower than that obtained in this research (685%), proving the high productive response of grass plants to fertilization in conditions of chemically degraded soil.

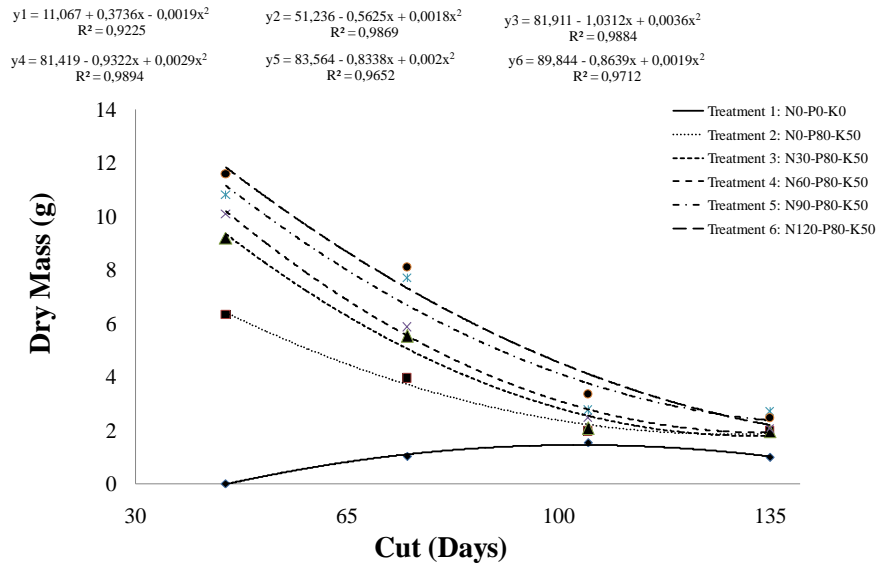
Increased forage production through nitrogen fertilization of pastures was mentioned by other authors (Lobo et al., 2014; Rezende et al., 2015; Machado et al., 2017).

**Figure 1.** Fresh weight of *B. decumbens* grass as a function of increasing amounts of nitrogen (Kg ha<sup>-1</sup>) every 30 days.



Source: Authors.

**Figure 2.** Dry mass of *B. decumbens* grass as a function of increasing amounts of nitrogen (Kg ha<sup>-1</sup>) every 30 days.



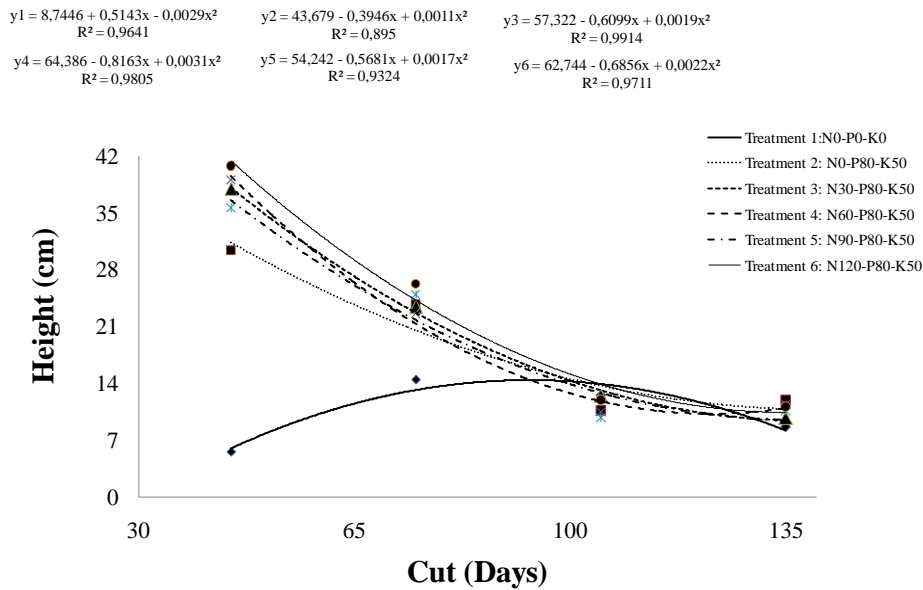
Source: Authors.

### Plant height

In the first cut at (45 DAP), there was an increase of 641% in the size of the grass (40,8 cm) of the treatment with the largest amount of N used 120 Kg ha<sup>-1</sup>, when compared to the size of the grass (5,5 cm) in the treatment without fertilization (Figure 3), this high increase proves the effect of fertilization for early forage supply. When evaluating cutting height of 7 cm in Jiggs grass, Maccari et al. (2019) observed dry mass accumulation from 50 kg ha<sup>-1</sup> of N.

Furthermore, Rodrigues (1997) determines the cutting height in the range of 30 to 40 cm for *B. decumbens*. In the first cut, all fertilized treatments reached this interval except for the treatment without fertilization, in the other cuts, all treatments did not reach this interval for the height of cutting, demonstrating the importance of fertilization in the availability of forage for the animal. However, changes caused by nitrogen fertilization in the growth of the grass cause the need for adjustments in the cutting height, aiming at harvest efficiency and greater production of quality forage (Maccari et al., 2019).

**Figure 3.** *B. decumbens* grass plant heights as a function of increasing amounts of nitrogen ( $\text{Kg ha}^{-1}$ ) every 30 days.



Source: Authors.

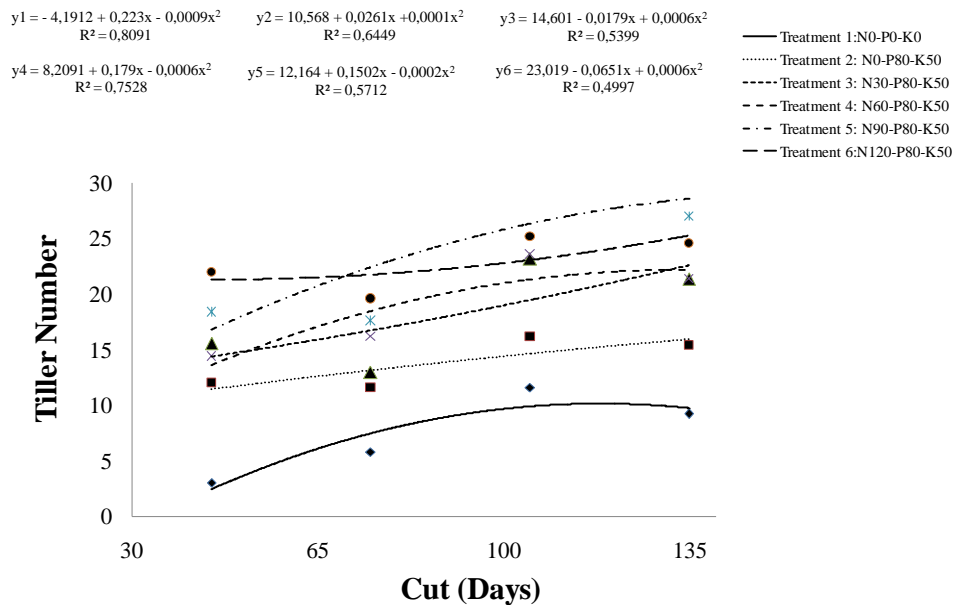
### Tilling

Tiller is the modular growth unit of forage grasses (Hodgson, 1990; Amorim et al., 2019), when analyzing the number of effective tillers, that is, those that are vegetatively active, a quadratic behavior was observed (Figure 4). It appears that the number of tillers was lower in the first cut compared to the others. This probably occurred, because in the establishment, the plants store much of the energy absorbed, for the formation of the root system and aerial part, while in the second phase the root system, already established, is able to absorb nitrogen, stimulating bud sprouting (LavreS & Monteiro, 2003).

Individually the tiller effectiveness is conditioned by biotic and abiotic factors, the productive viability of the grass is prolonged by the continuous replacement of dead tiller by effective ones (Santos et al, 2012; Costa et al., 2020).

Treatment 5 ( $90 \text{ Kg ha}^{-1}$ ), showed a greater development of effective tillers in relation to the other treatments, ending in the fourth cut, with a greater number of effective tillers, totaling 27 (Figure 4). This result denotes the importance of nitrogen in the production of new tillers (Gomide et al., 2018), which favors the persistence of post-feeding grass and trampling of animals in the pasture.

**Figure 4.** Number of effective *B. decumbens* grass tillers in treatments with increasing nitrogen levels (Kg ha<sup>-1</sup>) every 30 days.



Source: Authors.

### Water consumption

The water content in the soil is essential for plant growth, where there is an increase in the volume of cells, caused by biological processes and by the physical action of water entering the cells, causing elongation of the cell wall and expansion of plant structures (Paiva & Oliveira, 2006; Melo et al., 2020). Therefore, when assessing water consumption in *B. decumbens* plants, it was observed in terms of average daily consumption at the end of four aerial part cuts, causing an increasing consumption for treatments in which the amounts of nitrogen applied to mineral fertilization increased (Figure 5).

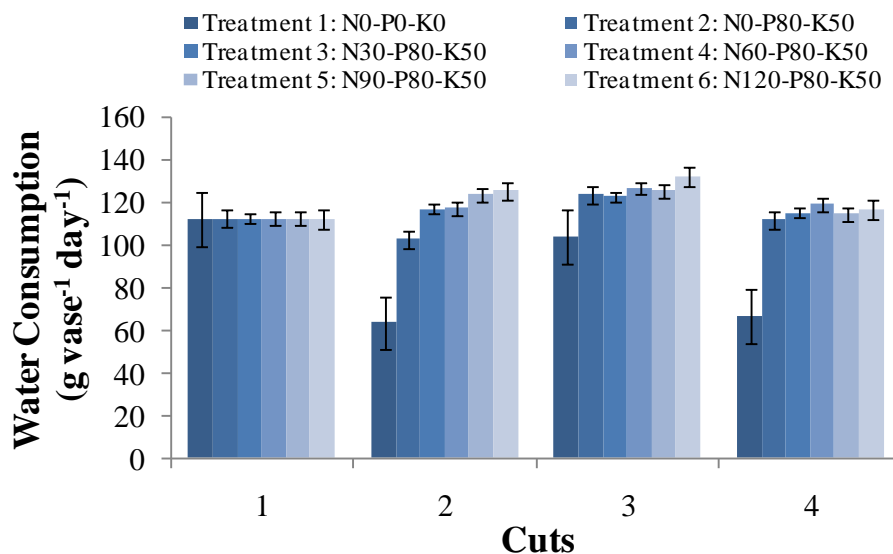
Recent studies have observed that grass production is influenced by the availability of water content in the soil (Dantas et al., 2016; Koetz et al., 2017). In this context, the daily water consumption for treatment without fertilization was 86,3 g day<sup>1</sup>. Regarding the cuts, there was a variability in daily water consumption, with no tendency to increase or decrease over time.

Depending on the values of daily water consumption by the plant-vase system, it is possible to estimate the total water consumption at 135 (DAP), after performing the fourth cut of the aerial part, reaching the average values of 11.650, 5 cm<sup>3</sup> of water for treatments without mineral fertilization and 16.402,5 cm<sup>3</sup> for the treatment that received the highest amount of

nitrogen (Figure 5). Mezzomo et al. (2020) when working with irrigation depths in Sudan grass, they emphasize the importance of correlating production with the total amount of water applied throughout the crop cycle, aiming at the rational use of irrigation systems and enabling economic analysis of the activity.

The highest average water consumption  $121,5 \text{ cm}^3 \text{ day}^{-1}$  was observed in the treatment with the highest amount of nitrogen fertilizer  $120 \text{ Kg ha}^{-1}$  (Figure 5), which produced the largest amount of fresh phytomass obtained in this work  $60,89 \text{ g vase}^{-1}$  (Figure 1). Therefore, it appears that there is a direct positive relationship between fertilization, water consumption, forage production.

**Figure 5.** Average daily water consumption by three plants of *B. decumbens*, due to the cut of the aerial part under mineral fertilization with increasing amount of nitrogen ( $\text{Kg ha}^{-1}$ ).



Source: Authors.

#### 4. Final Considerations

The maximum amount of nitrogen to be applied to the soil, aiming at the production of *B. decumbens* phytomass in the condition of chemical degradation of the soil, obtained in the work was  $120 \text{ Kg ha}^{-1}$ . In order to have a high production of aerial phytomass of *B. decumbens*, constant supply of water is necessary, as it favors the increase in the volume of cells, caused by biological processes and by the physical action of water entering cells.

In addition, the work allowed us to conclude that fertilization is an inexpensive and very important technique to recover the productive capacity of forage in the micro region of Brejo Paraibano, Northeast Brazil.

Future works associated with techniques for the recovery of degraded areas with soil conservation techniques are important to restore the productive capacity of degraded soils, as they prevent the removal of native vegetation from other areas of the Brejo Paraibano.

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