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AGRONOMIC PERFORMANCE OF *Urochloa brizantha* CV. MARANDU CULTIVATED IN CLAYEY AND SANDY SOIL SUBMITTED TO WATER AND NUTRITIONAL MANAGEMENT

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Keywords:
Fertilization
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Soil texture

ABSTRACT

Water and nutrient supply, as well as the soil texture, are some of the challenges that affect forage yield. Therefore, the objective of this work was to evaluate the agronomic performance of *Urochloa brizantha* cv. Marandu cropped in clayey and sandy soil submitted to water and nutritional management, in the municipality of Rio Verde, State of Goiás. The treatments consisted of a combination of soil with two textural classes (clayey and sandy), two levels of fertilization (A1: 30; 7 and 36 and A2: 45; 10.5 and 54 NPK per Mg DM, respectively), and seven water depths (0%, 25%, 50%, 75%, 100%, 125% and 150% of the crop evapotranspiration (ETc)), in four replicates. Crop performance was evaluated using SPAD index, plant height, leaf length, leaf width, leaf/stem ratio, crude protein, neutral detergent fiber, and dry matter. The data were subjected to multivariate data analysis. The principal component analysis allowed to observe that the first principal component explained 68.94% of the data, being characterized for promoting the best crop performance in relation to leaf length and width, characteristics that reflect in the other assessed variables. Forage performed poorly in winter because of the limitation of the climatic conditions. A higher yield was observed in the dry matter submitted to depths greater than 100% of ETc, regardless of the soil texture and the level of fertilization.

Palavras-chave:
Manejo de pastagem
Forrageira
Irrigação
Adubação
Textura de solo

DESEMPENHO AGRONÔMICO DE *Urochloa brizantha* CV. MARANDU CULTIVADA EM SOLO ARGILOSO E ARENOSO SUBMETIDA A MANEJO HÍDRICO E NUTRICIONAL

RESUMO

A oferta hídrica, nutricional e textura dos solos são alguns dos desafios que afetam a produtividade de forrageiras. Portanto, o objetivo deste trabalho foi avaliar o desempenho agronômico da *Urochloa brizantha* cv. Marandu cultivada em solo argiloso e arenoso submetida a manejo hídrico e nutricional, no município de Rio Verde, Goiás. Os tratamentos consistiram na combinação de solo com duas classes texturais (argiloso e arenoso), dois níveis de adubação (A1: 30, 7 e 36 e A2: 45, 10,5 e 54 de NPK por Mg de MS produzida, respectivamente) e sete lâminas de água (0%, 25%, 50%, 75%, 100%, 125% e 150% da evapotranspiração da cultura (ETc)), em quatro repetições. O desempenho da cultura foi avaliado através do índice SPAD, altura de planta, comprimento foliar, largura foliar, relação folha/colmo, proteína bruta, fibra em detergente neutro e massa seca. Os dados foram submetidos à análise multivariada de dados. Pela análise de componentes principais, foi possível observar que o primeiro componente principal explicou 68,94% dos dados, sendo caracterizados por promover o melhor desempenho da cultura em relação ao comprimento e largura foliar, características que refletem nas demais variáveis analisadas. A forrageira apresentou baixo desempenho no inverno em função da limitação das condições climáticas. Houve maior rendimento na produção de matéria seca submetida a lâminas superiores a 100% da ETc, independentemente da textura do solo e do nível de adubação.

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INTRODUCTION

Brazil has approximately 163 million hectares of pastures in use, accounting for almost 86% of beef production (ABIEC, 2020). Therefore, grasses are essential for Brazilian livestock, allowing the country to stand out as one of the largest exporters of animal protein produced on pasture.

Urochloa spp. is the genus of forage most cultivated in the country, considering its easy and rapid adaptation to edaphoclimatic circumstances. Concerning *Urochloa brizantha* cv. Marandu (syn. *Brachiaria brizantha* cv. Marandu), it is observed that it exhibits good primary production indexes, vitality, seed production capacity, ability to make small and large ruminants present the maximum production potential, due to the supply of forage in adequate proportion and good nutritional value (GERMANO *et al.,* 2018; EUCLIDES *et al.,* 2019; GURGEL *et al.,* 2020; HEIMBACH *et al.,* 2020).

On the other hand, in Central Brazil (Center-West), generally, from five to six months during the year, there is a reduction in precipitation, causing U. brizantha pastures, especially the Marandu grass, to reduce primary production, due to deceleration in tissue flow and tiller mortality (SBRISSIA *et al.,* 2010). Therefore, it is necessary to use management practices that can reduce the negative impact in periods of scarcity of precipitation on biomass production.

The use of irrigation can be a promising technique to meet the water requirements of forages under tropical climate conditions. In the analysis by Vitor *et al*. (2009), the challenge for the *Urochloa* genus is to investigate forage production systems, so that their qualities are highlighted and high-quality forage is produced. Therefore, it is necessary to develop researches that collaborate with the promotion of cultivation techniques and soil management for expressive performances (SILVA *et al.,* 2009).

In clayey textured soils, Marandu grass presents good agronomic indexes, as well as high secondary production, however, in the dry period, it exhibits a reduction in forage production (EUCLIDES *et al.,* 2019). In Quartzarenic Neosol (sandy texture), due to low natural nutrient indices, associated with a lower concentration of organic matter for soil water retention, marandu grass cultivated in this environment may exhibit reduced tillering (MESQUITA *et al.,* 2004).

In general, when some practice of water or nutritional management (fertilization) for forages is adopted, calculations of the water requirement of the crop or soil analysis are rarely or never considered nor the soil texture. As a result, it is expected that the knowledge on the water and nutritional demand in different soil conditions, allows contributing to the management of water and mineral fertilizers, providing greater productivity and forage quality, thus reducing costs when applying empirical knowledge.

Given the aforementioned reports, it is possible to suggest that the use of irrigation depths associated with the supply of nutrients can increase the production and nutritive value of marandu grass cultivated in soils with different textures. Therefore, the present work proposes to evaluate the hydric and nutritional conditions, through cultivation in sandy and clayey soil, to identify the factors that stimulate the best forage Growth in each season of the year, in the region of Rio Verde, Goiás.

MATERIAL AND METHODS

The experiment was conducted at the University of Rio Verde (UniRV), municipality of Rio Verde, State of Goiás, located at latitude 17°47’15” S and longitude 50°57’54” W, with an average altitude of 784 m, in the period from August 2019 to October 2020.

The average air temperature over the experimental period was 24.5°C, ranging between the maximum and the minimum in 29.4°C and 19.5°C, respectively. The rainfall volume during the conduction of the experiment was 1,559.6 mm (Figure 1), concentrated from the first to the eighth cycle (96.3%). In the first six cycles, the rainfall volume was higher than the water requirement of the plant, which during the 12 months was 1,248 mm. The volume of water applied in the control treatment (100% of ETc) was 1,139 mm considering the daily management, without considering the water reserve as the experiment was conducted using pots. The other treatments received proportional amounts to the applied depth. The mean crop evapotranspiration in spring, summer, autumn and winter was 4.54, 3.49, 2.57, and 3.48 mm day^{-1}, respectively. The overall mean of ETc was 3.52 mm day^{-1}.

The forage *Urochloa brizantha* cv. Marandu was grown in 112 pots with a capacity of 15 liters under field conditions. The experiment followed a completely randomized block design (DBC), with four replications, in which the treatments were arranged in a triple factorial scheme in 2x2x7. The treatments consisted of a combination of soil with two distinct textural classes (clayey and sandy); two fertilization levels (A1: 30; 7 and 36, and A2: 45; 10.5 and 54 of NPK per Mg of DM produced, respectively) and seven levels of irrigation depths (0; 25; 50; 75; 100; 125 and 150% of the maximum crop evapotranspiration (ETc)).

Urochloa brizantha was sown on August 31, 2019. The 15-cm height standardization cut was performed after the establishment of the forage (average height of 41 cm), 48 days after sowing. The other cuts were done every 28 days, totaling 13 cycles (October 18 2019 to October 16, 2020).

The soils used in the experiment were classified as HUMIC APLUDOX with clayey texture (clay > 35%); QUARTZARENIC NEOSOLS with a sandy texture (clay < 10%) (SANTOS *et al.,* 2018). Soils were collected in a 0-0.2 m layer in a "virgin" forest and analyzed to verify the need for supplementation (Table 1).

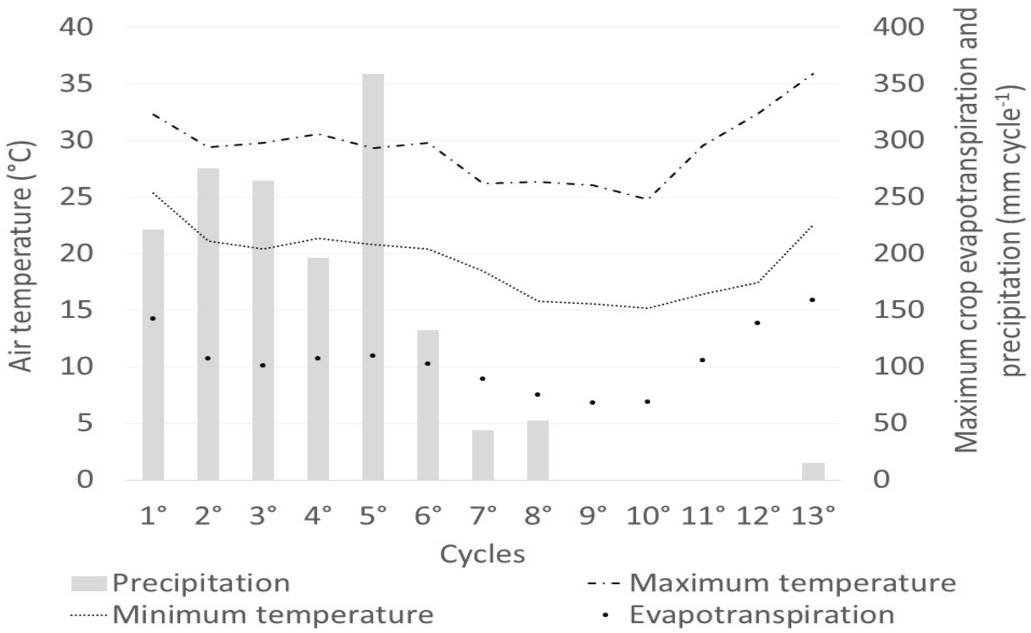

Figure 1. Climate monitoring over the experiment period in the city of Rio Verde, Goiás, from October/2019 to October/2020

Table 1. Chemical analysis of the clayey soil (RED LATOSOL) and Sandy soil (QUARTZARNIC NEOSOL) collected in the 0-0.2-m layer

T	Ca+Mg	Ca	K	Mg	Al	H+Al	K	P(Mel)	O.M.	pH_{CaCl2}
	------------- cmolc dm^{-3} -------------						mg dm^{-3}		g kg^{-1}	
Cla	0.33	0.28	0.07	0.05	0.45	4.6	29	0.33	25.0	4.28
Sand.	0.84	0.72	0.07	0.12	0.60	5.8	29	3.97	18.1	4.42
V	m	CEC	SB	Clay	Silt	Sand	Fe	Mn	Cu	Zn
%		cmolc dm^{-3}		----------- % -----------				mg dm^{-3}		
52.81	8.01	5.02	0.40	39.87	21.27	38.66	237.6	33.5	2.4	0.4
39.64	13.66	6.69	0.91	8.05	3.68	88.26	310.1	19,1	4,3	3,8

T: Soil texture; Cla.: Argisol; Sand.: Sandy; Ca: calcium; K: potassium; Mg: magnesium; Al: aluminum; H+Al: potential acidity; K: potassium; P: phosphorus; M.O.: organic matter; pH_{CaCl2}: active acidity; m: aluminum saturation; V: base saturation; CTC: cation exchange capacity; SB: sum of bases; Fe: iron; Mn: manganese; Cu: copper; Zn: Zinc

The soil was sieved in a 4-mm mesh sieve. Next, based on the physicochemical analyses, fertilization was carried out to correct soil fertility following Sousa *et al*. (2004) for forage.

Limestone with an RPTN (Relative Power of Total Neutralization) of 80% (the qualitative aspect of the limestone, translated in the function of the reactivity and the neutralizing power of the ground rock) was used. In addition, the method of necessity through base saturation was used to meet 50% (V%), as described by Sousa *et al*. (2004). The reaction time was 30 days. The fertilizers used were: potassium chloride (60% K_2O) single superphosphate (18% P_2O_5, 16% Ca and 8% S), triple superphosphate (46% P_2O_5 and 8% Ca) zinc sulfate (20% of Zn), copper sulfate (13% Cu), ammonium sulfate (20% N and 22-24% S) or urea (44% N).

The amount of 15 kg ha^{-1} of seeds with 80% cultural value was used. During the period of the experiment, complementary fertilization was carried out following the double and triple of 15; 3.5 and 18 kg of NPK (nitrogen, phosphorus, and potassium) per Mega gram (Mg) of dry matter (DM) yield every 28 days according to the methodology used by Vilela *et al*. (1998). The works carried out by Dantas *et al*. (2016) found that forage linearly responds to NPK fertilization when 50% more nutrients are used, thus, the dose of 100% higher than that proposed follows the recommendation of Malavolta (1980) for carrying out the work in pots and 200% to understand how the response of the crop will be. Therefore, doses of 30, 7, and 36 (A1) and 45; 10.5 and 54 (A2) kg of NPK per Mg of DM yield were used. Fertilization was performed within 72 hours, after the productivity analysis.

The treatments were organized from T1 to T14 with clayey soil and T15 to T28 with sandy soil. Treatments T1 to T7 and T15 to T21 received fertilization A1 and T8 to T14 and T22 to T28, the A2 fertilization. The irrigation depths decreased from T1 to T7, T8 to T14, T5 to T21, and T22 to T28 (Table 2).

Meteorological data for irrigation management were collected at the Rio Verde Automatic Weather Station (A025) and supplied by the National Institute of Meteorology (INMET, 2020). The daily calculation of ETo (reference evapotranspiration) was performed in the software System for the Management of Irrigated Agriculture (MARIANO *et al.,* 2011), using the Penman-Monteith method (FAO Standard) developed by Allen *et al*. (1998). In addition, the *Brachiaria* forage coefficient (kc) equal to 1.0 was used (SANTOS *et al.,* 2019) to obtain the maximum crop evapotranspiration (ETo = ETc).

Regarding the biometric indices, the following were evaluated: SPAD index, leaf length and width, plant height, leaf/stem ratio, and yield. The SPAD index was measured every 28 days, using a portable SPAD-502® meter, on the first fully expanded leaf, in the morning, between 8:00 and 9:00 am.

Leaf length, leaf width, and plant height were measured every 28 days, before forage cutting, using a measuring tape and a graduated ruler. Leaf length was determined on the first fully expanded leaf, measuring from the ligule of the stem to the apex of the leaf. The width of the leaf was determined from the center of the leaf, from one end to the other. Plant height was determined from the base of the soil inside the pot to the apex of the leaf without interference.

For the leaf/stem ratio, the entire sample was weighed, then the leaf was detached from the stem in the sheath, with the aid of a stylet. The stem was weighed separately to obtain the leaf/stem ratio (L/S).

Because of the large volume of samples, forage

Table 2. Treatments used for the cultivation of *Urochloa brizantha* cv. Marandu, Rio Verde, Goiás

Texture	Fertilization	Maximum crop Evapotranspiration (%)						
Clayey	A1	0	25	50	75	100	125	150
	A2	0	25	50	75	100	125	150
Sandy	A1	0	25	50	75	100	125	150
	A2	0	25	50	75	100	125	150

Note.: A1 = Nitrogen = 30 kg t^{-1} DM; Phosphorus = 7 kg t^{-1} DM; Potassium = 36 kg t^{-1} DM. A2 = Nitrogen = 45 kg t^{-1} DM; Phosphorus = 10.5 kg t^{-1} DM; Potassium = 54 kg t^{-1} DM qualitative evaluations were carried out by using composite samples per treatment of all the material collected during the experimental period. Thus, it was possible to carry out the determination of crude protein (CP) and neutral detergent fiber (NDF). Analyses were performed in the laboratory, following the methodology of Silva and Queiroz (2006), using the Kjeldahl extractor method.

Dry matter (yield) was defined with the execution of cuts every 28 days, simulating a direct grazing system. The forage was manually harvested and cut at a height of 15 cm from the ground with the aid of a pot-shaped steel jig, following the guidelines of Santos *et al*. (2019). Samples were taken from the cut forage to be weighed in fresh form and taken to the oven with forced air circulation and constant temperature of 65°C for 72 hours, for dry mass determination (LACERDA *et al.,* 2009).

The multivariate analysis was performed using cluster (CA) and principal components (PC) analyses. The normality test was processed, followed by the Euclidean distance between the accessions and, the Ward method was used as a connection method. The original dataset (SPAD index, plant height, leaf length and width, leaf/stem ratio, and dry matter yield) was resized for a set of new latent variables through PC analysis. CA and PC were performed in the STATISTICA 12 software.

RESULTS AND DISCUSSION

Forage showed the best SPAD index and average morphometric performance in spring-summer compared to autumn-winter (Table 3). The best performance of the forage provides the greatest availability of fresh mass and, consequently, in dry mass.

The best SPAD indexes were obtained in the treatments in sandy soil conditions, with A2 fertilization and irrigation depths of 50 to 100% of ETc, with treatment T25 (49.64) in spring and summer (57.04), T26 in autumn (46.26), and T24 in winter (49.89). Mazero *et al*. (2020) in evaluating the SPAD index in *Urochloa brizantha* cv. Paiaguás grown with doses of plant ash obtained values between 40 and 50. These data represent how active, photosynthetically, the leaves are and, therefore, it is possible to assess whether the plants are well-nourished with nitrogen, due to the fact of the existence of a significant correlation between the intensity of the green color with the content of chlorophyll and the concentration of N in the leaves (GIL *et al.,* 2002).

The period of least oscillation in the average cutting height between treatments was summer, followed by autumn. In winter, the climatic conditions of solar radiation and air temperature, inhibited the development of the plant, presenting a lower average cut height, which affects the dry mass yield. Results similar to those obtained by Dantas *et al*. (2016) in the same cultivar, however, using doses of organic nitrogen, which was treated sewage effluent.

The highest performance in the average cutting height of forage was in the summer season, in the T1 treatment (86.88 cm), followed by the spring, in the T15 (75.92 cm), in the autumn, it was the T11 (46.63 cm), and in winter, the T15 (29.70 cm). The increase in irrigation depths increased the average plant height of the forage. Except in winter, the clayey soil condition under a high water supply of 150 mm depths presented a better performance in relation to the sandy soil under high water offers of 150 mm depths. In summer and winter, irrigation depths greater than 100% of ETc presented higher plant height.

The increase in leaf length also results in a

Table 3. SPAD index, plant height, leaf length and width, and dry matter of *Urochloa brizantha* cv. Marandu, in Rio Verde, Goiás, 2019/2020

Analysis	Spring	Summer	Autumn	Winter	Mean
SPAD index	46.1±1	51.3±2.1	42.1±2.0	42.6±3.6	45.5±2.8
Height (cm)	70.2±26.0	80.7±8.9	42.3±9.6	23.8±2.3	54.2±11.7
Length (cm)	32.7±5.7	33.0±2.2	27.5±3.9	16.9±1.5	27.3±3.3
Width (cm)	2.2±0.2	2.1±0.1	2.0±0.1	1.8±0.1	2.0±0.1
Dry matter (%)	30.0	53.0	14.6	2.3	-

greater fresh mass yield. In winter, the treatment T15 (21.73 cm) showed the best performance with the others and T1 (35.61 cm), T9 (35.23 cm) and T8 (35.16 cm) (spring), T9 (35.16 cm) (summer), and T10 (30.63 cm) (autumn) stood out in the other seasons.

Leaf width was the evaluation that oscillated the least between the seasons of the year, showing a decrease from spring to winter. The treatments that showed greater leaf width were T1 (2.37 cm), T26 (2.32 cm), T25 (2.25 cm), and T24 (2.03 cm).

In winter, even with moderate performance with the increase in irrigation depths, weather conditions stabilized dry matter yield. In spring-summer, it accounted for 83% of dry matter production. Similar results were obtained by Dantas *et al*. (2020), Santos *et al*. (2019), and Dantas *et al*. (2016) using the same forage and using increasing doses of fertigation, also obtained a reduction in fresh and dry mass in winter and an increase in dry and fresh mass in the spring-summer period.

Under high irrigation depth supplies (≥ 100%) the clayey textured soil promoted the highest leaf/stem ratios through the sandy soil, which was on average 50.8% higher. The condition of cultivation in pots, with little or no competition for light, promoted leaf elongation without, or negligibly promotion of the steam. Similar results were obtained by Rodrigues *et al*. (2008) evaluating the combination of nitrogen and potassium doses in the development of *Urochloa brizantha*. CV Xaraés.

Stabilization was observed in the crude protein (CP) contents in forage, as a function of irrigation depths in clayey soil conditions, even with high levels of fertilization.

Analyses of the principal components variables (PCs) were generated. The results explained two independent processes, depending on the treatments adopted (Table 4). For the sandy soil with the lowest level of A1 fertilization, PC1 and PC2 explained 83.02% of the data presented, whereas, at the highest level of fertilization, it was 72.43%. Regardless of the fertilization level, in the sandy soil, the variables height and length stood out in PC1 and the SPAD index in PC2. As a result, these variables were strongly influenced by the interaction between water depth, soil texture, and fertilization.

Height, length, and other parameters correlated with each other with the best results (or highest values) in the irrigation depths of 75-150%, indicating, therefore, for this condition of the soil

Table 4. Variance explained along with the principal components in sandy soil conditions, with A1 to A2 fertilization, as a function of irrigation depths in the cultivation of *Urochloa brizantha* cv. Marandu, in Rio Verde, Goiás, 2019/2020

Sandy A1				
Variable	PC1 (68.94%)		PC2 (14.08%)	
	R^2	EV (%)	R^2	EV (%)
SPAD index	- 0.68	11.32	0.58	39.96
Height	- 0.96	22.42	-0.06	0.47
Length	- 0.94	21.64	-0.05	0.35
Width	- 0.73	13.20	0.45	24.26
L/S ratio	- 0.81	16.24	-0.39	18.22
Dry matter	- 0.79	15.15	- 0.37	16.70
Sandy A2	PC1 (50.04%)		PC1 (22.39%)	
Spad index	- 0.42	6.07	0.78	45.85
Height	- 0.88	26.26	0.03	0.07
Length	- 0.80	21.58	-0.25	4.95
Width	- 0.76	19.36	0.47	16.99
L/S ratio	- 0.53	9.57	-0.59	26.33
Dry matter	- 0.71	17.14	-0.27	5.79

A1 = Fertilization using 30; 7 and 36 kg ha^{-1} and A2 = Fertilization using 45; 10.5 and 54 kg ha^{-1} of nitrogen, phosphorus nd potassium, respectively per Mg dry matter produced; PC = Principal component; R^2 = Coefficient of determination; EV = explained variance; L/S = leaf/stem (sandy) and fertilization (A1), water depths of at least 75%. When the highest level of fertilization (A2) was evaluated, the data indicated better performance of the variables analyzed from the 50% irrigation depth.

Forage cultivation with depths greater than 100% of ETc in sandy soil, provided higher forage yield, regardless of the level of fertilization used (Figure 2a and b).

A shorter Euclidean distance was found in treatments (T17 and T16), in sandy soil with A1 fertilization, associated with irrigation depths of 100 and 125% of ETc (Figure 3a), differing from treatment T21. When the fertilization was raised to the level (A2), there was the formation of two independent and heterogeneous groups with the smallest Euclidean distance, which was (T26 and T24), in the irrigation depths of 50 and 100mm, followed by (T27 and T25), associated with depths of 25 and 75% of ETc, completely different from treatment T23, which had the longest Euclidean distance (Figure 3b).

Principal component analysis (PCs) for clayey-soil treatments is also explained by two independent processes, depending on the treatments adopted (Table 5). For the A1 fertilization level, PC1 explained 56.21% and PC2 explained 15.91%, both summed 72.12% of the variance in the data shown here, with emphasis on width, L/S ratio, leaf length, and plant height in PC1 and SPAD index in PC2. In the A2 fertilization, PC1 explained 56.51% and PC2 16.81% of the variance, with emphasis on the variables L/S ratio, plant height, and leaf length and in PC1 and leaf width in PC2.

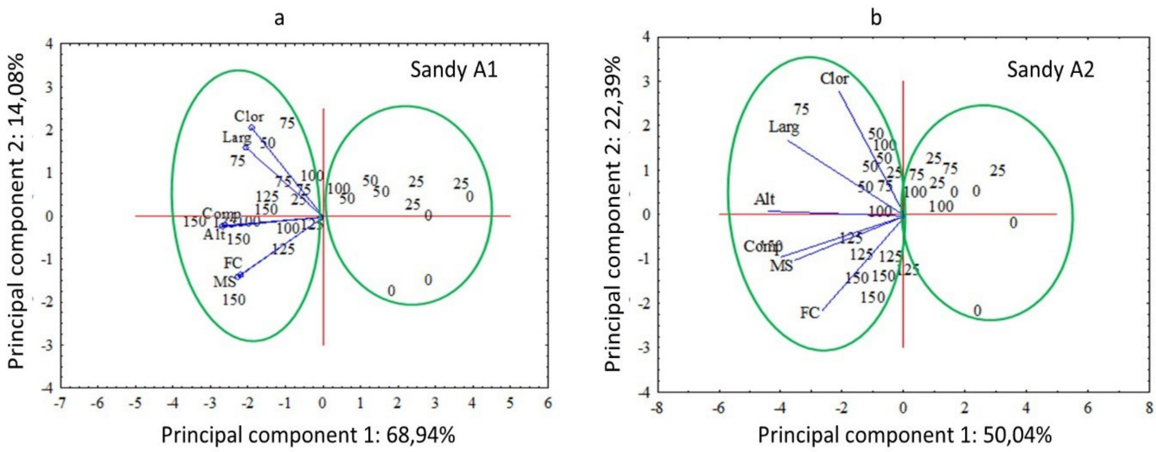

Figure 2. Principal component analysis according to the treatments, in a sandy soil condition with A1 (a) and A2 (b) fertilization as a function of irrigation depths in the cultivation of *Urochloa brizantha* cv. Marandu, in Rio Verde, Goiás, 2019/2020

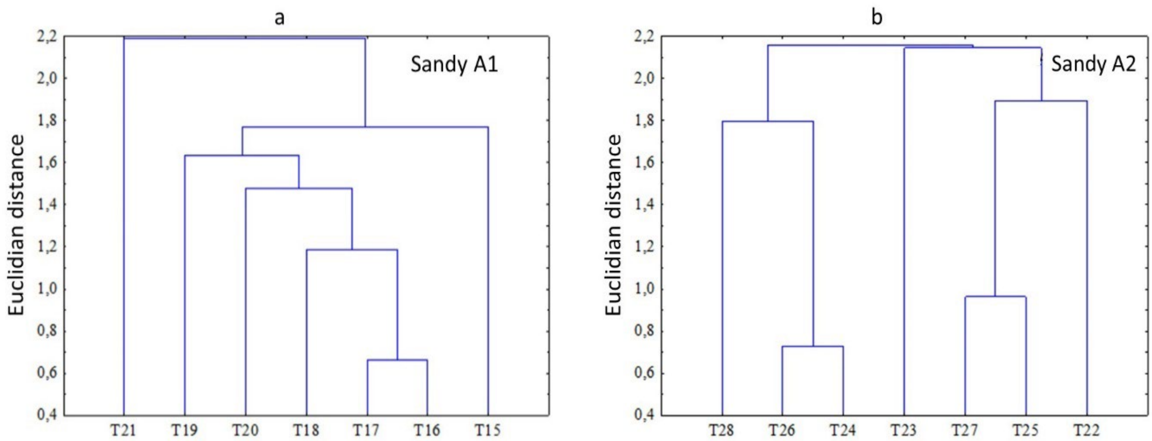

Figure 3. Dendrogram between the similarity of treatments in the cultivation of *Urochloa brizantha* cv. Marandu in sandy soil condition, with two levels of fertilization (A1 and A2), in Rio Verde, Goiás, 2019/2020

A behavior similar to the sandy soil condition was obtained in clayey soil in which there was a longer plant length and leaf width, consequently, greater dry matter yield when irrigation depths greater than 100% ETc were used (Figure 4). An increase in the average height and average length of the forage was observed. Therefore, dry matter increased in the higher irrigation depths, forming two independent sets, as a consequence.

The inverse increase in the SPAD index as a function of the other reported characteristics is likely to be related to a reduced lower leaf expansion, which concentrates nutrients, which may increase the nutritional levels of the forage (ABREU *et al.,* 2020).

An average increase was found in forage yield, due to irrigation depths in a sandy soil condition, regardless of the fertilization level. The clayey soil showed a reduction or stabilization of dry matter yield caused by the rise in irrigation depths.

Table 5. Variance explained along with the principal components under clayey soil conditions, with A1 to A2 fertilization, as a function of irrigation depths in the cultivation of *Urochloa brizantha* cv. Marandu, in Rio Verde, Goiás, 2019/2020

Clayey A1				
Variable	PC1 (56.21%)		PC2 (15.91%)	
	R^2	EV (%)	R^2	EV (%)
SPAD index	- 0.53	8.56	-0.78	64.09
Height	- 0.77	17.76	-0.19	3.83
Length	- 0.80	19.26	0.19	4.08
Width	- 0.84	21.19	0.15	2.53
L/S	- 0.80	19.13	-0.07	0.54
DM	- 0.68	14.07	-0.48	24.91
Clayey A2	PC1 (56.51%)		PC2 (16.81%)	
SPAD index	- 0.70	14.76	0.55	30.48
Height	- 0.82	19.83	-0.34	11.74
Length	- 0.82	19.92	-0.38	14.48
Width	- 0.66	13.02	0.60	36.52
L/S ratio	- 0.87	22.34	-0.05	0.32
Dry matter	- 0.58	10.11	-0.25	6.43

A1 = Fertilization using 30; 7 and 36 kg ha^{-1} and A2 = Fertilization using 45; 10.5 and 54 kg ha^{-1} of nitrogen, phosphorus nd potassium, respectively per Mg dry matter produced; PC = Principal component; R^2 = Coefficient of determination; EV = explained variance; L/S = leaf/stem

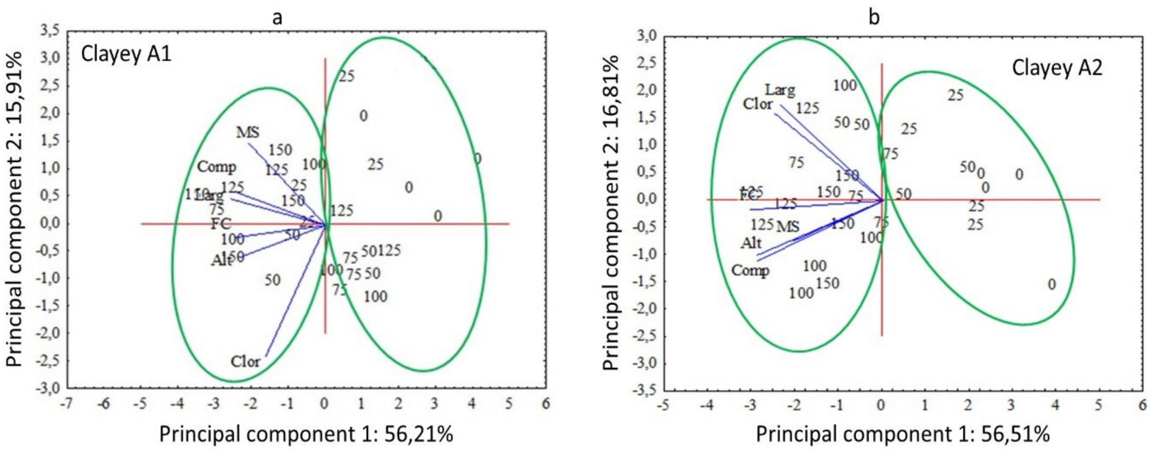

Figure 4. Principal components analysis according to the treatments in clayey soil condition with A1 (a) and A2 (b) fertilization as a function of the irrigation depths in *Urochloa brizantha* cv. Marandu cultivation in Rio Verde, Goiás, 2019/2020

Possibly, clayey soil remained with fewer pores, hindering the respiration system of the roots, as a consequence.

Irrigation blades from 50 to 100% of ETc restricted their development, and less than 50% of ETc, the lowest values of leaf height was observed, resulting in lower dry yield. The A2 fertilization provided greater dry matter production compared to the A1 fertilization.

The greater availability of forage obtained with nitrogen fertilization can be attributed to the effects of nitrogen, which promotes a significant increase in the rates of enzymatic reactions and plant metabolism. According to Colozza *et al*. (2000), the higher the SPAD index content in forage leaves, the greater the availability of nitrogen, increasing photoassimilates that directly influence the morphogenic and structural characteristics of the forage. Increases in forage production with the availability of higher doses of nitrogen and different irrigation depths were also found by Mistura *et al*. (2006), Mistura *et al*. (2007), Lopes *et al*. (2003), and Marcelino *et al*. (2002).

Despite the lack of correlation, the clayey soil had similar behavior to the sandy soil, which also formed two groups, independent and heterogeneous, with the shortest Euclidean distance in the treatments (T6 and T1) under irrigation supply of 25 and 100 % of ETc, followed by (T7 and T4), associated with irrigation depths of 0 and 75% of ETc, in which the T2 treatment showed the longest Euclidean distance, completely differing from the others, in clayey soil at the level of fertilization A1 (Figure 5a). When the fertilization was raised to the level (A2), a smaller Euclidean distance was found in the treatments (T10 and T8) at the 100 and 150 mm irrigation depths, completely different from the T9 treatment (Figure 5b), which presented the longest Euclidean distance.

The treatments, which have the highest and the lowest irrigation depth, showed greater variation in forage production compared to the others. All treatments, regardless of soil texture and fertilization levels, showed the importance of using irrigation for the production of dry mass in the pasture.

A greater similarity was observed between the treatments when a greater irrigation depth and lower level of fertilization (A1), in a sandy soil condition (Figure 6a) was available. This treatment differed from the treatment with smaller irrigation depth T28. In clayey soil texture, a clustering by similarity was observed between the same fertilization levels (Figure 6b) in which A1 and A2 fertilization were similar for depths 50 and 125% of ETc, also similar between 100 and 150%, not following the clustering criterion caused by the rise in irrigation depth.

Based on the data joint analysis, not separating per soil texture or irrigation depths, it was sought to verify the similarity between the treatments, therefore, the similarity dendrogram analysis was performed. The greatest similarity between treatments was obtained for T5; T12 and T3 and

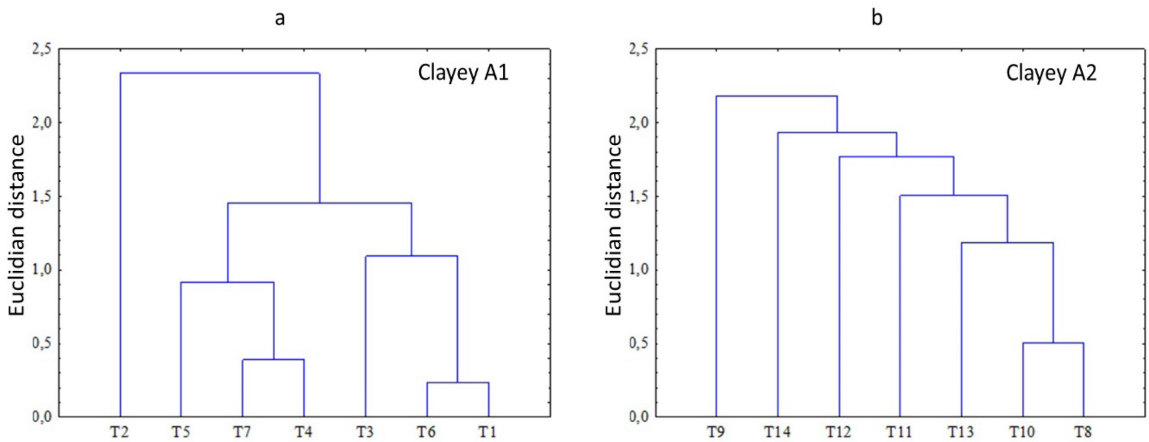

Figure 5. Dendrogram between the similarity of treatments in the cultivation of *Urochloa brizantha* cv. Marandu in clayey soil condition, with two levels of fertilization (A1 and A2), in Rio Verde, Goiás, 2019/2020

T17 (Figure 7), followed by treatments T1; T6, and T18. A similarity was observed between the same levels of fertilization, in which only soil texture varied as fertilization or irrigation depths were increased. Thus, a heterogeneous behavior was observed as a function of the treatments.

The following relationships can also be observed: similarity between T18 and T14, T18 in sandy soil A1 at 75% of depth, T14 in clayey soil A2 at 0% depth. When using sandy textured soil of poor fertility, associated with 75% water depths, the results of the agronomic performance of marandu grass tend to be similar to sandy textured soil, when using high fertility soil, without the need to replenish the groundwater. The similarity between T10 and T13, that is, T10 in clayey soil A2 at 100% depth and T13 in clayey soil A2 under the supply of irrigation depths of 25% ETc.

The treatments that showed the best performance in forage production were similar to others with differentiated treatment, demonstrating that the management with smaller depth and/or

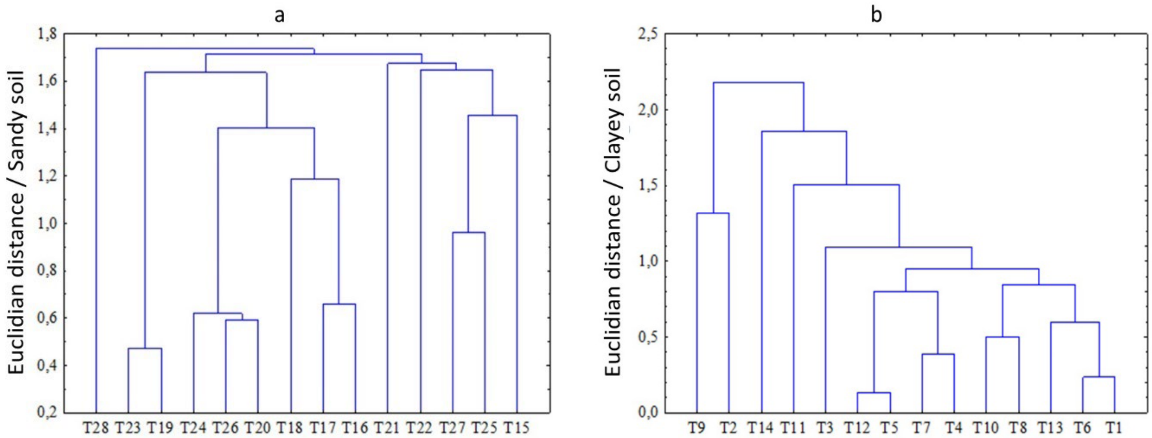

Figure 6. Dendrogram between the similarity of treatments in the cultivation of *Urochloa brizantha* cv. Marandu in sandy (a) and clay (b) soil condition, regardless of the fertilization level in Rio Verde, Goiás, 2019/2020

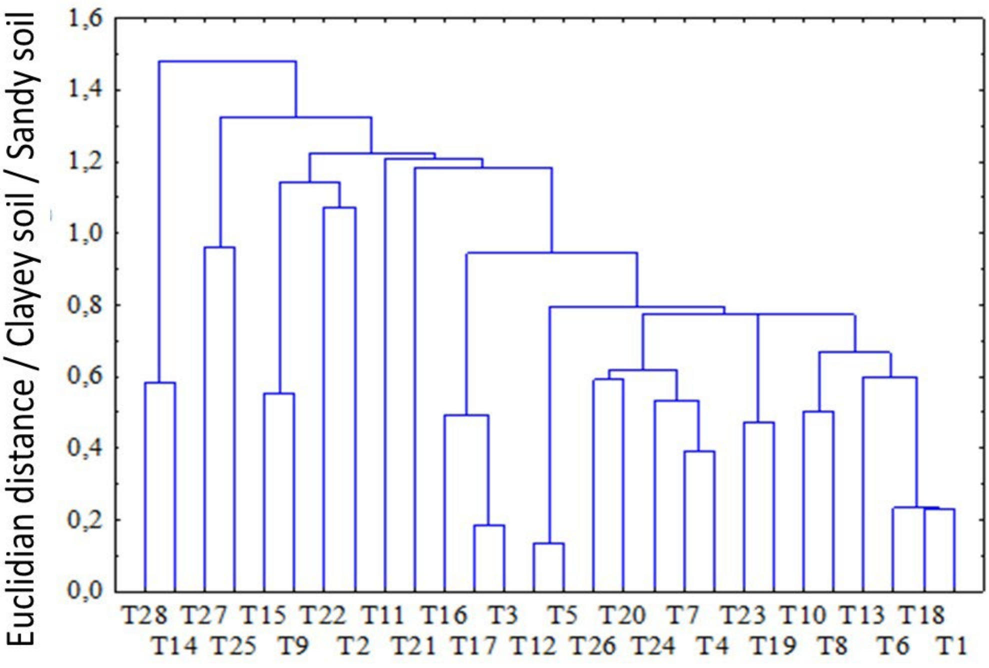

Figure 7. Dendrogram between the similarity of treatments in the cultivation of *Urochloa brizantha* cv. Marandu in Rio Verde, Goiás, 2019/2020

less fertilization can present similar results. These observations are true for treatments T15 and T9, in which the latter reduced the irrigation depth by 25%, but increases the level of fertilization. Treatments T22 and T2 have a greater Euclidean distance, however, the change in soil texture, from sandy to clayey, reduces the irrigation depth and the level of fertilization, maintaining the similarity in the dry matter yield. Another example was T1 with T18 and T6, which are similar, but all of which maintain the same fertilization characteristics, however, reducing irrigation depths and varying the soil texture.

CONCLUSIONS

Based on the results found in the conditions used for the execution of this experiment, it can be inferred that:

- A relevant increase was found in plant height and dry matter yield of *Urochloa brizantha* cv. Marandu subjected to different irrigation depths, however, it did not show significance when subjected to fertilization levels and soil texture.
- A higher yield was observed in the dry matter yield submitted to layers greater than 100% of ETc, regardless of the soil texture and the fertilization level.
- Forage showed poor performance in winter compared to other seasons because of the weather conditions, particularly due to the reduction in the mean air temperature.

AUTHORSHIP CONTRIBUTION STATEMENT

FERREIRA, M.A.A.: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software; **ESSER, R.**: Conceptualization, Resources, Software; **SANTOS, G.O.**: Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing; **TAVARES, R.L.M.**: Software, Supervision, Validation.

DECLARATION OF INTERESTS

The authors declare that they have no knowledge of a conflict of interest that could have appeared to influence the work reported in this paper.

REFERENCES

ABIEC - Associação Brasileira das Indústrias Exportadoras de Carne. Beef Report: Perfil da Pecuária no Brasil 2020. Available <http://abiec.com.br/publicacoes/beef-report-2020>. Accessed on: 10 de Nov. de 2020.

ABREU, V. L. S.; GOLIN, H. O.; REZENDE, R. P.; FERNANDES, P. B.; THEODORO, G. F.; FRANCO, G. L.; DIFANTE, G. S. Ammonium sulfate affect the structural characteristics, biomass and crude protein of BRS Tamani grass. **Journal of Agricultural Studies**, v. 8, n. 4, p. 450, 2020.

ALLEN, R. G.; PEREIRA, L. S.; RAES, D.; SMITH, M. Crop evapotranspiration-guidelines for computing crop water requirements. Rome: FAO Irrigation and Drainage, 1998. 56 p.

COLOZZA, M. T.; KIEHL, J. C.; WERNER, J. C. Produção de matéria seca, concentração de nitrogênio e teor de clorofila em Panicum maximum cv. Aruana adubado com nitrogênio. In: **Anais…** [CD-ROM] Montevideo: Asociacion Latinoamericana de Producion Animal, 2000.

DANTAS, G. F.; FARIA, R. T.; SANTOS, G. O.; DARLI, A. B.; PALARETTI, L. F. Produtividade e qualidade da *Urochloa* irrigada no outono/inverno. **Engenharia Agrícola** v. 36, n. 3, p. 469-481, 2016.

DANTAS, G. de F.; FARIA, R. T. de.; COSTA, N. R.; SANTOS, G. O.; FERRAUDO, A. S. Morfhogenic and structural characteristics of marandu grass affected by fertigation with treated sewage efluente and cutting height. **Engenharia Agrícola**, v. 40, n. 6, p. 692-702, 2020.

EUCLIDES, V.P.B.; MONTAGNER, D.B.; MACEDO, M.C.M.; ARAÚJO, A.R.; DIFANTE, G.S.; BARBOSA, R.A. Grazing intensity affects forage accumulation and persistence of Marandu palisade grass in the Brazilian savannah. **Grass and Forage Science**, v. 1, p. 1-13, 2019.

GERMANO, L. H. E.; VENDRUSCOLO, M. C.; DANIEL, D. F.; DALBIANCO, A. B. Produtividade e características agronômicas de *Urochloa brizantha*cv. Paiaguás submetida a doses de nitrogênio sob cortes. **Boletim de Indústria Animal**, v. 75, p. 1-14, 2018.

GIL, P. T.; FONTES, P. C. R.; CECON, P. R.; FERREIRA, F. A. Índice SPAD para o diagnóstico do estado de nitrogênio e para o prognóstico da produtividade de batata. **Horticultura Brasileira**, v. 20, p. 611-615, 2002.

GURGEL, A. L. C.; DIFANTE, G. S.; EMERENCIANO NETO, J. V.; COSTA, M. G.; DANTAS, J. L. S.; ITAVO, L. C. V.; PEREIRA, M. G.; RODRIGUES, J. G.; OLIVEIRA, I. L. S.; BEZERRA, J. I. G. Supplementation of lamb ewes with different protein sources in deferred marandu palisadegrass (*Brachiaria brizantha* cv. Marandu) pasture. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 72, p. 1901-1910, 2020.

HEIMBACH, N. S.; ÍTAVO, C. C. B. F.; ÍTAVO, L. C. V.; DIFANTE, G. S.; DIAS, A. M.; BRUMATTI, R. C.; GOMES, M. N. B.; BAUR, C. D.; MORAES, G. J.; COSTA, M. C. M.; KOZERSKI, N. D.; LEAL, E. S.; GURGEL, A. L. C. Different grass availabilities of tropical pasture on performances and carcasses of lambs. **Tropical Animal Science Journal**, v.43, n.3, p.211-218, 2020.

INSTITUTO NACIONAL DE METEOROLOGIA (INMET). Banco de dados meteorológicos para ensino e pesquisa. Available in: <http://www.inmet.gov.br/> Accessed 16 out 2020.

LACERDA, M. P. C.; QUEMÉNEUR, J. J. G.; ANDRADE, H.; ALVES, H. M. R; VIEIRA, T. G. C. Mapeamento preliminar de solos com horizonte B textural e B nítico na região de Lavras, MG. **Ciência Agrotecnologia**, v. 33, n. 3, p. 788-795, 2009.

LOPES, R.S.; FONSECA, D.M.; OLIVEIRA, R.A. NASCIMENTO JUNIOR, D.; ANDRADE, A. C.; STOCK, L.A.; MARTINS, C. E. Disponibilidade de matéria seca em pastagens de capim elefante irrigadas. **Ciência e Agrotecnologia**, v. 27, n. 6, p. 1388-1394, 2003.

MALAVOLTA, E. A. Elementos de nutrição mineral de plantas. São Paulo: Ceres, 1980.

MARCELINO, K. R. A.; LEITE, G. G.; VILELA, L.; DIOGO, J. M. da S.; GUERRA, A. F. Influência de nitrogênio e tensões hídricas sobre o valor nutritivo do Marandu (Brachiaria brizantha) cultivado no cerrado. In: **Anais...** [CD-ROM] Recife: Sociedade Brasileira de Zootecnia, 2002.

MARIANO, J. C. Q.; SANTOS, G. O.; FEITOSA, D. G.; HERNANDEZ, F. B. T. **Sistema para manejo da agricultura irrigada** - SMAI versão 2.0 copyright© UNESP Ilha Solteira. 2011.

MAZERO, H. M.; BONFIM-SILVA, E. M.; FERRAZ, A. P. F.; SIMEON, B. G.; SILVA, T. J. A. da. Avaliação de nitrogênio em capim paiaguás submetido a doses de conza vegetal. XLIX Congresso Brasileiro de Engenharia Agrícola - CONBEA 2020, de 23 a 25 de novembro de 2020. **Anais...** Congresso On-line. 2020.

MESQUITA, E. E.; PINTO, J. C.; FURTINI NETO, A. E.; SANTOS, I. P. A.; TAVARES, V. B. Teores críticos de fósforo em três solos para o estabelecimento de capim-mombaça, capim-marandu e capim-andropogon em vasos. **Revista Brasileira de Zootecnia**, v. 33, n. 2, p. 290-301, 2004.

MISTURA, C.; FAGUNDES, J. L.; FONSECA, D. M.; MOREIRA, L. M.; VITOR, C. M. T.; NASCIMENTO JÚNIOR, D. N.; RIBEIRO JÚNIOR, J. I. Disponibilidade e qualidade do capim-elefante com e sem irrigação adubado com nitrogênio e potássio na estação seca. **Revista Brasileira de Zootecnia**, v. 35, n. 2, p. 372-379, 2006.

MISTURA, C.; FONSECA, D. M.; MOREIRA, L. M.; FAGUNDES, J. L.; MORAIS, R. V.; QUEIROZ, A. C. de.; RIBEIRO JÚNIOR, J. I. Efeito da adubação nitrogenada e irrigação sobre a composição químico-bromatológica das lâminas foliares e da planta inteira de capim elefante sob pastejo. **Revista Brasileira de Zootecnia**, v. 36, n. 6, p. 1707-1714, 2007.

RODRIGUES, R. C.; MAOURÃO, G. B.; BRENNECKE, K.; LUZ, P. H. de C.; HERLING, V. R. Produção de massa seca, relação folha/colmo e alguns índices de crescimento do *Brachiaria brizantha* cv. Xaraés cultivado com a combinação de doses de nitrogênio e potássio. **Revista Brasileira de Zootecnia**, v. 37, n. 3, p. 394-400, 2008.

SANTOS, H. G.; JACOMINE, P. K. T.; ANJOS, L. H. C.; OLIVEIRA, V. A.; LUMBRERAS, J. F.; COELHO, M. R.; ALMEIDA, J. A.; CUNHA, T. J. F.; OLIVEIRA, J. B. **Sistema Brasileiro de Classificação de Solos.** Embrapa CNPS, 5 ed. 2018.

SANTOS, G. O.; FARIA, R. T.; RODRIGUES, G. A.; DANTAS, G. F.; COSTA, N. R. Productivity and nutrient extraction by *Brachiaria brizantha* fertigated with treated sewage effluent. **Australian Journal of Crop Science**, v. 13, n. 4, p. 494-501, 2019.

SBRISSIA, A. F.; DA SILVA, S. C.; SARMENTO, D. O. L.; MOLAN, L. K.; ANDRADE, F. M. E.; GONÇALVES, A. C.; LUPINACCI, A. V. Tillering dynamics in palisadegrass swards continuously stocked by cattle. **Plant Ecology**, v. 206, p. 349-359, 2010.

SILVA, D. J.; QUEIROZ, A. C. Análise de alimentos: métodos químicos e biológicos. 3. ed. Viçosa: UFV, 2006.

SILVA, F. F.; SÁ, J. F.; SCHIO, A. R.; ÍTAVO, L. C. V.; SILVA, R. R.; MATEUS, R. G. Suplementação a pasto: disponibilidade e qualidade x níveis de suplementação x desempenho. **Revista Brasileira de Zootecnia**, v. 38, p. 371-389, 2009.

SOUSA, D. M. G.; LOBATO, E.; REIN, T. A. Adubação com fósforo. In: SOUSA, D. M. G.; LOBATO, E., Eds. **Cerrado: Correção do solo e adubação**. 2.Ed. Planaltina, Embrapa Cerrados, p. 147-168, 2004.

VILELA, L.; SOARES, W. V.; SOUSA, D. M. G. de; MACEDO, M. C. M. Calagem e adubação para pastagens na região do cerrado. Planaltina: Embrapa Cerrados, 1998.

VITOR, C. M. T.; FONSECA, D. M; CÓSER, A. C., MARTINS, C. E.; NASCIMENTO JÚNIOR, D.; RIBEIRO JÚNIOR, J. I. Produção de matéria seca e valor nutritivo de pastagem de capim-elefante sob irrigação e adubação nitrogenada. **Revista Brasileira de Zootecnia**, v. 38, n. 3, p. 435-442, 2009.