



GROWTH OF UROCHLOA IRRIGATED IN CLAYEY AND SANDY SOIL SUBMITTED TO NUTRITIONAL MANAGEMENT IN THE CERRADO

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Keywords:

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ABSTRACT

The reduction in water supply in specific areas and the high costs of agricultural inputs resulted in the need for agronomic management capable of reducing the pressure on water resources and promoting economic development. The objective of this work was to evaluate the response of *Urochloa brizantha* cv. Marandu grown in clayey and sandy soils submitted to nutritional and water management in the municipality of Rio Verde, state of Goiás. The treatments consist in combining two levels of fertilization (A1: 30, 7 and 36 and A2: 45, 10.5 and 54 of NPK per Mg of DM produced,) and seven water depths (0%; 25%; 50%; 75%; 100%; 125% and 150% of crop evapotranspiration (ETc)), in four replications. Crop performance was evaluated employing SPAD index, plant height, leaf length, leaf width, neutral detergent crude fiber, and dry matter. The rise in the irrigation depths significantly affected the performance of the forage and despite not having a significant difference, the production of dry matter may be higher when in soil with A2 fertilization. A significant influence was observed in the number of seedlings emergence from 7 to 21 days in Sandy soil as a function of clayey soil, on chlorophyll, and plant height as a function of A2 fertilization concerning A1 and irrigation depths in all analyzed variables.

Palavras-chave:

Pastagem
Forrageira
Irrigação
Adubação
Textura de solo

CULTIVO DE UROCHLOA IRRIGADA EM SOLO ARGILOSO E ARENOSO SUBMETIDA A MANEJO NUTRICIONAL NO CERRADO

RESUMO

Com a redução da oferta hídrica em áreas específicas e os altos custos de insumos agrícolas, se faz necessário o manejo agrônômico para amenizar a pressão sobre os recursos hídricos e promover o desenvolvimento econômico. O objetivo deste trabalho foi avaliar a resposta 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, proteína bruta, fibra em detergente neutro e matéria seca. A elevação das lâminas de irrigação influenciou de forma significativa no desempenho da forrageira e apesar de não haver diferença significativa, a produção de matéria seca pode ser maior quando em condição de solo argiloso com adubação A2. Houve influência significativa no número de emergência de plântulas dos 7 aos 21 dias em solo arenoso em função do solo argiloso, na clorofila e altura de plantas em função da adubação A2 em relação A1 e das lâminas de irrigação em todas as variáveis analisadas.

INTRODUCTION

The reduction in the water supply in productive areas and the high costs of farming inputs resulted in the need for agronomic management capable of reducing the pressure on water resources (SCHIMITZ & BITTENCOURT, 2017) and promoting the economic development of the crops, in addition to opening new areas. According to Rizato *et al.* (2019), despite its importance for animal production in the country, most pastures in Brazil are inadequately and inefficiently managed, therefore requiring agronomic management capable of obtaining maximum crop productivity.

Irrigation management in pasture areas is influenced by weather factors, which define the amount to be irrigated, such as frequency, depth, and type of application. The demand for nutrients varies according to the season and general pasture management (DANTAS *et al.*, 2016). The number of nutrients extracted from the soil by the forage plant must be proportional to the forage production (WERNER *et al.*, 1997); however, De Paula *et al.* (2017) described that forage has a positive performance in soils with low fertility. Irrigated pastures typically have a greater demand for nutrients than the rainfed as irrigation generally increases pasture productivity (ALVIM *et al.*, 1986).

On the other hand, albeit exhibiting moderate demand on soil fertility, at certain times of the year (drought period) a reduction of 70% is observed in the production of *Brachiaria brizantha* cultivars Marandu, Xaraés, and Piatã (EUCLIDES *et al.*, 2008) during the water shortage. In irrigated conditions, *Brachiaria brizantha* has shown satisfactory results in growth. In similar conditions to the field experiment observed by Dantas *et al.* (2020), however, using fertigation with treated sewage effluent, resulted in yield gains for *Urochloa* even in unfavorable soil and climatic conditions.

Irrigation management plays a very important role in the management of forages. According to Dantas *et al.* (2016), it has shown significant results in productivity of adequate adjustment of water depth in different seasons. In this context, it is necessary to properly establish the water demand

for the region so that the efficient use of water and the good development of the culture will occur.

Véras *et al.* (2020) found that cultivars of *Urochloa* spp. 'Marandu' and 'Basilisk' are good options to be managed in Quartzarenic soils (11.4% clay) as at adequate management conditions (nutrition: 100 Mg.ha⁻¹ de N; 105 Mg.ha⁻¹ de P₂O₅; 164 Mg.ha⁻¹ de K₂O), they exhibit good tillering rates, indicating that they will have high forage canopy longevity/perenniality.

In addition to irrigation, the use of nitrogen fertilizer in forages promotes full vegetative development, in addition to positively influencing its tillering (GURGEL *et al.*, 2020), providing an increase in the nutritive value of forage. The nutritional value can be described by the quantification of macro and micronutrients and the contents of crude protein (CP) and neutral detergent fiber (NDF) (VITOR *et al.*, 2009).

Forage is an agronomic species that is rarely cultivated in irrigated systems due to the lack of knowledge and adequate management techniques that allow the production of fresh matter throughout the year (SILVA *et al.*, 2009) as in addition to irrigation, nutritional management is vital, in which both techniques must be suitable for each soil texture to achieve maximum crop yield. Ferreira *et al.* (2021), in growing *Urochloa*, did not obtain an increase in productivity as a function of soil texture, but with increasing irrigation depths.

Given the aforementioned reports, it can be suggested that the use of irrigation depths associated with the supply of nutrients may increase the production and nutritional value of marandu grass growing in soils of different textures. Therefore, the objective of this study is to propose an evaluation of the performance of forage submitted to water and nutritional conditions through cultivation in sandy and clayey soil, in the region of Rio Verde, state of Goiás.

MATERIAL AND METHODS

The experiment was carried out 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, at an average altitude of 784 m, from August 2019 to October 2020.

The soils used in the experiment were classified as: BRAZILIAN OXISOL with clay texture (clay > 35%); QUARTZARENIC NEOSOLO with a sandy texture (clay < 10%) (Santos *et al.*, 2018). Soils were collected from the 0-0.2 m layer in virgin forest and analyzed to verify the need for supplementation (Table 1).

The breaking of soil clods was carried out in a 4-mm mesh sieve, based on the physical-chemical analyses. The fertilization was carried out to correct soil fertility based on Sousa *et al.* (2004) for forage.

Limestone with RPTN (Relative Power of Total Neutralization) of 80% (a qualitative aspect of limestone, translated as a function of reactivity and neutralization power of ground rock) was used. In addition, the need method via 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% K₂O) simple superphosphate (18% P₂O₅, 16% Ca, and 8% S), triple superphosphate (46% P₂O₅ and 8% Ca) zinc sulfate (20% of Zn), copper sulfate (13% of Cu), ammonium sulfate (20% of N and 22-24% of S) or urea (44% of N).

The forage *Urochloa brizantha* cv. Marandu was grown in 112 vase units with a capacity of 15 L under field conditions. The experiment followed a completely randomized block design (DBC), with four replications, and the treatments were arranged in a 2x2x7 triple factorial scheme.

The treatments consisted in combining soil with two distinct textural classes (clay and sandy); two levels of fertilization (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 maximum crop evapotranspiration (ET_c)).

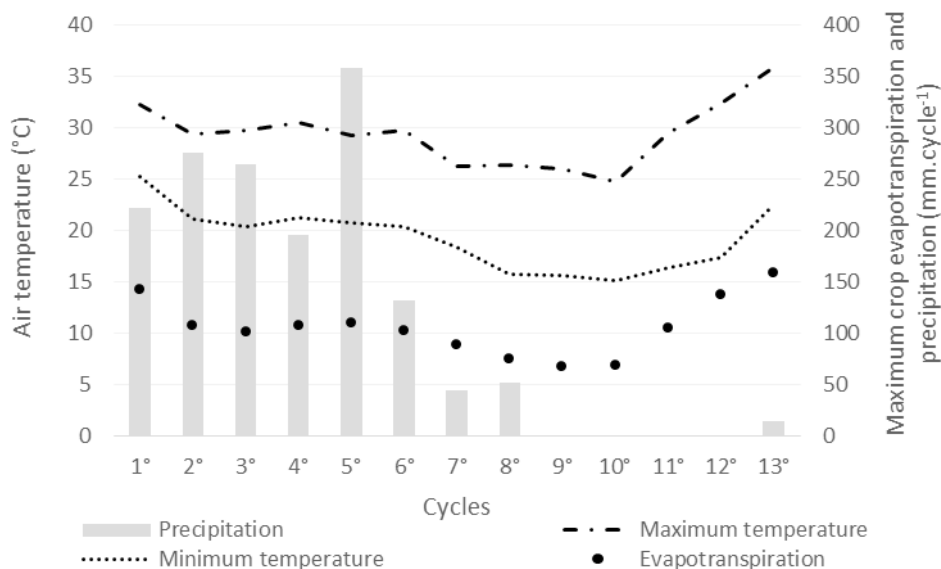
Urochloa brizantha was sown on August 31, 2019. The uniformity cut at 15 cm height was carried out after the establishment of the forage (average height of 41 cm), 48 days after sowing. The other cuts occurred every 28 days, totaling 13 cycles (October 18, 2019, to October 16, 2020).

The mean air temperature during the experiment was 24.5°C, approximately, the maximum and minimum temperatures were 29.4°C and 19.5°C, respectively. Rainfall during the experiment was 1,559.6 mm (Figure 1), concentrated from the first to the eighth cycle (96.3%). In the first 6 cycles, the volume of precipitation was higher than the water requirement by the plant, which was 1,248 mm during the twelve months. The volume of water applied in the control treatment (100% of the ET_c) was 1,139 mm, considering the daily management, without considering water reserve as the experiment was performed in vases. The other treatments received proportional amounts to the applied water depth. The mean crop evapotranspiration in spring, summer, fall, and winter were 4.54, 3.49, 2.57, and 3.48 mm.day⁻¹, respectively. The overall mean ET_c was 3.52 mm.day⁻¹.

Table 1. Chemical analysis of clayey (Brazilian Oxisol) and sandy (Quartzarenic Neosol) soils collected in the 0-0.2 m depth

T	Ca+Mg	Ca ⁺²	K ⁺²	Mg ⁺²	Al	H+Al	K	P (Melich ⁻¹)	O.M.	pH _{CaCl2}	
	----- cmol _c .dm ⁻³ -----							mg.dm ⁻³	g.Mg ⁻¹		
Clayey	0.33	0.28	0.07	0.05	0.45	4.6	29	0.33	25.00	4.28	
Sandy	0.84	0.72	0.07	0.12	0.60	5.8	29	3.97	18.10	4.42	
V	M	CEC	SB	Clay	Silt	Sand	Fe	Mn	Cu	Zn	
	%	cmol _c .dm ⁻³		----- % -----			mg.dm ⁻³				
Clayey	52.81	8.01	5.02	0.40	39.87	21.27	38.66	237.60	33.5	2.4	0.4
Sandy	39.64	13.66	6.69	0.91	8.05	3.68	88.26	310.10	19.1	4.3	3.8

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



Source: INMET (2020)

Figure 1. Weather monitoring over the experiment in the municipality of Rio Verde, Goiás, 10/2019 to 10/2020

The equivalent of 15 Mg.ha⁻¹ of seeds with 80% cultural value was used. During the experiment, complementary fertilization was carried out following the double and triple of 15; 3.5 and 18 Mg of NPK (nitrogen, phosphorus, and potassium) per Megagram (Mg) of dry matter (DM) produced every 28 days according to the methodology used by Vilela *et al.* (1998). Works carried out by Dantas *et al.* (2016) found that the forage responds linearly to NPK fertilization when 50% more nutrients are used, thus, the dose of 100% higher than the proposed follows guidelines of Malavolta (1980) for conducting the experiment in vases and 200% to understand how the culture will respond. Therefore, doses of 30, 7, and 36 (A1) and 45, 10.5, and 54 (A2) Mg of NPK per Mg of DM produced were used. Fertilizations occurred within 72 hours, after yield analysis.

The treatments using clayey soil were denominated T1 to T14 and those using sandy soil were denominated T15 to T28. Treatments T1 to T7 and T15 to T21 received A1 fertilization and T8 to T14 and T22 to T28, the A2 fertilization. The irrigation depths decreased from T1 to T7, from T8 to T14, from T5 to T21, and from T22 to T28.

The weather data for irrigation management were collected at the Automatic Weather Station of Rio Verde (A025) and provided by the National

Institute of Meteorology (INMET, 2020). The daily calculation of ETo (reference evapotranspiration) was performed using the *Sistema para Manejo da Agricultura Irrigada* (System for Irrigated Agriculture Management) software (MARIANO *et al.*, 2011), based on the Penman-Monteith method (FAO Standard) developed by Allen *et al.* (1998). In addition, the coefficient of *brachiaria* forage (kc) equal to 1.0 (SANTOS *et al.*, 2019) was used, obtaining the maximum evapotranspiration of the crop (ETo = ETc).

Regarding the biometric indices, the following were evaluated: SPAD index, chlorophyll a and b, leaf length and width, plant height, and yield. The SPAD (Soil Plant Analysis Development) index was measured every 28 days, using a portable SPAD-502[®] meter, on the first fully expanded leaf, in the morning, between 8 a.m. and 9 a.m. Chlorophyll was quantified using Chlorofilog Falker.

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

Because of the large volumes of the samples, qualitative evaluations of the forage used a composite sample per treatment of all material collected during the experimental period. Thus, it was possible to determine crude protein (CP) and neutral detergent fiber (NDF). The analyses were carried out in the laboratory, following the methodology of Silva and Queiroz (2006), using the Kjeldahl extractor method.

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

The test of Tukey was used at 1% and 5% significance levels with the aid of the SISVAR statistical program (FERREIRA, 2011) and regression analysis when there was significance.

RESULTS AND DISCUSSION

In the emergence of *Urochloa brizantha* cv. Marandu, soil texture had a significant effect on all evaluations (7, 14, and 21 days). Also, fertilization at 7 days showed interference, and interaction was

found between fertilization and irrigation depths at 14 days (Table 2). There was no influence of irrigation depths on seedling emergence. According to Bewley and Black (1985), soil texture influences seed germination both in the degree of seed/moisture contact and in water conductivity, and different germination responses may occur in clayey and sandy soils with the same water potential.

Paulino *et al.* (2004) evaluated the effect of water stress and sowing depth on the emergence of *Brachiaria brizantha* cv. MG-5 concluded that the ideal depth for germination is 4 cm with continuous water availability, which explains the absence of a significant effect of irrigation depths found in this study, due to the initial phase of the cultivation period. Rainfall was uniform after sowing.

A significant variation was observed in seedling emergence for sandy textured soil that presented a better performance concerning clayey soil, after *U. brizantha* cv. Marandu sowing at 7, 14, and 21 days after sowing (DAS) (Table 3). The best performance of the sandy soil concerning the clayey one can be explained by the greater predominance of macropores, which possibly favored the emergence of seedlings. According to Souza *et al.* (2016), the texture of soil can positively or negatively influence seedling emergence. Also, these same authors reported in their study that soils with greater moisture retention may interfere with the seedling emergence process, as they create a more humid environment, which may contribute to

Table 2. Analysis of variance of *Urochloa brizantha* cv. Marandu seedling emergence at 7, 14, and 21 days after sowing, in Rio Verde, Goiás, 2019/2020

Source of variation	DF	7 DAS	14 DAS	21 DAS
Block	3	1.04 ^{ns}	1.55 ^{ns}	1.43 ^{ns}
Soil (S)	1	21.19*	53.06*	12.14*
Fertilization (A)	1	4.72*	0.09 ^{ns}	0.34 ^{ns}
Depth (L)	6	1.21 ^{ns}	0.94 ^{ns}	1.31 ^{ns}
S x A	1	0.59 ^{ns}	2.37 ^{ns}	0.25 ^{ns}
S x L	6	1.24 ^{ns}	1.27 ^{ns}	0.98 ^{ns}
A x L	6	1.94 ^{ns}	2.93*	2.11 ^{ns}
S x A x L	6	0.93 ^{ns}	1.62 ^{ns}	0.99 ^{ns}
Error	81	-	-	-
Mean	-	2.09	5.34	7.30
CV (%)	-	70.74	34.50	31.19

^{ns}Not significant; * Significant by the F at 5% probability

the proliferation of microorganisms.

Among the fertilization levels, there was a difference at 7 DAS, with better performance at the A2 level of fertilization in relation to A1. A1 and A2 fertilization levels did not vary over time (14 and 21 DAS). According to De Paula *et al.* (2017), the forage has a positive performance in soils with low fertility, with no effects caused by high fertilization in the initial phase. In addition to the texture and nutrient availability, Bunch and Delouche (1969) point out that the cultural vigor of the seeds is an important prerequisite in the implantation of crops, combined with favorable environmental conditions.

The interaction between fertilization levels and irrigation depths (Figure 2) occurred when 25% of ETc was available in soil with greater availability of fertilizers (A2), which presented a better performance concerning the one with less availability (A1). The other treatments showed

no interaction between irrigation depths and fertilization levels.

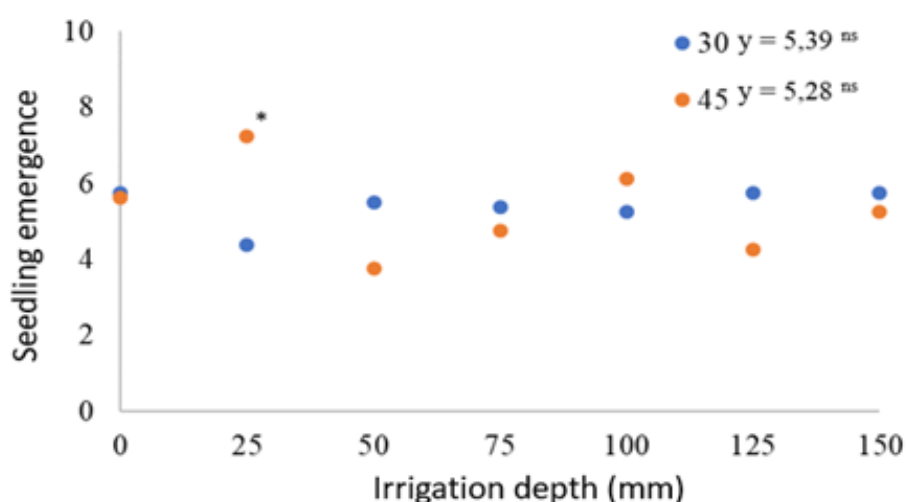
Irrigation depth was the only variation factor that significantly influenced dry matter production. Similar results were obtained by Dantas *et al.* (2016). Soil texture promoted significant variation for leaf width, not influencing the other analyses evaluated.

Fertilization levels influenced plant height and chlorophyll index, and irrigation depths influenced all analyzed variables. There were interactions between soil texture, fertilization, and irrigation depths for leaf length (Table 4). According to Bezerra *et al.* (2020), soil texture has little influence on the organogenesis process of the structural characteristics of tillers of cultivars *U. brizantha* ‘Piatã’ and ‘Marandu’ as the process of appearance of organs during the initial phase of leaf area gain is genetically predetermined in the plant (GASTAL & LEMAIRE, 2015).

Table 3. *Urochloa brizantha* cv. Marandu seedling emergence at 7, 14, and 21 days after sowing in Rio Verde, Goiás, 2019/2020

Soil	7 DAS	14 DAS	21 DAS
Clayey	1.45 b	4.07 b	6.55 b
Sandy	2.73 a	6.61 a	8.05 a
Fertilization levels			
A1	1.78 b	5.39 a	7.42 a
A2	2.39 a	5.28 a	7.17 a

Means followed by the distinct letters in the column for soil or fertilization are different from each other by the test of Tukey at 5%



^{ns}Not significant regression at 5%. *Fertilization significant difference within irrigation depth by the F test at 5%

Figure 2. *Urochloa brizantha* cv. Marandu seedlings emergence at 14 days after sowing in different irrigation depths in Rio Verde, Goiás, 2019/2020

No oscillations were observed for the variables chlorophyll, plant height, and dry matter among the soil types. On the other hand, the clayey soil increased the values of leaf width by 4%. Fertilization levels did not affect width and dry matter, however, with the A2 fertilization level, there was an increase in chlorophyll concentration, but, on the other hand, this dose caused a reduction in height (Table 5). Long-term fertilization can provide better forage performance.

Although there are no statistical differences in dry matter production as a function of soil texture and fertilization levels, the average weight gain is 5,884 and 3,634 Mg.ha⁻¹ year, considering soil texture and fertilization levels, respectively. The use of grazing efficiency of 75% may promote a gain in animal unit (AU = 450 Mg) considering the soil texture of 0.75 AU.ha⁻¹ per grazing cycle and only fertilization levels of 0.46 ha⁻¹ per grazing cycle.

Plant height was reduced by 1.3% as a function

of sandy soil texture compared to clayey soil. Fertilization levels provided better plant height performance and chlorophyll index, when A1 and A2 were available, respectively. Under the specified conditions, the forage presented an average increase of 1% in plant height and chlorophyll content.

On the other hand, taking into account the effects of the genotype-environment interaction, Gastal and Lemaire (2015) point out that the specific weight of the tiller, as well as the biomass production of tropical grasses, can be influenced by the soil chemistry, as for plants to express the maximum accumulation of biomass, an adequate supply and/or absorption of essential nutrients is necessary, associated with adequate soil and climate conditions for plant growth.

No average increase was observed in chlorophyll indices and plant width as a function of irrigation depths up to 75 mm and 100 mm, respectively, and linear growth for plant height and dry matter (Figure 3).

Table 4. Analysis of variance of the variables: chlorophyll (CP), height, length, width, and dry matter (DM) of *Urochloa brizantha* cv. Marandu, grown in Rio Verde, Goiás, 2019/2020

	DF	CP	Height	length	Width	Dry matter
Block	3	1.96 ^{ns}	1.41 ^{ns}	0.91 ^{ns}	0.91 ^{ns}	0.73 ^{ns}
Soil (S)	1	0.52 ^{ns}	2.62 ^{ns}	1.61 ^{ns}	4.99*	33.10**
Fertilization (F)	1	7.27**	9.05**	3.12 ^{ns}	0.05 ^{ns}	2.53 ^{ns}
Irrigation depth (D)	6	3.94**	16.64**	20.65**	2.97*	43.71**
S x F	1	1.11 ^{ns}	0.21 ^{ns}	0.10 ^{ns}	0.69 ^{ns}	2.87 ^{ns}
S x D	6	0.88 ^{ns}	1.31 ^{ns}	1.71 ^{ns}	0.91 ^{ns}	4.89**
F x D	6	0.69 ^{ns}	0.28 ^{ns}	0.99 ^{ns}	0.88 ^{ns}	0.53 ^{ns}
S x F x D	6	1.32 ^{ns}	1.77 ^{ns}	3.17**	0.74 ^{ns}	0.99 ^{ns}
Error	81	-	-	-	-	-
CV%	-	9.46	4.36	4.66	8.56	12.33

^{ns} Not significant; **, * Significant at 1 and 5% of probability by the F test, respectively

Table 5. Values of chlorophyll, plant height, leaf width, and dry matter of *Urochloa brizantha* cv. Marandu, grown in Rio Verde, Goiás, 2019/2020

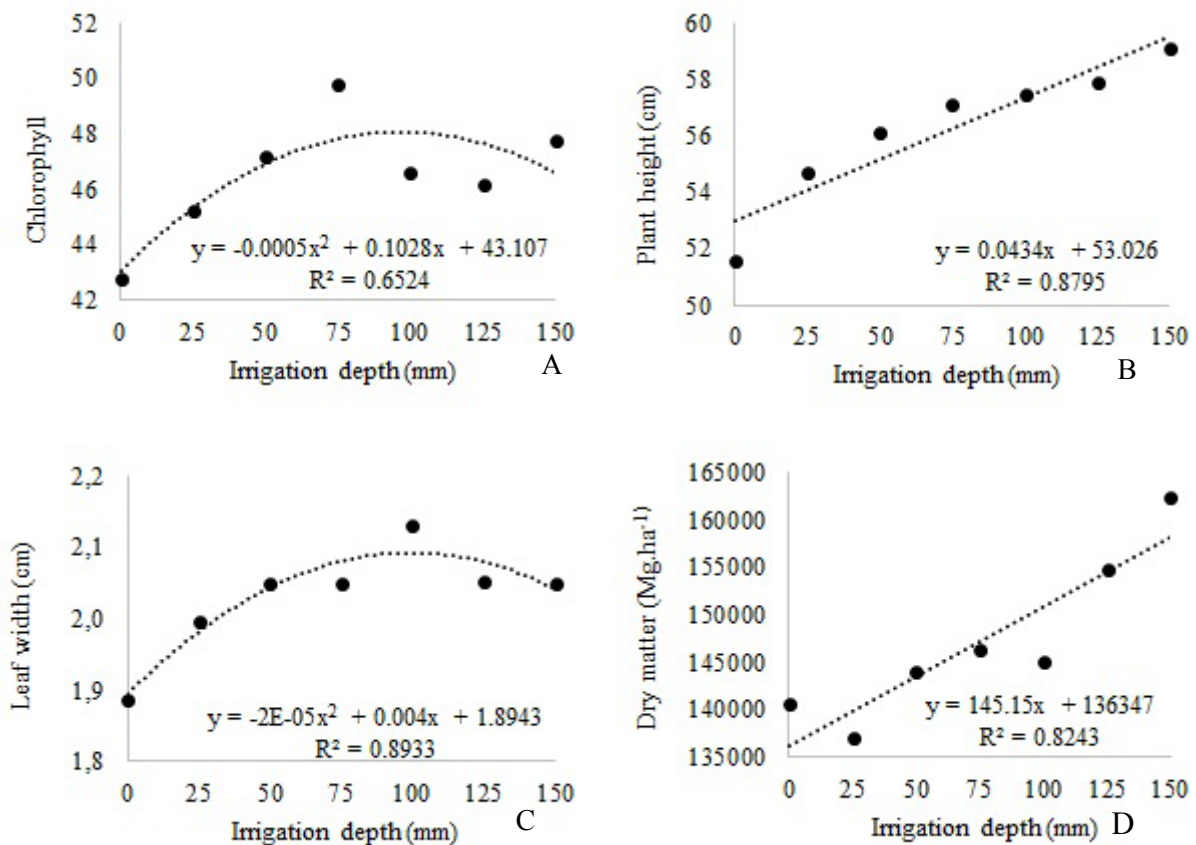
Soil	Chlorophyll	Height (cm)	Width (cm)	Dry matter (Mg.ha ⁻¹)
Sandy	46.20 A	55.91 A	1.99 B	144.290 A
Clayey	46.81 A	56.65 A	2.07 A	150.174 A
Fertilization				
A1	45.38 b	56.98 a	2.02 a	145.415 a
A2	47.62 a	55.58 b	2.03 a	149.049 a

The same upper-case letters in the column between soil and lowercase letters between fertilization are not statistically different by the F test (p≤0.05)

Chlorophyll contents as a function of irrigation depths were better adjusted using the second-degree equation; however, with a low determination coefficient response ($R^2 = 65\%$). Thus, the use of an irrigation depth of 103 mm distributed in 28 days (cycle) will result in an estimation of a chlorophyll content of 49 (Figure 3a). Regarding the height, the values show a better fit for the first-degree equation ($R^2 = 88\%$) (Figure 3b), while the width in the increasing water depths fitted better to the quadratic model ($R^2 = 89\%$) (Figure 3c). Alencar *et al.* (2009), Lopes *et al.* (2014), and Dupas *et al.* (2010) also observed this behavior in forages. The dry matter values were adjusted to a first-degree equation ($R^2 = 82\%$), therefore, as the irrigation supply increases, there is an increase in biomass (Figure 3d). This behavior shows that the forage responds linearly to the increase in irrigation depths, resulting in greater production of fresh and, consequently, dry matter in the Cerrado region.

The average forage chlorophyll index at every 28 days, regardless of the treatment adopted, was 45.5 ± 2.8 (Figure 4). The average SPAD index in spring, summer, autumn, and winter was 46.1 ± 1.6 ; 51.3 ± 2.1 ; 42.1 ± 2.0 , and 42.6 ± 3.6 , respectively. The best chlorophyll indexes were obtained in treatments in which the plants received better nutrition (A2) in sandy soil conditions. According to Bonfim-Silva *et al.* (2013), there is a direct relationship between the availability of nutrients with the intensity of green color and the chlorophyll content in the leaves.

The average forage cutting height every 28 days, regardless of the treatment adopted, was 54.2 ± 11.7 cm (Figure 5). The mean cutting height in spring, summer, autumn, and winter was 70.2 ± 26.0 ; 80.7 ± 8.9 ; 42.3 ± 9.6 , and 23.8 ± 2.3 cm, respectively. According to the increase in irrigation depths, there was an increase in the average forage plant height. Except in winter, the condition of clayey soil under



*Significant regression at 5% probability

Figure 3. Chlorophyll (a), plant height (b), width (c) and dry matter (d) of *Urochloa brizantha* cv. Marandu in different irrigation depths, in Rio Verde, Goiás, 2019/2020

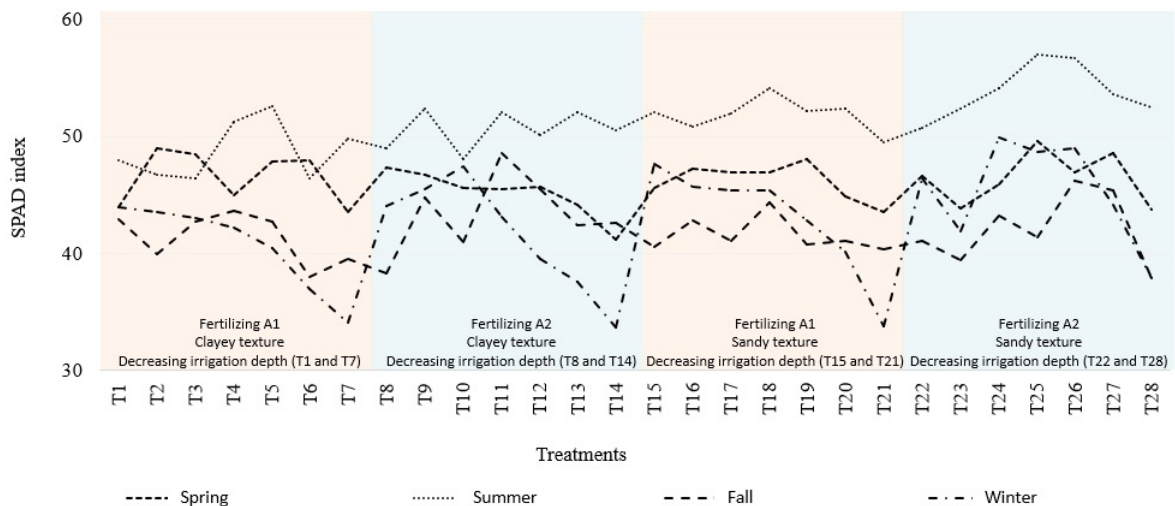


Figure 4. *Urochloa brizantha* cv. Marandu SPAD index over the seasons grown in Rio Verde, Goiás, 2019/2020

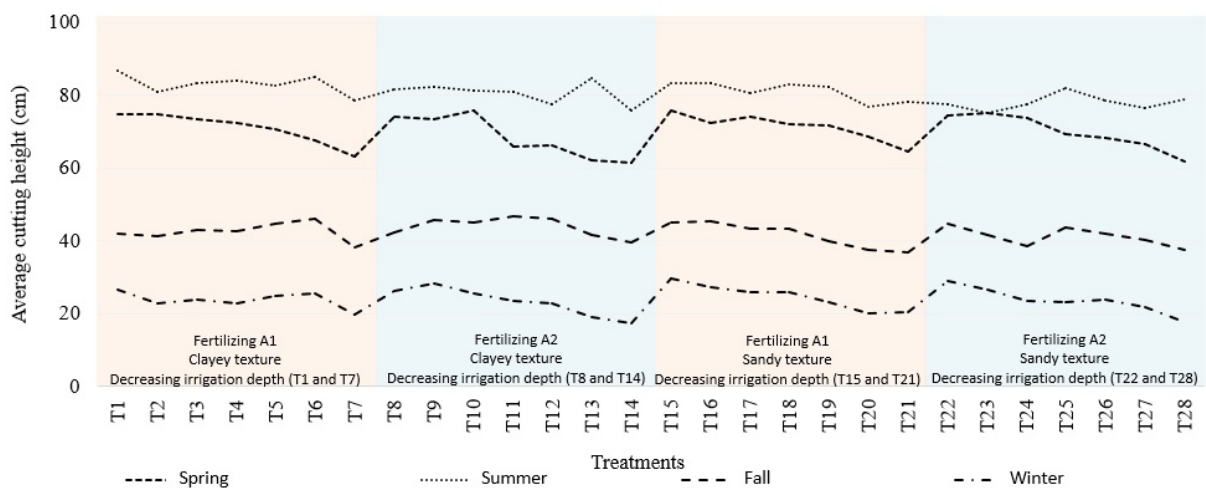


Figure 5. Mean height at cutting of *Urochloa brizantha* cv. Marandu over the season grown in Rio Verde, Goiás, 2019/2020

high water supplies at 150 mm depths, presented a better performance in relation to sandy soil under high water supplies at 150 mm depths. In summer and winter, irrigation depths greater than 100% of ETc presented higher plant height. According to Dantas *et al.* (2016), this results from the reduction in the intensity of solar radiation and, consequently, the air temperature.

The average leaf length of the forage every 28 days, regardless of the treatment adopted, was 27.3 ± 3.3 cm (Figure 6). The average leaf length in spring, summer, autumn, and winter was 32.7 ± 5.7 ; 33.0 ± 2.2 ; 27.5 ± 3.9 , and 16.9 ± 1.5 cm, respectively. Periods of greater intensity of solar radiation promoted the competition for

forage growth, lengthening, being inverse in winter, period of lesser amount of radiation and consequently, temperature, therefore inhibiting the crop performance in relation to the other seasons. Similar results were obtained by Dantas *et al.* (2016) and Ferreira *et al.* (2021).

In clayey soil, the use of A1 fertilization, associated with 25 mm of irrigation depth caused a reduction in leaf length (10.7%). In the same irrigation depth associated with the A2 supply in sandy soil, a reduction in leaf length (1%) was recorded. Also, the use of 100 mm depth in clayey soil with A2 fertilization caused a reduction in length (10.8%) (Table 6).

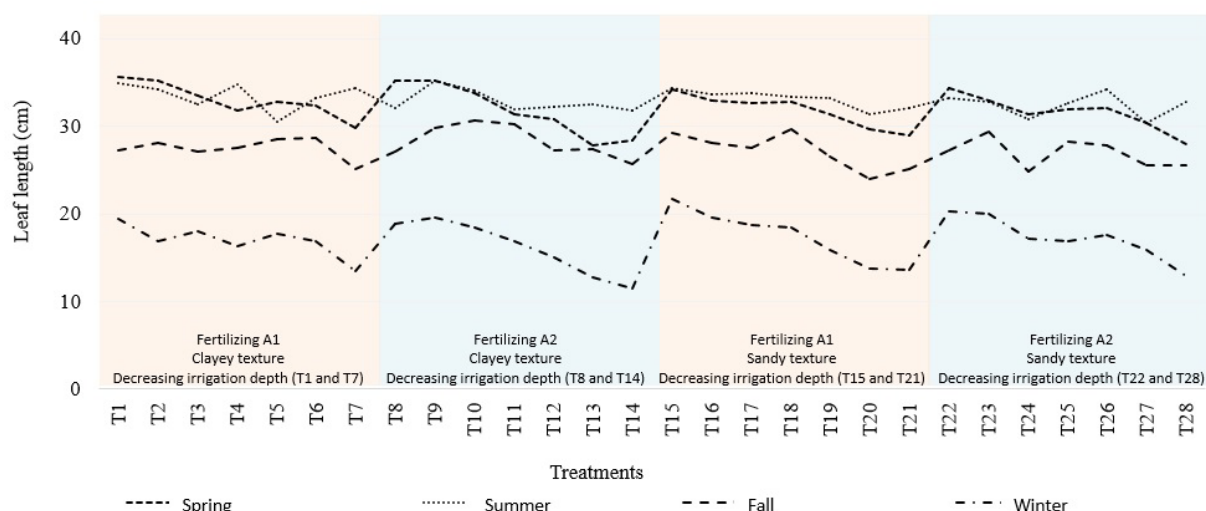


Figure 6. Mean leaf length of *Urochloa brizantha* cv. Marandu over the seasons in Rio Verde, Goiás, 2019/2020

Table 6. Mean values of leaf length (cm) of *Urochloa brizantha* cv. Marandu, grown in Rio Verde, Goiás, 2019/2020

Irrigation depth (mm)	Fertilization			
	A1		A2	
	Sandy	Clayey	Sandy	Clay
0	26.37 aA	25.50 aA	24.88 aA	25.36 aA
25	28.22 aA	25.19 bA	25.67 aB	25.94 aA
50	27.64 aA	27.22 aA	26.75 aA	28.38 aA
75	28.13 aA	28.90 aA	27.91 aA	27.82 aA
100	28.15 aA	28.59 aA	29.58 aA	26.41 bB
125	29.04 aA	28.95 aA	30.33 aA	29.07 aA
150	29.73 aA	30.24 aA	28.62 aA	29.11 aA

The same lower-case letters between the soil in each fertilization and the upper-case letter between fertilization in each soil in the row are not statistically different from each other by the F test ($p \leq 0.05$)

An average increase was observed in this experiment for forage leaf length as a function of irrigation depths, regardless of soil texture and fertilization levels (Figure 7).

According to the adopted treatments, no significant variation was observed for the average width of the forage leaf, and, every 28 days, regardless of the treatment adopted, the average value was 2.0 ± 0.1 cm (Figure 8). The average leaf width in spring, summer, autumn, and winter was 2.2 ± 0.2 ; 2.1 ± 0.1 ; 2.0 ± 0.1 , and 1.8 ± 0.1 cm, respectively. The treatments with sandy soil texture and A2 fertilization had better performance in relation to the others, except for the T1 treatment.

An average increase was found in dry matter yield as a function of irrigation depths (ETc) regardless of soil texture and fertilization level (Figure 9).

In water stress conditions, Marandu grass shows dramatic reductions in the rate of leaf elongation and biomass accumulation (PEZZOPANE *et al.*, 2015). Therefore, to increase primary production in periods of low rainfall (fall/indoor) in the Cerrado, the use of irrigation projects is a promising strategy. On the other hand, under conditions of poorly drained soils, with high humidity or waterlogging, marandu grass may exhibit low growth capacity for roots and aerial part (chlorosis,

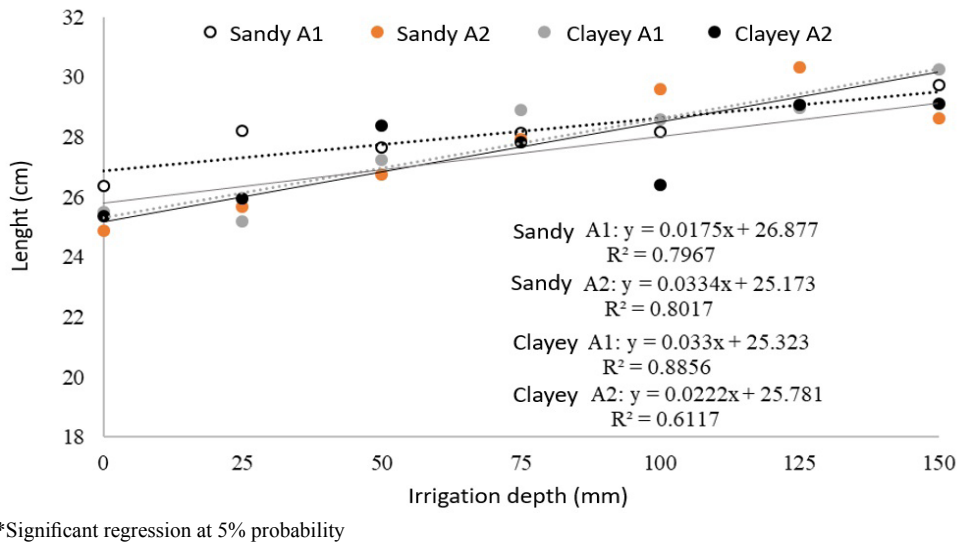


Figure 7. Leaf Length of *Urochloa brizantha* cv. Marandu in sandy and clayey soil in different fertilization and irrigation depths, in Rio Verde, Goiás, 2019/2020

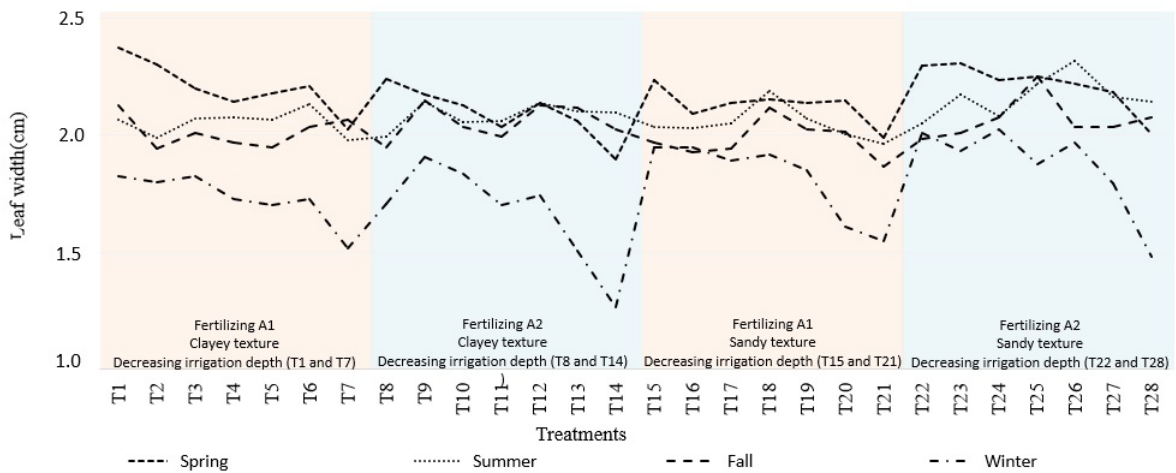


Figure 8. Mean leaf width of *Urochloa brizantha* cv. Marandu during the seasons in Rio Verde, Goiás, 2019/2020

premature wilting, and reduction in photosynthetic rate, compromising its respective canopy longevity (VISSER *et al.*, 2003).

Stabilization was observed in crude protein (CP) levels in forage as a function of irrigation depths in clayey soil conditions, even with the rise in the fertilization levels (Figure 10). In sandy soil conditions, there was an increase in CP as a function of irrigation depths at the A1 fertilization level and a reduction in the A2 fertilization level (Figure 10). According to De Paula *et al.* (2017), high amounts of fertilizers do not promote a similar increase in leaf quality, nor do irrigation depths,

except in sandy soil.

Soil is among the abiotic factors that influence the concentration of nutrients in the plant (GASTAL & LEMAIRE, 2015; GURGEL *et al.*, 2020). Therefore, in soils with a higher concentration of organic matter, high bioavailability of nutrients, associated with the absence of water stress potentiated the photosynthetic processes in the plant which is shown by the high values in the SPAD indexes observed in the leaf area, as well as the improvement in the nutritional value (CP > 10%) in the aerial part of the forage canopy (MAIA *et al.*, 2014; CASTILLO *et al.*, 2019).

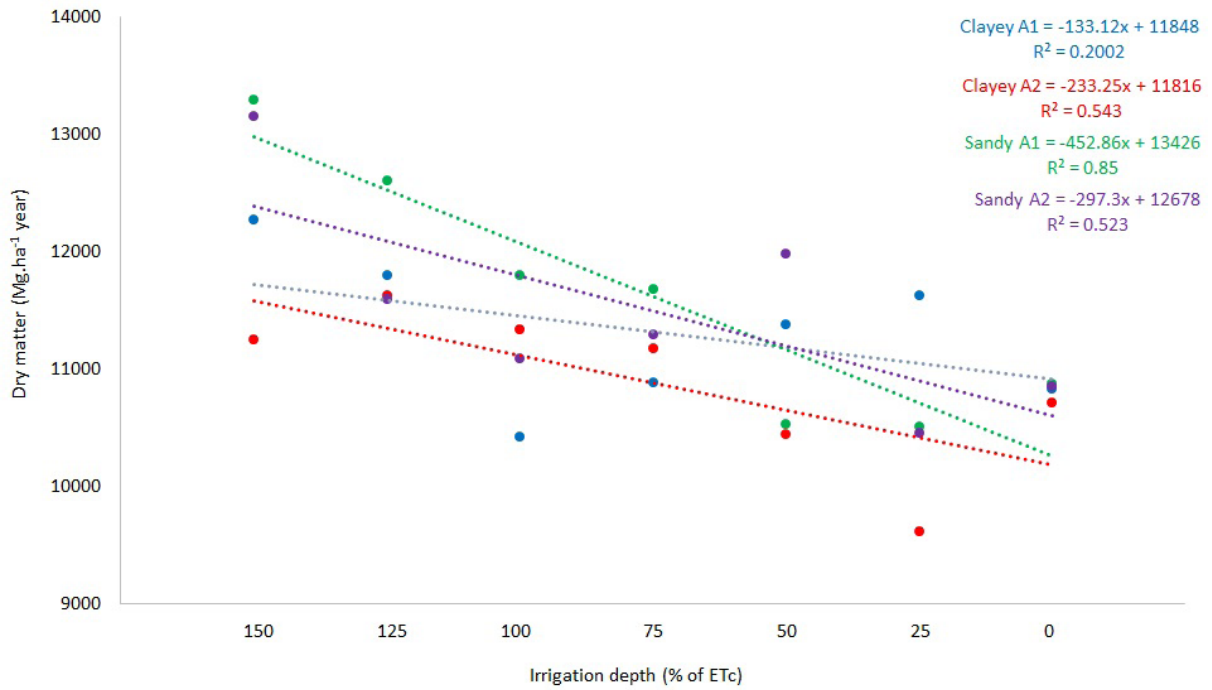


Figure 9. Average dry matter yield of *Urochloa brizantha* cv. Marandu according to the treatments adopted in Rio Verde, Goiás, 2019/2020

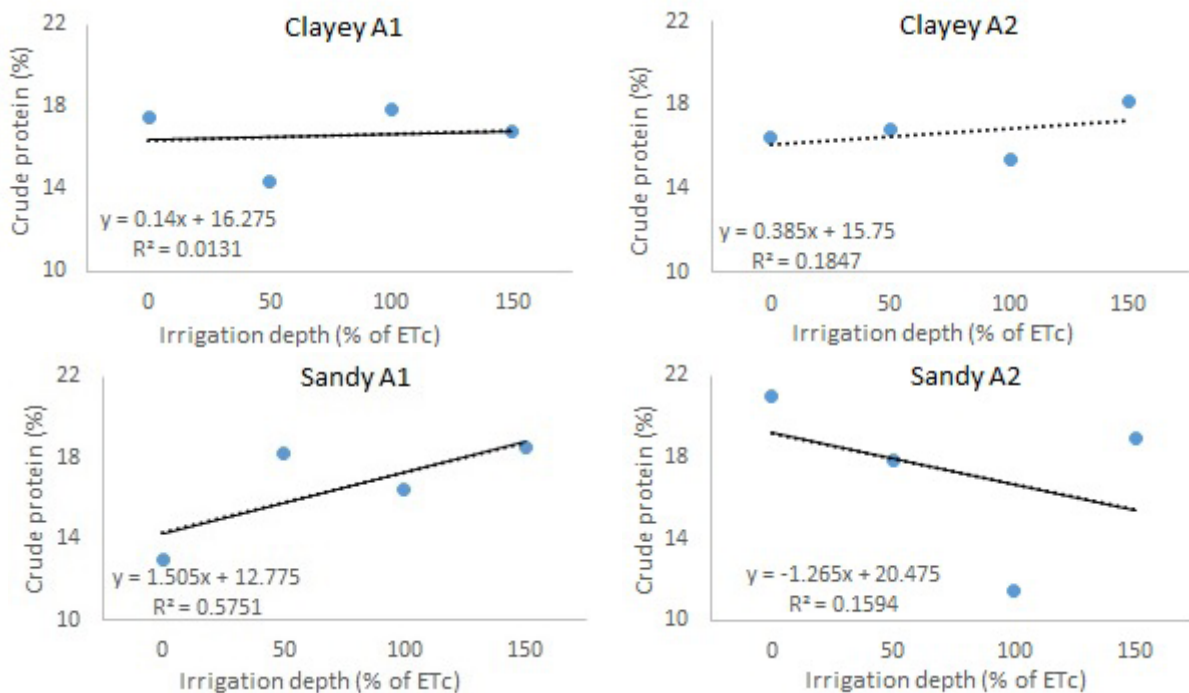


Figure 10. Crude protein (%) in *Urochloa brizantha* cv. Marandu as a function of the irrigations depths in different soil textures and fertilization levels in Rio Verde, Goiás

The average value for the respective treatments was 87.94% (clay A1), 87.03% (A2 sandy), 93.76% (A2 clay), and 96.73% (A1 sandy). The NDF content in the forage as a function of the increase

in irrigation depths decreased in conditions of clayey soil and A1 fertilization and A2 sandy soil and increased in conditions of clayey soil and A2 fertilization and A1 sandy soil (Figure 11).

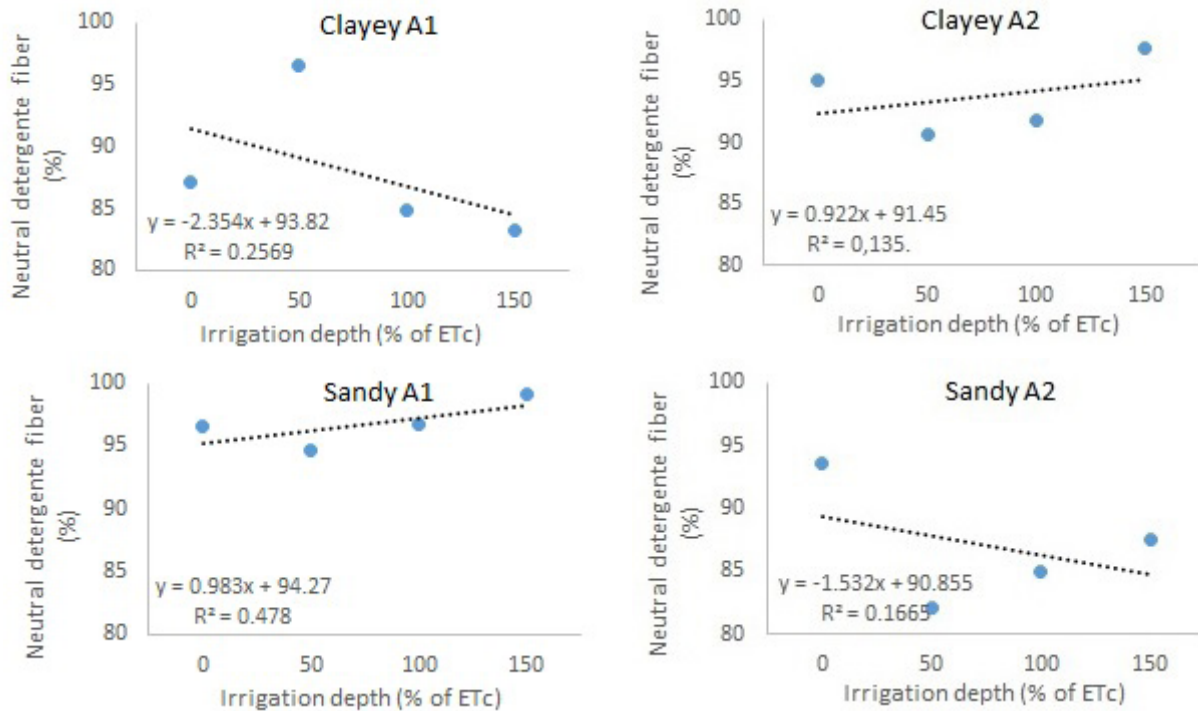


Figure 11. Neutral detergent fiber (%) in *Urochloa brizantha* cv. Marandu as a function of the irrigations depths in different soil textures and fertilization levels in Rio Verde, Goiás

It is expected that in *U. brizantha* pastures, the values of neutral detergent fiber show percentages values of less than 80%. If higher estimates are obtained, it is suggested that the management adopted induced the plant to accumulate fibrous material, which is not desirable, as it will reduce the nutritive value of the produced forage in addition to reducing the efficiency of forage harvesting during grazing (BENVENUTTI *et al.*, 2009; EUCLIDES *et al.*, 2016; FERREIRA *et al.*, 2021).

Despite only one year of data analysis, it is suggested that the treatment is long-lasting to verify the forage response in atypical year conditions; however, it is observed that the increase in irrigation depths has a proportional increase in the production of dry matter, regardless of soil texture and fertilization levels.

CONCLUSIONS

Based on the results found in the conditions in which this experiment was carried out, it can be inferred that:

- The rise in the irrigation depths significantly influences the performance of the forage and

although there is no significant difference, the production of dry matter can be higher in clayey soil conditions using A2 fertilization.

- A significant influence was found on the number of seedlings emergence from 7 to 21 days in sandy soil as a function of clayey soil, on chlorophyll, and plant height as a function of A2 in relation to A1 fertilization and irrigation depths in all analyzed variables.
- Plant height and dry matter yield were higher due to the rise in irrigation depths, regardless of soil texture and fertilization level.
- The treatments provided a crude protein content of more than 10% and an average neutral detergent fiber of 91%.

AUTHORSHIP CONTRIBUTION STATEMENT

FERREIRA, M.A.A.: Conceptualization, Funding acquisition, Investigation, Software, Writing – original draft; **SANTOS, G.O.:** Methodology, Project administration, Resources, Supervision, Writing – review & editing.

DECLARATION OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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