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INFLUÊNCIA DAS CARACTERÍSTICAS FÍSICO-HÍDRICAS DE DOIS SOLOS DO CERRADO MATOGROSSENSE NAS VARIÁVEIS PRODUTIVAS DO CAPIM HUMIDÍCOLA[1]

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1 RESUMO

No estado do Mato Grosso ocorrem solos com diferentes características físico-hídricas, as quais influenciam na disponibilidade de água do solo e consequentemente na produção de espécies forrageiras. Objetivou-se testar a influência das características físico-hídricas de dois solos da região sul de Mato Grosso sobre o armazenamento de água no solo (*ARM*) e a relação deste com as variáveis morfofisiológicas do capim *Urochloa humidicola*. Para tal, foram avaliados dois experimentos de campo em pastagens formadas. Os experimentos foram instalados em duas localidades do sul do Mato Grosso, com diferentes características edafoclimáticas. O delineamento experimental utilizado foi em blocos casualizados com 24 tratamentos e três repetições. Durante o período experimental, foram mensuradas as variáveis do capim e do solo. As variáveis resposta foram submetidas a análise de variância pelo teste F ao nível de 5% e análise de regressão. Para as variáveis físico-hídricas do solo foi utilizada a estatística descritiva. As variáveis morfofisiológicas do capim *U. humidicola* variam em função do local, sendo a disponibilidade hídrica no solo o principal fator determinante. O experimento que apresentou maior armazenamento de água no solo durante o período experimental obteve maior precisão para a maioria das variáveis do capim *U. humidicola*, na relação com *ARM*.

Palavras-chave: armazenamento de água no solo, física do solo, crescimento de pastagem.

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INFLUENCE OF THE PHYSICAL-WATER CHARACTERISTICS OF TWO SOILS OF THE CERRADO MATOGROSSENSE ON THE PRODUCTIVE VARIABLES OF HUMIDICOLA GRASS

2 ABSTRACT

The state of Mato Grosso soil events with different physical-hydric characteristics, which influence the availability of soil water and consequently in the production of forage species. The objective was to test the influence of the physico-hydric characteristics of two soils in the southem region of Mato Grosso on the water storage in the soil (*ARM*) and its relationship with the morphophysiological variables of *Urochloa humidicola* grass. For such, two field experiments were evaluated in formed pastures. The experiments were installed in two locations in the south of Mato Grosso, with different edaphoclimatic characteristics. The experimental design used was in randomized blocks with 24 treatments and three replications. During the experimental period, the variables of grass and soil were measured. The response variables were subjected to analysis of variance by the F test at the 5% level and regression analysis. Descriptive statistics were used for soil physico-hydric variables. The morphophysiological variables of *U. humidicola* grass vary depending on the location, with water availability in the soil being the main determining factor. The experiment that showed the highest water storage in the soil during the experimental period obtained greater precision for most variables of *U. humidicola* grass, in relation to *ARM*.

Keywords: grassland growth, soil physics, soil water storage.

3 INTRODUÇÃO

The Cerrado is located in the central region of the state of Mato Grosso, and it is estimated that approximately 30% of the land use in this biome is occupied by pastures (SCARAMUZZA *et al.*, 2017). Considering this extensive cultivated area, extensive agricultural production systems predominate, with pasture being the main source of feed for animals. Therefore, forage production is susceptible to edaphoclimatic variations in the Cerrado, particularly rainfall distribution and soil physical characteristics, with the latter being one of the main factors influencing soil water retention (KLEIN; KLEIN, 2015). In this scenario, for the same forage species cultivated in different regions, there is variability in soil water availability.

According to Reatto *et al*. (2008), the most common soils in the Cerrado are Latosols (48%), Neossolos (22%), and Ultisols (13%). Owing to the different physical characteristics observed in each of these soil classes, the aim is to minimize the effects of water deficit through knowledge of soil structure, with the aim of improving the quality of forage planning and management during the dry season, whether in rainfed or irrigated systems. Furthermore, in grazing systems, some conditioning factors, such as animal factors and pasture degradation, significantly influence soil physical properties (MOREIRA *et al*., 2005; SILVA; MEDINA; JOLOMBA, 2017).

In the region of Goiânia-GO, a comparison of the results observed in recovered pasture and degraded pasture indicated that the plant attributes and chemical and physical attributes of the soil were better in the area with recovered pasture (MOREIRA *et al*., 2005).

Given the importance of forage species in the agricultural context of the state of Mato Grosso, understanding the variation in the physical–hydric properties of the soil in different regions and, consequently, the relationship between water storage in the soil and the growth and development of pastures becomes relevant since the water deficit or surplus affects the metabolic and structural processes of this group of plants (DUARTE *et al*., 2019).

In this sense, the objective of this work was to test the influence of physical-hydric characteristics on soil water storage and its relationship with the morphophysiological variables of *Urochloa grass. humidicola*, in two regions of southern Mato Grosso.

4 MATERIALS AND METHODS

4.1 Experimental location and characteristics

Two identical experiments were analyzed simultaneously, from March 2019 to March 2020, at two locations in the Central-South Mesoregion of the state of Mato Grosso, the first (*E1*) being at the Experimental Farm of the Federal University of Mato Grosso, Cuiabá Campus, MT, located in the municipality of Santo Antônio de Leverger - MT, with geographic coordinates 15° 51' S, 56° 04' W, altitude of 141 m above sea level, climate type Aw (KÖPPEN; GEIGER, 1928) and soil classified as PLANOSOL NÁTRICO Órtico vertisolic (EMBRAPA, 2018), and the second (*E2*) at the Federal Institute of Education, Science and Technology of Mato Grosso, São Vicente Campus, located in São Vicente da Serra, with coordinates 15° 49' S, 55° 25' W, altitude of 800 m above sea level, climate type Aw (KÖPPEN; GEIGER, 1928) and soil classified as Dystrophic RED-YELLOW LATOSSOIL (EMBRAPA, 2018).

Urochloa grass pasture *humidicola was* established more than thirty years ago and has been used exclusively for horse and cattle grazing. The design used was a randomized block design (DBC) with 24 treatments (which consisted of 24 cuttings) and 3 replicates, with a total area of 10.0 × 61.5 m, a useful area of 6.0 × 48.0 m and plots measuring 2.0 × 2.0 m, with 0.5 m between plots and 1.0 m between blocks and the border.

Initially, a standardization cut was performed in each experiment at a height of 0.1 m from the soil surface on 03/31/2019 (*E1*) and 04/01/2019 (*E2*). From these dates, the evaluations began, with a difference of one day between the experiments and fixed cutting ages every 14 days.

4.2 Variables analyzed in grass and soil

In each plot, the following variables were obtained for *U. humidicola grass*: canopy height (*AD*, m), forage productivity (*PF*, kg ha $^{-1}$), leaf area index (*LAI*, m ^{2} m $^{-2}$) and specific leaf area (*SLA*, m ^{2} kg $^{-1}$); and for soil: bulk density (D_g, kg m $^{-3}$), total porosity (*PT*, m ^{3} m $^{-3}$), saturated soil hydraulic conductivity (K_0, cm h $^{-1}$), and the soil water retention curve (*SWC*) at matric potentials of 0, -6, -33, -60, -100, -500, -1,000 and -1,500 kPa, and soil water storage (*SWC*, mm).

To assess canopy height, a millimeter ruler was used to measure the height between the base of the tillers and the curvature of the last fully expanded leaf. The average height over the study period was determined by measuring four points per plot.

Forage productivity was measured by cutting the pasture in an area of 1.0 ^{m2}, which was then weighed on an analytical balance to obtain fresh matter (*MF*) and dried in a forced circulation oven at 55°C for 72 hours to obtain forage dry matter (*DM), according to Silva and Queiroz (2002). DM* was then considered the forage productivity of *U. humidicola grass*.

To obtain the *LAI, the specific leaf area (SLA)* was first measured by measuring the length and width of 20 leaves per plot with a graduated ruler, thus calculating the leaf area (*LA*), as proposed by Stickler (1961) for Poaceae. The leaves were then weighed fresh and dried in a forced circulation oven at 55°C for 72 hours to obtain the leaf dry matter (*LDM*). The *SLA* was calculated by dividing the *LA* by the *LDM*.

The *IAF* was calculated by multiplying the *AFE* by the *DM* and dividing by the sampled soil area.

For the soil physical–hydraulic variables, procedures were carried out according to the methodology proposed by Teixeira *et al*. (2017). Disturbed and undisturbed samples were collected in a central trench of the experiments at three depths: 0–0.30, 0.30–0.60, and 0.60–0.90 m. For the disturbed samples, 0.200 kg of soil was removed at each depth, which was used to estimate moisture at matric potentials of -500, -1,000, and -1,500 kPa, in the *WP4C psychrometer. Dewpoint potential meter*. The undisturbed samples were taken in stainless steel cylindrical rings with the aid of a Kopecky-type auger, with four replicates per depth, and were used to estimate moisture at matrix potentials of 0 (saturated moisture), -6 (tensile table), -33, -60, and -100 (richards chamber) and the variables K_0 (constant head permeameter), D_g and *PT*.

The moisture datasets for each matric potential were fitted to the Brooks and Corey (1964) model via *SWRC* (soil water retention curve) (DOURADO NETO *et al*., 1990).

The available water capacity in the soil (*CAD*) was also calculated in both experiments, considering depths from 0 to 0.90 m, resulting in values of 181.3 mm (*E1*) and 211.5 mm (*E2*).

Rainfall data were obtained at the conventional Padre Ricardo Remetter meteorological stations and at the IFMT Campus São Vicente station, which are located close to the experimental locations.

The soil texture was measured with disturbed samples collected at depths of 0 to 0.30 and 0.30 to 0.60 m, with four replicates per block, via a Dutch auger. In the laboratory, analysis was performed via the pipette method, and the class was determined by the textural triangle (SANTOS *et al*., 2005). The soil texture components in the two experiments are described in Table 1.

Table 1 - Analysis of the granulometric fractions and textural classes of the soil in the experiments with *U. humidicola grass* at two soil depths.

Experiment	Prof. (m)	Sand	Silt	Clay	Textural class
		(g kg $^{-1}$)			
E1	0 – 0.30	758	140	103	sandy loam
	0.30 – 0.60	806	98	95	sandy loam
CV (%)		**2.86**	**24.85**	**22.21**	
E2	0 – 0.30	669	82	249	loamy -clayey -sandy
	0.30 – 0.60	628	58	314	loamy -clayey -sandy
CV (%)		**4.03**	**9.1**	**21.74**	

Source: Os autores.

From the disturbed soil samples collected at depths of 0 to 0.30, 0.30 to 0.60, and 0.60 to 0.90 m, in three replicates, at the time of forage sampling, the volumetric soil moisture was obtained at each cutting age via gravimetry (TEIXEIRA *et al*., 2017). The soil water storage was subsequently calculated via equation (1) according to (LIBARDI, 2005).

$$ARM = \bar{\theta} \text{ x } z_i \quad (1)$$

where $\bar{\theta}$ is the average volumetric water content of all the soil layers (m ^{3} m $^{-3}$) and z_i is the sum of all the soil layers (mm).

4.3 Statistical analysis

The pasture variables were subjected to analysis of variance via the F test at the 5% probability level, and the significant effects were evaluated via regression analysis at the 1% and 5% probability levels, in which the cutting age corresponded to the independent variable and the morphophysiological characteristics corresponded to the dependent variables.

To compare the effects of water availability on the growth of *U. humidicola*, linear relationships were established between the dependent variables and soil water storage. Descriptive statistics were used for the soil physical and water variables.

5 RESULTS AND DISCUSSION

5.1 Analysis of soil physical–hydric variables

There was a difference between the averages of the soil physical–hydric variables in the two experiments (Table 2), which was expected, given that they are soils of different classes and physical properties, as observed in the textural analysis (Table 1).

Table 2. Descriptive statistics of soil physical–hydric variables in the experiments with *U. humidicola grass* at three soil depths: Santo Antônio de Leverger (*E1*) and São Vicente da Serra (*E2*).

Exper.	Prof. (m)		D_g (kg m $^{-3}$)	*PT* (m ^{3} m $^{-3}$)	K_0 (cm h $^{-1}$)
		Average	1925	0.3341	0
	0 – 0.30	Median	1939	0.3339	0
		Standard Deviation	0.0448	0.0150	0
		Variance	0.0020	0.0002	0
		Average	1,871	0.3463	0.1035
E1	0.30 – 0.60	Median	1,895	0.3454	0.1051
		Standard Deviation	0.0536	0.0148	0.0222
		Variance	0.0029	0.0002	0.0004
		Average	1,851	0.3345	0.0762
	0.60 – 0.90	Median	1,840	0.3374	0.0665
		Standard Deviation	0.0177	0.0099	0.0451
		Variance	0.0003	0.00001	0.0020
		Average	1,458	0.4757	0.0882
	0 – 0.30	Median	1,443	0.4678	0.0951
		Standard Deviation	0.0699	0.0219	0.0651
		Variance	0.0049	0.0005	0.0042
		Average	1,418	0.5094	0.1124
E2	0.30 – 0.60	Median	1,425	0.5244	0.1034
		Standard Deviation	0.0714	0.0293	0.0590
		Variance	0.0051	0.0008	0.0035
		Average	1,342	0.5138	0.1534
	0.60 – 0.90	Median	1,300	0.5312	0.1623
		Standard Deviation	0.1061	0.0395	0.0618
		Variance	0.0113	0.0016	0.0038

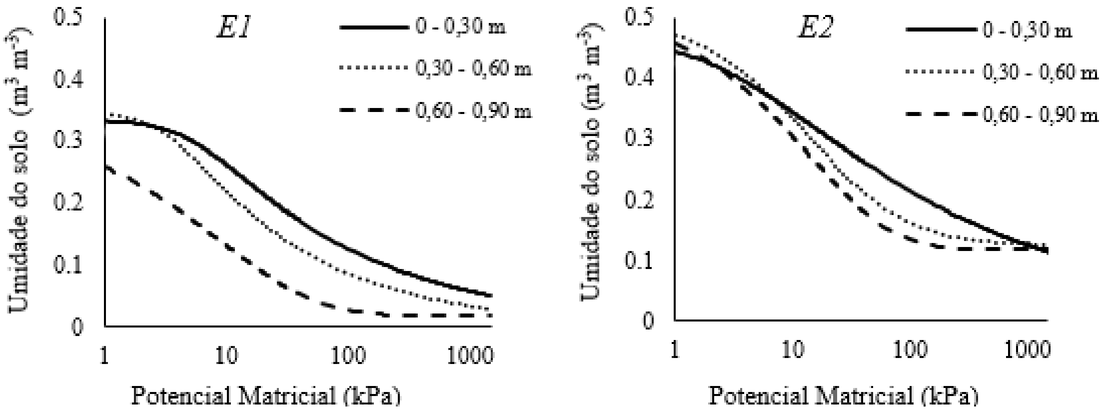
D_g - global density; *PT* - total porosity; K_0 - hydraulic conductivity of saturated soil.

The D_g values were greater in the 0 to 0.30 m layer, indicating greater soil compaction at the surface. This is also evident when observing the *PT* and *K0* *values*, which were lower in this layer. These results can be explained by the animal grazing process in both areas, which had a greater influence on the soil in experiment *E1*, which presented zero K_0. Furthermore, the soil in this area is classified as Planossolo, a soil characterized by low permeability (JACOMINE, 2009).

The D_g results of experiment *E1* were close to the values reported by Corrêa *et al*. (2003), for the same soil class, which varied from 1,640 kg m $^{-3}$ to 2,080 kg m $^{-3}$, at depths of 0 to 1.0 m. In experiment *E2*, despite the influence of animals, the D_g *values* were below the values obtained by Ramos *et al*. (2010), of 1,589 kg m $^{-3}$ in a pasture area of marandu grass under Red–Yellow Latosol, in southwestern Mato Grosso.

The *CRA* presented average moisture values ranging from 0.0170 mm to 0.3467 mm in experiment *E1* and from 0.1132 mm to 0.5185 mm in *E2* (Figure 1).

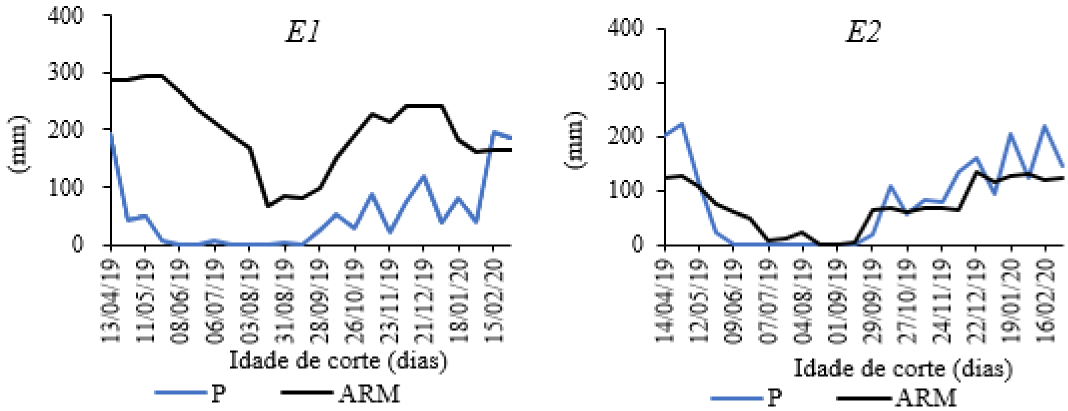
Figure 1. Soil water retention curve (*CRA) of the U.* grandis experiments. *humidicola* in Santo Antônio de Leverger – MT (*E1*) and São Vicente da Serra (*E2*) at three soil depths.



Despite the greater water retention capacity in experiment *E2*, the *ARM* was lower *than that in E1. The ARM* values ranged from 66.5 to 294.3 mm, and the precipitation ranged from 0 to 195.1 mm in experiment *E1*. In experiment *E2*, the *ARM* varied from 1.0 to 135.6 mm, and the precipitation ranged from 0 to 222.0 mm.

Figure 2 shows that in experiment *E1, the ARM* values remained above the *CAD* in 62% of the total period evaluated, whereas in *E2, the ARM* values remained below the *CAD* in all periods.

Figure 2. Behavior of rainfall (*P*) and soil water storage (*ARM*) in experiments *E1* and *E2* between 2019 and 2020.



One explanation for these results lies in the location of the experimental areas. In *E1*, the pasture is located in a floodplain area with periodic flooding, which favors water retention even during the dry season. Moreover, in *E2*, the area is mountainous, with varying soil depths, resulting in greater surface water runoff and lower infiltration and soil water retention rates.

U. humidicola grass variables as a function of cutting age

There was an effect of cutting age on all the variables analyzed for *U. humidicola grass* ($p<0.05$) in both experiments (Table 3).

Table 3. Summary of the analysis of variance for the variables of *U. humidicola grass*: canopy height (*AD*, m), forage productivity (*PF*, kg ha $^{-1}$), specific leaf area (*AFE*, m ^{2} kg $^{-1}$) and leaf area index (*LAI* m ^{2} m $^{-2}$) as a function of cutting age.

Exp.	FV	GL	Mean Square			
			AD	***PF***	***AFE***	***IAF***
E1	Cutoff age	23	0.0184*	5.1141*	0.0096*	0.1668*
	Block	2	0.0014	0.3659	0.0018	0.0252
	Residue	46	0.0004	0.2075	0.0024	0.0141
	Total	71	-	-	-	-
	CV (%)		2.35	6.66	2.48	8.91
E2	Cutoff age	23	0.0229*	2,1729*	0.0099*	0.0791*
	Block	2	0.0028	0.6048	0.0018	0.0311
	Residue	46	0.0002	0.1211	0.0008	0.0051
	Total	71	-	-	-	-
	CV (%)		2.06	5.75	1.48	6.05

* significant at the 5% probability level.

Linear regression analysis was performed for all *U grass variables.* However, for the relationship with soil water storage, only the models that obtained statistical significance are presented.

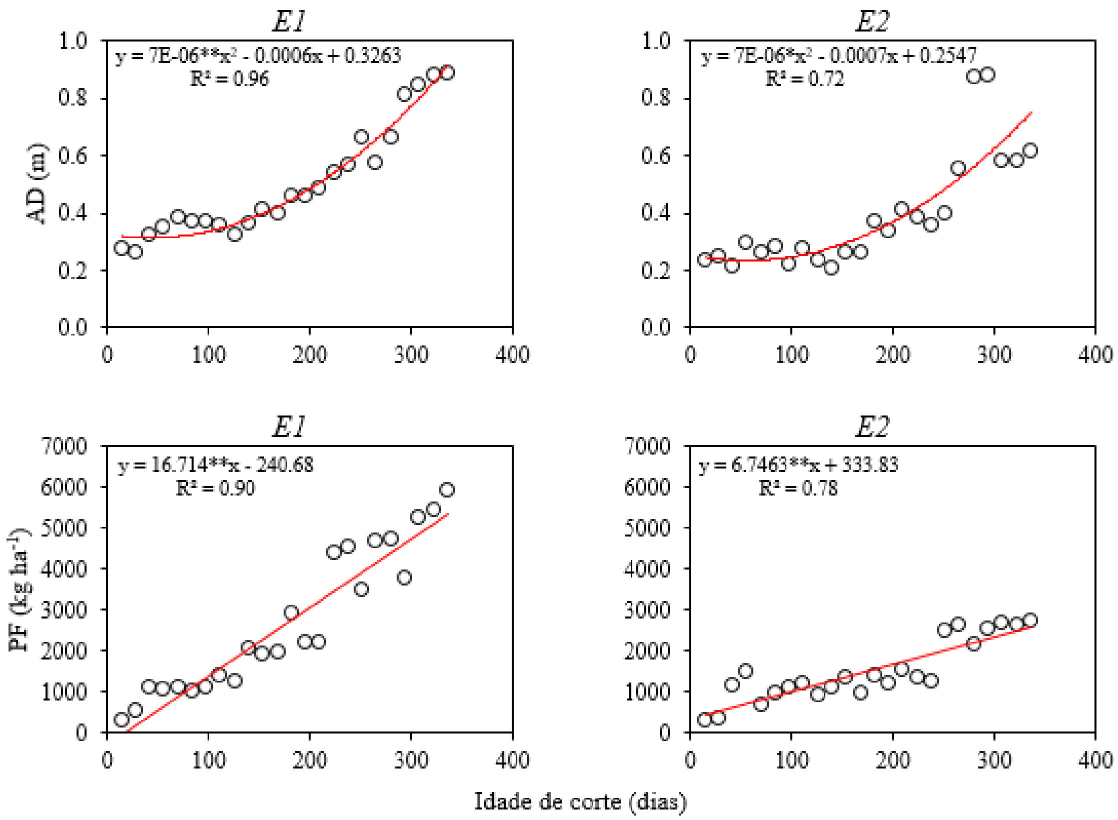
Despite the edaphoclimatic differences between the experiments, the response variables followed similar models depending on the cutting age. However, the mean values of the variables in experiment *E1* reached higher values, reflecting the greater accuracy of the models.

The canopy heights in both experiments were similar, varying between 0.2587 m and 0.8847 m in *E1* and between 0.2097 m and 0.8787 m in *E2*.

Forage productivity was the response variable that presented the greatest variation between the experiments, with oscillations from 287.2 kg ha $^{-1}$ to 5,902.03 kg *ha-1 in experiment E1 and from 289.5 kg ha-1 to 2,750.67 kg ha-1 in E2. These results show that the performance of U. humidicola* grass in terms of *forage* yield was favorable in waterlogged soil*,* demonstrating *its* satisfactory adaptation in floodplain soils (QUEIROZ *et al*., 2012).

Figure 3 shows that, despite the high precision of the models, forage productivity as a function of cutting age (RIBEIRO-SANTOS *et al*., 2023) presented a greater relationship in experiment *E1* than in *E2*.

Figure 3. Linear relationships between the morphophysiological variables of *U. humidicola,* canopy height (*AD*) and forage productivity (*PF*), as a function of cutting age in experiments *E1* and *E2*.



The leaf area index also differed between the experiments (Figure 4), ranging from 0.57 m ^{2} m $^{-2}$ to 7.92 m ^{2} m $^{-2}$ in *E1* and from 0.54 m ^{2} m $^{-2}$ to 4.32 m ^{2} m $^{-2}$ in experiment *E2*. *Some LAI* values observed in *E1* were higher than those reported in the literature for *U. humidicola grass*, as demonstrated by Danelichen *et al*. (2014), who reported average monthly *LAI values* ranging from 1.62 m ^{2} m $^{-2}$ to 6.18 m ^{2} m $^{-2}$, in Santo Antônio de Leverger, MT.

LAI values with greater accumulation of precipitation that occurred in different years.

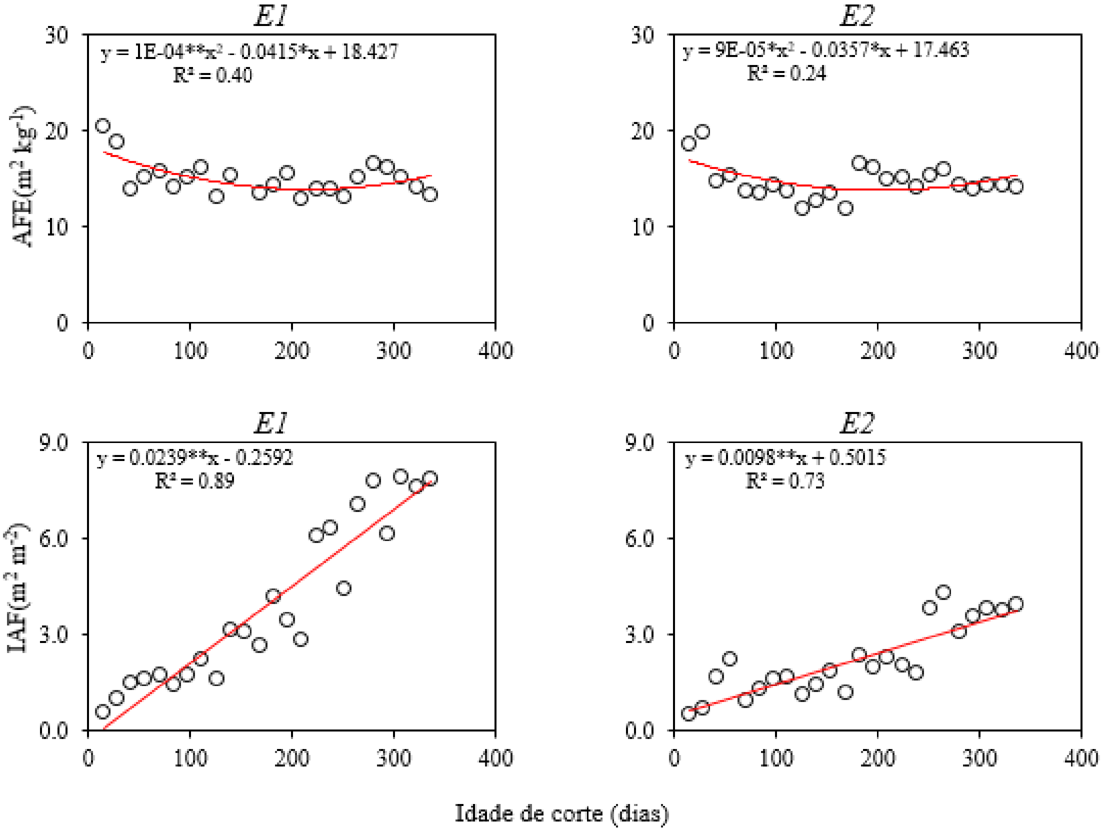
The dry matter observed at each cutting age was considered in the *IAF* calculation, which explains the high values of this variable in experiment *E1*, which resulted in greater forage productivity in some periods.

The specific leaf area varied from 12.95 m ^{2} kg $^{-1}$ to 20.58 m ^{2} kg $^{-1}$ in *E1* and from 11.97 m ^{2} kg $^{-1}$ to 19.87 m ^{2} kg $^{-1}$ in *E2*. The overall average *AFE* in *E1* was 15.06 m ^{2} kg $^{-1}$, which was higher than that in experiment *E2*, which was 14.75 m ^{2} kg $^{-1}$.

Urochloa cultivars *brizantha*, Pezzopane*, etc*. (2015) reported average *AFE values* of 12.58 m ^{2} kg $^{-1}$ for the Piatã cultivar, 13.04 m ^{2} kg $^{-1}$ for the Paiaguás cultivar, 15.50 m ^{2} kg $^{-1}$ for the Marandu cultivar and 14.50 m ^{2} kg $^{-1}$ for the Xaraés cultivar.

The authors reported a reduction in the *AFE* in all cultivars subjected to water deficit compared with the control. Therefore, although Pezzopane's work *et al*. (2015) was carried out in a greenhouse, and the average *AFE values* obtained for the Marandu cultivar (15.50 m ^{2} kg $^{-1)}$ and for the Xaraés cultivar (14.50 m ^{2} kg $^{-1)}$ were very close to the values obtained in this work for *U. humidicola* grass in experiment *E1* (15.06 m ^{2} kg $^{-1}$) and in experiment *E2* (14.75 m ^{2} kg $^{-1}$). Despite the quadratic relationship between the *AFE* and cutting age in both experiments, the precision was greater in experiment *E1*, as shown in Figure 4.

Figure 4. Linear relationships between the morphophysiological variables of *U. humidicola,* specific leaf area (*AFE*) and leaf area index (*IAF*), as a function of cutting age in experiments *E1* and *E2*.



In terms of the relationships between the response variables of *U. humidicola* and soil water storage, the quadratic model fit best for experiment *E1*, and the linear model fit best for experiment *E2* (Figure 5 and Figure 6).

Figure 5. Linear relationships between the morphophysiological variables of *U. humidicola,* canopy height (*AD*) and forage productivity (*PF*), as a function of soil water storage (*ARM*) in experiments *E1* and *E2*.

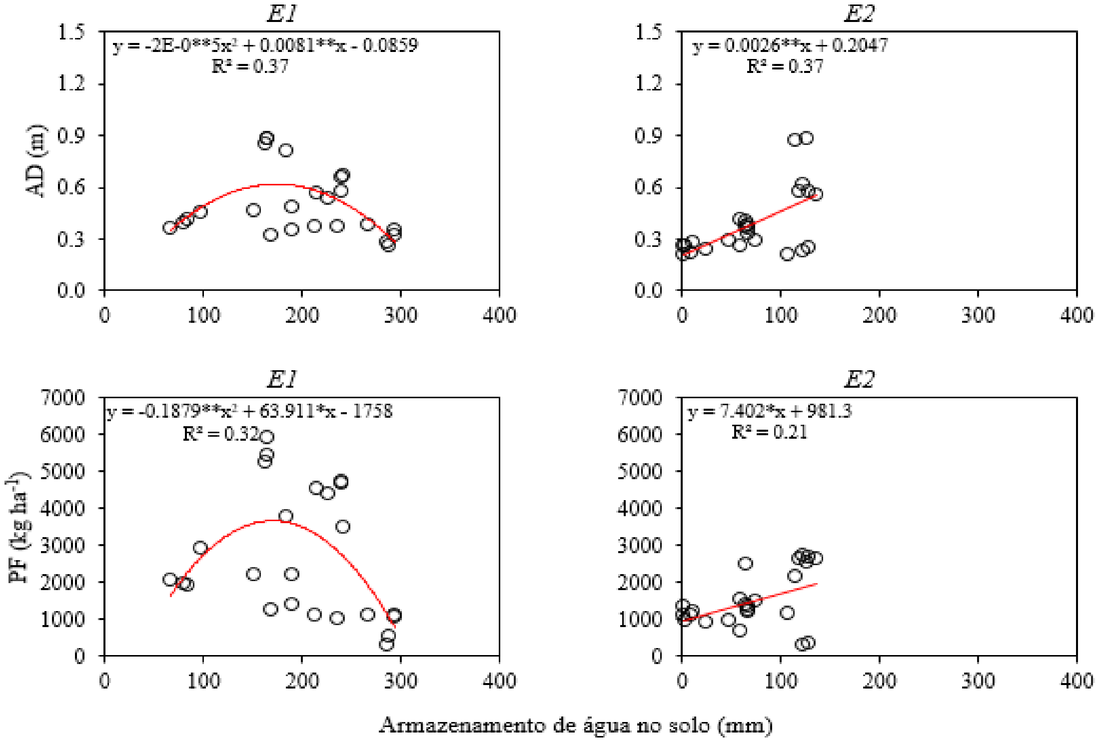
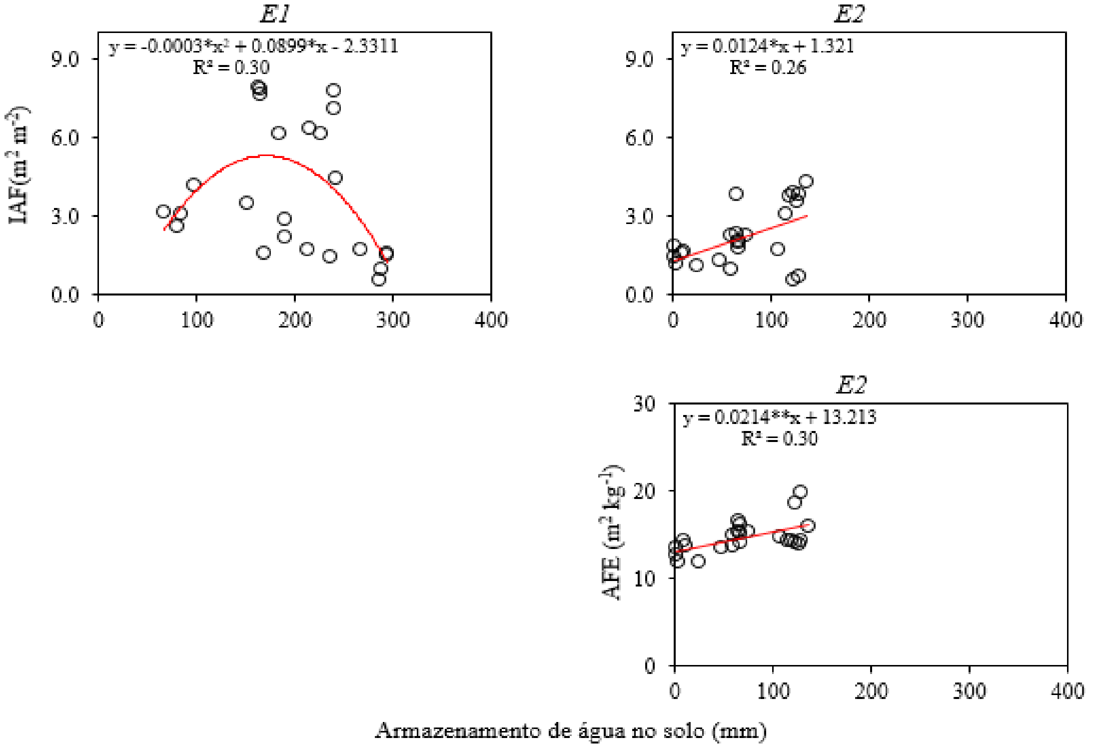


Figure 6. Linear relationships between the morphophysiological variables of *U. humidicola,* i.e., the leaf area index (*LAI*) and specific leaf area (*AFE*), as a function of soil water storage (*ARM*).



Owing to the adaptive characteristics of *U. humidicola*, its performance in terms of forage productivity was more favorable in the experiment in which the *ARM* was greater than the CAD for more than 50% of the total period evaluated.

When evaluating the morphogenesis of six species of the genus *Urochloa* under different soil water conditions, Duarte *et al*. (2019) reported that the species U. *humidicola cv*. Compared with U. humidicola, Tully was more tolerant to both water deficiency and flooding. Llanero, U. *decumbens* cv. Basilisk, *U.* ruziziensis cv. Kenedy, *U.* brizantha cvs. BRS Piatã and Xaraés.

As observed for forage productivity, the *LAI* of experiment *E1* was positively influenced by the relatively high soil water content during the analysis period, whereas for the relationship between the *AFE* and *ARM*, the linear model was significant only for experiment *E2*.

This is probably associated with the similar behavior of the *AFE* in relation to the *ARM* in experiment *E2*, demonstrating the greater sensitivity of this response variable to soil water availability.

The Cerrado region is composed of soils of different textural classes, which significantly affects water storage and availability, especially for tropical forage crops. However, the results obtained in this study demonstrated that terrain relief positively influences soil water storage over a prolonged period, even in sandy soils with low water retention capacity.

Specifically, for the grass *U. humidicola*, greater water availability in the soil under field conditions had a positive effect on most of its productive components.

6 CONCLUSIONS

1. The morphophysiological variables of *U. humidicola* vary depending on location, with water availability in the soil being the main determining factor resulting from the physical–hydric characteristics of the soil and consequently the water storage in the soil of each region.

2. In addition to the specific leaf area, the morphophysiological variables of U. humidicola grass were more closely related to the ARM in the experiment located in floodplain soil, which has higher values of soil water storage.

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