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Production and morphophysiological responses of *Panicum maximum* cv. BRS Zuri to water availability

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Abstract

Due to the increasing intensification of livestock farming and agricultural systems, there is demand for highly productive forage species. *Panicum maximum* cv. BRS Zuri is forage that has good productivity, vigor and promotes good animal performance. The objective of this study was to evaluate the morphophysiological and production characteristics of *Panicum maximum* cv. BRS Zuri subjected to water availability in Fluvic Neosol (Entisol). A potted-plant experiment was conducted in a greenhouse at the Federal University of Rondonópolis, Brazil. The experimental design was completely randomized, with five levels of water availability, corresponding to 25, 50, 75, 100 and 125 % of the maximum soil water holding capacity, and six replicates, in three successive cuts. The variables analyzed were: soil pH, SPAD index, plant height, leaf area, shoot dry mass, root dry mass, root volume, water consumption and water use efficiency. Water availability influenced the development of *Panicum maximum* cv. BRS Zuri, with the highest results between 67 % and 111 % of the maximum soil water holding capacity. The results show that the production and morphological responses were negatively influenced by water availability levels of 25 % and 125 %. These results makes it possible to affirm that, under the studied conditions, the cultivar BRS Zuri showed moderate adaptation to 125% water availability (excess water).

Keywords: Drought; pH of soil; chlorophyll; dry matter production; grass.
Abbreviations: Al_Aluminum, B_Boron, Ca_Calcium, CEC_Cation exchange capacity, Cu_Copper, DAE_Days after emergence, Fe_Iron, H_Hydrogen, K_Potassium, Mg_Magnesium, M_Aluminum saturation, MM_Mineral matter, NP_Neutralization power, OM_Organic matter, TRNP_Total relative neutralizing power, S_Sulfur, V_Base saturation, Zn_Zinc.

Introduction

Brazil has the second largest cattle herd in the world, with approximately 220 million animals, according to the United States Department of Agriculture (USDA 2019). In 2019, Brazil exported 1.84 million tons of beef, obtained revenues of US$ 7.59 billion and consolidated itself as the world's largest exporter of the product, according to the Brazilian Association of Meat Exporting Industries (ABIEC 2020). The State of Mato Grosso leads the cattle raising activity, with 31.7 million head, equivalent to 14.8 % of the national herd (IBGE 2017).

Pasture is main source of food for the Brazilian cattle herd, and 95 % of the slaughtered animals are reproduced, backgrounded and finished exclusively in the pasture (Lobato et al., 2014). Thus, in general, pastures do not meet the nutritional requirements of cattle, as they are not managed properly, often due to the lack of knowledge about their physiological conditions of growth and nutritional composition (Araújo et al., 2010; Dill et al., 2015).

Inadequate management of these pastures results in the reduction of mass production, which reduces their support capacity and, consequently, the production performance is compromised, because cattle need minerals, vitamins, water and proteins, which are obtained from the consumption of pastures (Oliveira and Couto, 2018).

Thus, animal production in tropical regions, as in the Cerrado of Mato Grosso, has climatic seasonality as the main obstacle, because this region is characterized by two well-defined periods, dry and rainy, which causes water stress in the pastures by either flooding or water deficit, leading to an irregular supply of pastures during the year (Kroth et al., 2015; Silva et al., 2020).

Therefore, the choice of the type of pasture to be cultivated in this region is a determining factor to optimize animal production in pastures. Grasses of the genus *Panicum* are among the most used forages in animal production system due to their nutritional quality and productivity (Silva et al. 2016). The species *Panicum maximum* cv. BRS Zuri, among the forage grasses, stands out for being tall and having cespitose growth, high nutritional value, high productivity, regrowth vigor, support capacity and resistance to froghopper (EMBRAPA 2014). As this cultivar is relatively new, released in 2014, there are few studies involving its adaptation to flooding and drought.

In view of the above, the objective was to evaluate the production and morphophysiological responses of *Panicum* *maximum* cv. BRS Zuri subjected to water availability and cultivated in a Fluvic Neosol (Entisol). The hypothesis of this study was that regions with the presence of Fluvic Neosol (Entisol) are subject to variations in water levels in the soil, and that pastures cultivated in this type of soil need to be adapted to these conditions without negatively altering their production, morphological and physiological characteristics.

Results and Discussion

Effect of water availability on soil pH

Water availability influenced the pH values of the soil cultivated with *Panicum maximum* cv. BRS Zuri (Figure 1). The lowest value of soil pH (4.07) was observed under water availability of 66.3%. This result can be correlated with the absorption of nutrients by plants, leaving the soil more acidic during this process (Luo et al., 2015; Fang et al., 2017), because the greatest development and growth and consequently greater nutrient extraction occurred under the intermediate levels of water availability to which the plants were subjected. At intermediate pH (4.5–7.5) as in the studied soil (Figure 1), most buffering is promoted by the cation exchange capacity of the soil (CEC) (Yang et al., 2012). During the acidification process, the soils release basic cations (e.g., Ca^{2+} and Mg^{2+}) retained on the surfaces, exchange them for H^+ and thus neutralize the increase in acidity. Once the basic cations have been exhausted (mainly by absorption of plants), H^+ is released from the soil (Yang et al., 2012; Mass Junior et al., 2016).

The highest value of soil pH (5.8) was observed under water availability of 125%. In general, soils subjected to excess water (flooding) increase the accumulation of CO_2, causing the pH in most flooded soils to reach a balance of around 6.0, close to neutrality (Camargo et al., 1999; Kaur et al., 2020).

In flooded soils, there is a reduction in the amount of oxygen that compromises the absorption by roots and the action of microorganisms, which consequently are not able to perform denitrification and reduction of iron, sulfates and also manganese, so the soil pH is altered (Mass Junior et al., 2016). For soil pH to increase, two conditions are necessary: a well-developed reduction process and the sufficient presence of reduced elements (electron acceptors) (Mass Junior et al., 2016). Thus, a probable explanation for the pH increase is that there is an increase in concentrations of the soluble form of ions, such as Fe^{2+} and Mn^{2+}, formed under reduced conditions, as they are more basic than when under oxidized conditions, hence increasing the pH value (Mass Junior et al., 2016).

Effect of water availability on the SPAD index

Water availability influenced the values of the SPAD index in the three cuts of the cultivar BRS Zuri (Figure 2). In the first, second and third cuts, the highest values of SPAD index were observed under water availability of 25%, while the lowest values of SPAD index (34.0, 32.7 and 36.0) were obtained under water availability levels of 89.9, 87.2 and 125%, respectively (Figure 2).

In the first and second cuts of the plants, it can be observed that the lower SPAD index results from their good development, as chlorophyll was better distributed and little concentrated. In the third cut, the reduction of SPAD index occurred as water availability increased. This reduction may be indicative of chlorosis in the leaves, since their yellowing was observed under conditions of flooded soil, causing the reading of the SPAD index to decrease. The same phenomenon was observed by Bonfim-Silva et al. (2014) when subjecting the hybrid *Brachiaria* cv. Mulato II (convert HD364 grass) to water availability. The authors emphasize that this reduction may be associated with anoxia or hypoxia experienced by the root system of the grass.

The highest values (47.5, 38.5 and 42.9) of SPAD index were observed under water availability of 25% in the three cuts of the grass (Figure 2). Such higher SPAD index may be associated with the effect of nutrient concentration that occurs in plants under water deficit conditions, which showed lower growth. Santos et al. (2013), in a study with tropical grasses subjected to water availability, observed the highest SPAD readings under water availability levels of 25 and 100%, corroborating the results observed in this study.

In the first two cuts of the cultivar BRS Zuri, it was observed that from the moment water availability approaches 125%, this SPAD index tends to increase its value (Figure 2). The two conditions of extreme, water availability of 25% and 125%, led to higher values of SPAD index, which may have occurred due to the reduced development of leaf mass, which caused N to become more concentrated in the leaves.

The effect of a higher water availability of 125% was more pronounced in the SPAD index when compared to a lower water availability of 25%, this may have occurred because conditions with excess water, such as in the 125% treatment, are detrimental to the uptake of N by plant roots and also under waterlogged conditions due to reductions in the net photosynthetic rate (Liu et al., 2014; Wu et al., 2014; Oluwole et al., 2020).

Height of plants of the Panicum Maximum grass

Plant height is a variable related to light interception, being one of the pasture variables that have greater consistency on forage production (Rayburn and Griggs, 2020). Statistically, there was a significant difference for plant height in the first and second cuts of the cultivar BRS Zuri as a function of the water availability levels used in *Neossolo Flúvico* (Entisol). The lowest values of plant height were observed under water availability of 25% (Figure 3). Water availability levels of 87.5%, 111.4% and 85.3% resulted in the highest heights, 47.4, 43.7 and 42.5 cm, respectively. These results show that plants of the cultivar BRS Zuri have greater sensitivity to water deficit, compared to the others, including soil flooding/waterlogging.

The growth rate of the plant begins to decrease when the water content falls below the water saturation point of the tissue, probably what occurred under water availability of 25%. Under drought conditions, the photosynthesis rate decreases, which is probably related to a decrease in RuBisCo activity (Kalaji and Loboda, 2010). Under water deficit conditions, plants reveal the mechanisms to combat dehydration. Initially, plants increase their contents of abscisic acid (ABA) and synthesize stress proteins that protect cell membranes and participate in osmotic regulation (Farooq et al., 2009; Kalaji and Loboda, 2010), and then, as a consequence of ABA concentration, shoot growth is inhibited (Staniak and Kocoń, 2015), with direct effect on plant height.

In accordance with this observation, Santos et al. (2012) subjected wheat (*Triticum aestivum* L.) cultivars to water deficit at the beginning of flowering, in a greenhouse, and reported that the reduction in plant height is due to the reduction of cell turgor and to other factors involved in physiological processes.

Leaf area of the Panicum Maximum grass

Leaf area is an important factor in pasture production, as it is directly related to photosynthesis and its productivity potential. There was a significant difference at 1% probability level for leaf area in the three cuts as a function of the water availability applied. The water availability levels that resulted in the largest leaf areas (5,104.0, 3,196.0 and 2,957.9 cm² pot^{-1}) were 76.6, 88.0 and 74.2% (Figure 4).

In the three cuts evaluated, *Panicum maximum* cv. BRS Zuri showed a reduction in leaf area under water availability levels of 25% and 125% (Figure 4), which may have occurred because the cultivar was affected by water stress (drought and flooding). Reduction of leaf area is an early response to water availability, determined by a lower rate of cell expansion (Durand et al., 1997). In this study, leaf area decreased remarkably with the lowest water availability (25%) and highest water availability (125%), as reported for other grasses (Borrajo et al., 2018; Viciedo et al., 2020).

In the second cut of the plants, under water availability of 125%, there was little reduction in leaf area compared to the availability levels of 75% and 100%, which may be associated with greater tolerance to prolonged periods of flooding, with plants becoming more tolerant to this type of stress.

Leaf area is associated with the area of assimilation, light interception and photosynthetic rate of the plants, and its alteration can modify some variables such as stem elongation rate and tillering rate, consequently changing some structural characteristics of the canopy such as plant height, number of leaves and size of tillers (Euclides et al., 2010), so this variable plays an important role in the biomass production of pastures (Silva et al., 2015; Mezzomo et al., 2020).

Shoot dry mass of the Panicum Maximum grass

Water availability influenced the shoot dry mass production of *Panicum maximum* cv. BRS Zuri. The highest values (35.7, 36.8 and 25.2 g pot^{-1}) were obtained under water availability levels of 80.4, 97.2 and 76.3% in the first, second and third cuts, respectively (Figure 5). Dry mass production is the result of complex interactions between different physiological processes. Most of these processes are negatively affected by drought or flooding stress (Saud et al., 2017; Silva et al., 2020; Viciedo et al., 2020).

In the three cuts of the plants, lower production of shoot dry mass (8.1, 11.3 and 6.6 g pot^{-1}) was observed under water availability of 25%. Similar results were reported by Pezzopane et al. (2015), who observed a reduction in the shoot dry mass of *Brachiaria brizantha* (Paiaguás grass) in circumstances of water deficit.

The flooding condition also reduced the shoot dry mass of the cultivar BRS Zuri. Silva et al. (2009) evaluated seven cultivars of *Panicum maximum* (including Massai, Mombasa and Tanzania) and observed that flooding significantly reduced total forage production.

Silva et al. (2014) explain that the production capacity of the shoots of a plant is a result of the action of its root system, as both interact. Root growth under physically limited conditions significantly reduces the total weights of the plants, suggesting that this growth is related to the functional capacity of the root system and also the balance between the root system and shoots will always be reestablished.

Root dry mass and volume of the Panicum Maximum grass

There was a significant effect of water availability on root dry mass and volume of *Panicum maximum* cv. BRS Zuri. Water availability of 88% was the one that promoted the highest root dry mass production, equal to 94.0 g pot^{-1} (Figure 6A). The highest root volume was 0.25 dm³ pot^{-1}, obtained under water availability of 79.0% (Figure 6B).

The higher values of root mass and volume result in greater exploration in the soil profile, which leads to greater utilization of nutrients and capacity to reach deeper water reserves (Silva et al., 2020). The growth of forage species is represented not only by the aerial part, but also by its root development, since the root is the path for the entry of water and nutrients (Silva et al., 2014; Silva et al., 2020).

When comparing the two extreme conditions to which the plants were subjected, it can be noted that in the flooded soil, the cultivar BRS Zuri produced the higher root dry mass and root volume compared to plants that received the lowest water availability. Thus, it can be inferred that the cultivar BRS Zuri has greater sensitivity to water deficit than to the flooding condition, and this result may be attributed to the formation of adventitious roots of *Panicum maximum*, as shown in Figure 7.

In plants that undergo relatively long periods of flooding, such as those under water availability of 125%, one of the most common morpho-anatomical forms in response to hypoxia and/or anoxia is the formation of aerenchyma (Colmer and Voesenek, 2009; Takahashi et al., 2014). These aerenchyma tissues are mainly of the lysigenous type: they are formed by dead cortical cells (Yamauchi et al., 2013). This is due to increased ethylene synthesis, which contributes to cell wall degradation and aerenchyma formation (Takahashi et al., 2014).

The root volumes of plants subjected to water availability levels of 50% and 125% were similar, showing that the plants were less sensitive to flooding, results that differ from those reported by Silva et al. (2009), who observed a reduction in the root accumulation of *Panicum maximum* cv. Tanzania under flooding conditions, and those observed by Silva et al. (2007), who reported an abrupt decrease in root biomass production by the cv. Tupi after the second week of flooding. These results demonstrate that *Panicum maximum* cv. BRS Zuri has higher tolerance to flooding than the *Brachiaria* and *Panicum maximum* cultivars studied by the cited authors.

Water consumption and water use efficiency

The maximum values of water consumption (12.3, 18.6 and 13.5 L pot^{-1}) for the first, second and third cuts were observed under water availability levels of 83.3, 108.5 and 81.7%, respectively (Figure 8A). The highest values of water use efficiency were 67.5, 86.5 and 67.7%, with production of 2.8, 2.2 and 2.0 g L^{-1} for the three cuts, respectively (Figure 8B). Efficiency in the use of water directly implies the sustainability of production systems (Koetz et al., 2017).

The water consumption of Zuri grass showed a behavior similar to those of leaf area and shoot dry mass. In a study with nitrogen and sulfur in the production and water use by *Brachiaria decumbens* Stapf in degradation, Bonfim-Silva; Monteiro; Silva (2007) also observed the same result for water consumption, explaining that this occurred because crop evapotranspiration was influenced by leaf area and higher dry mass production.

Water availability of 25% was the one that resulted in the lowest water consumption, with 4.1, 6.0 and 4.5 L pot^{-1}, in the first, second and third cuts, respectively.

Table 1. Chemical and granulometric characterization of Fluvic Neosol collected in the 0-0.2 m layer.

pH	P	K	S	Ca	Mg	Al	H+Al	CEC	O.M	BS	m
$CaCl_2$	------mg dm^{-3}-------			-----------cmol$_c$ dm^{-3}------------					g kg^{-1}	-----%-----	
5.3	20.4	47.0	2.0	4.3	0.8	0.0	2.7	7.9	21.0	65.9	0.0
Zn	Mn	Cu	Fe	B		Clay		Silt		Sand	
----------mg dm^{-3}----------------						---------------------g kg^{-1}----------------------					
10.5	68.0	0.8	93.0	0.13		145.0		150.0		705.0	

P=Phosphorus; K=Potassium; S=Sulfur; Ca=Calcium; Mg=Magnesium; Al=Aluminium; H=Hydrogen; CEC=Cation Exchange Capacity; O.M.=Organic Matter; BS=Base Saturation; m= aluminum saturation; Zn=Zinc; Mn=Manganese; Cu=Copper; Fe=Iron; B=Boron.

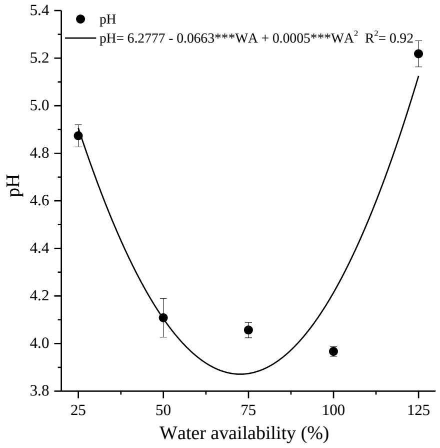

Fig 1. pH of Fluvic Neosol after the cultivation of *Panicum maximum* cv. BRS Zuri grass submitted to water availability. WA=Water Availability. *** Significant at 0.1% probability.

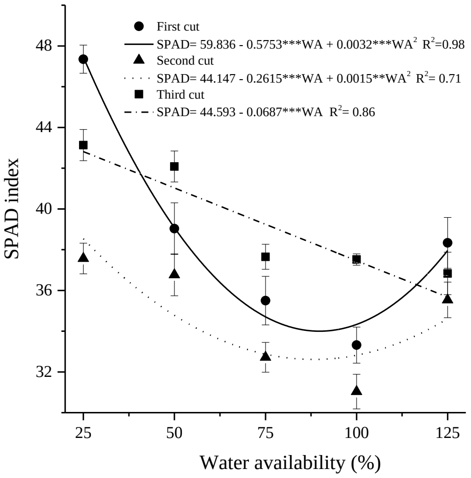

Fig 2. SPAD index of *Panicum maximum* cv. BRS Zuri grass submitted to water availability in Fluvic Neosol in the first, second and third cuts of the plants. WA= Water Availability. *** and ** Significant at 0.1 and 1% probability, respectively.

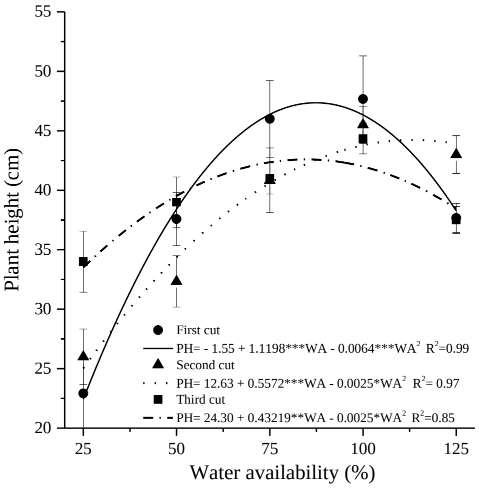

Fig 3. Plant height of *Panicum maximum* cv. BRS Zuri grass submitted to water availability in Fluvic Neosol in the first, second and third cuts of the plant. WA= Water Availability. PH= Plant Height. ***, ** and * Significant at 0.1, 1 and 5% probability, respectively.

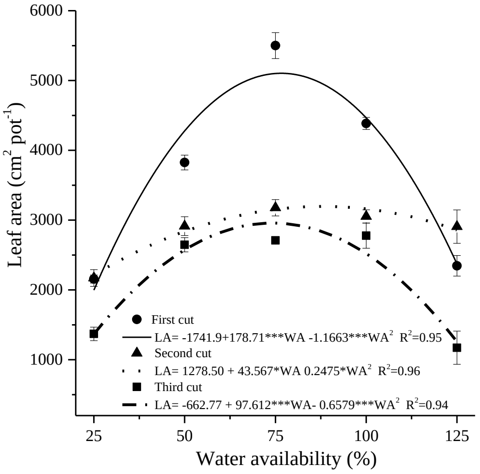

Fig 4. Leaf Area of *Panicum maximum* cv. BRS Zuri grass submitted to water availability in Fluvic Neosol in the first, second and third cuts of the plant. WA= Water Availability. LA= Leaf Area. ***, *, - Significant at 0.1, 5% probability, respectively.

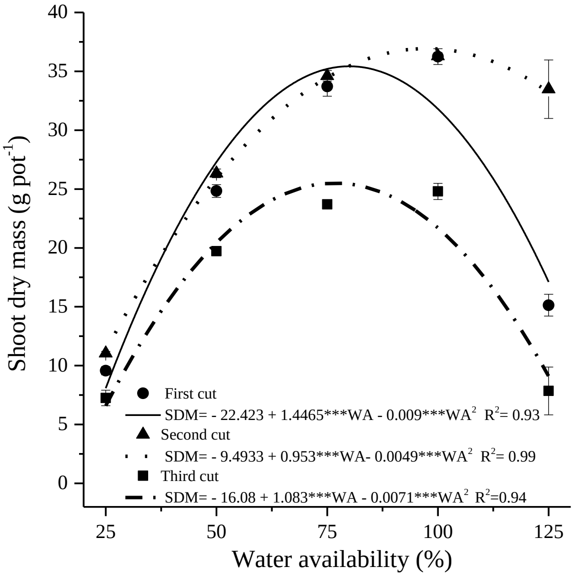

Fig 5. Shoot dry mass of *Panicum maximum* cv. BRS Zuri grass submitted to water availability in Fluvic Neosol in the first, second and third cuts of the plants. WA= Water Availability. SDM = Shoot dry mass. *** Significant at 0.1% probability.

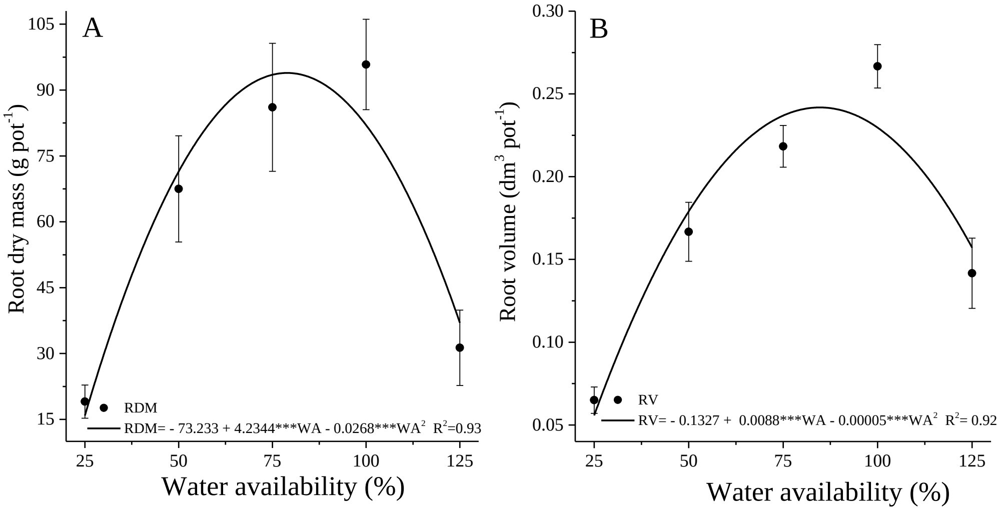

Fig 6. Root Dry Mass (A) and Root Volume (B) of *Panicum maximum* cv. BRS Zuri grass submitted to water availability in Fluvic Neosol. WA= Water Availability. DRM= Dry Root Mass. RV= Root Volume. *** Significant at 0.1% probability.

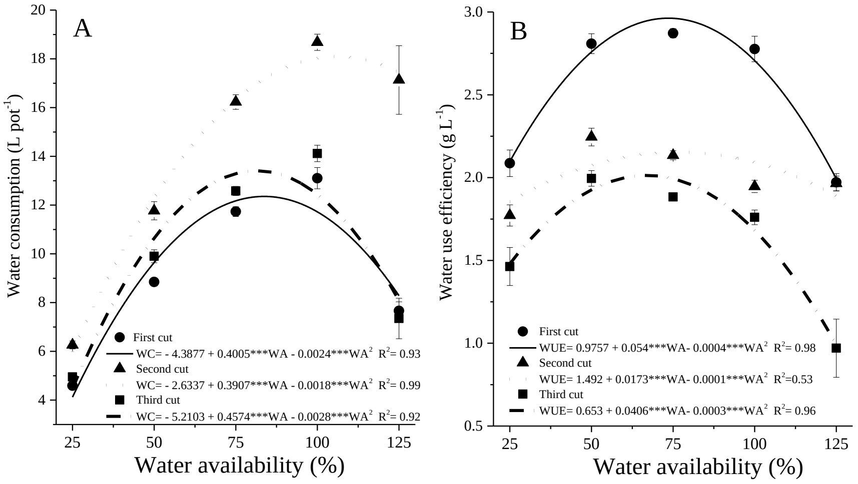

Fig 7. Water consumption (A) and water use efficiency (B) of *Panicum maximum* cv. BRS Zuri grass submitted to water availability in Fluvic Neosol in the first, second and third cuts of the plants. WA= Water Availability. WC= Water Consumption. WUE= Water Use Efficiency *** Significant at 0.1% probability.

These results are similar to those observed for leaf area, in which the lowest values were found at water availability of 25%.

Santos et al. (2013), working with *Brachiaria brizantha* cultivars (Marandu and BRS Piatã) under two conditions of water availability, observed that there was a reduction in leaf area as a mechanism used to minimize water consumption and balance its water relations under water stress conditions. Corroborating this observation, Barboza and Teixeira Filho (2017) explain that the rapid regulation of stomatal conductance allows plants to reduce water consumption, avoiding excessive loss in the dry period.

The water use efficiencies under water availability of 25% in the first and second cuts were higher than 125%. In a study on the physiological responses of forages to water deficit and low temperatures, Oliveira et al. (2017) explain that during the initial stages of water stress, the efficiency of water use can increase, because the stomata close by inhibiting perspiration. The productivity of plants limited by water, depends on the amount available for this resource and the efficiency of its use by the plant (Bonfim-Silva et al., 2012).

In the second cut, the water use efficiency was higher under water availability of 125% compared to the water deficit condition, which may be associated with reduced water absorption as physiological response of the plant caused by soil flooding (Silva et al., 2020).

Therefore, the knowledge on the water consumption of plants is essential for the production system to be properly managed, avoiding water and energy waste, when irrigation is used, and avoiding production losses in periods of low rainfall (Ali et al., 2007).

Materials and Methods

Soil characterization

The experiment was conducted in a greenhouse, with Fluvic Neosol (16°27'50.36" S and 54°34'49.34" W), classified according to the Brazilian Soil Classification System (EMBRAPA 2018) and equivalent to Entisols Fluvents in the Soil Taxonomy of the USDA (Soil Survey 2014). Soil samples for conducting the experiment were collected at depth of 0-0.2 m, air dried and passed through a 2-mm-mesh sieve. Chemical and particle-size characterization (Table 1) was performed according to Teixeira et al. (2017).

Design and implementation of the experiment

The experimental design adopted was completely randomized, with five water availability levels, corresponding to 25, 50, 75, 100 and 125 % of the maximum soil water holding capacity, with six replicates, totaling 30 experimental units. Each experimental unit was represented by one 5 dm³ pot with five plants of *Panicum maximum* cv. BRS Zuri.

The maximum soil water retention capacity was determined in the laboratory in pots of the same volume used in the experiment, in three replications. The pots were filled with air-dried soil, weighed and placed in plastic trays. Water was added up to two thirds of the height of the pots, so that it saturates the soil by capillarity. After soil saturation, the pots were removed from the tray and placed on a support to observe the drainage of not retained water. When drainage ceased, the pots were weighed again and the maximum water retention capacity of the soil was obtained by difference.

The maximum water holding capacity of the soil was determined using the methodology proposed by Bonfim-Silva et al. (2011). During the experiment, irrigation was performed manually by the gravimetric method, aiming to replace the water lost by evapotranspiration. The irrigation of all experimental plots was maintained at 60 % of the maximum soil water holding capacity until the plants reached the height of 5 cm. After this period, differentiation began with irrigation according to treatments, with 25, 50, 75, 100 and 125 % of the maximum soil water holding capacity. For the 125% treatment, a water depth of approximately 2 cm was maintained on the soil surface along the experiment.

Fertilization

Fertilization was performed at sowing with phosphorus, potassium and micronutrients, in the recommendations of

150, 100 and 50 mg dm^{-3}, applying 4.17, 0.86 and 0.25 g pot^{-1}, respectively. The nitrogen (N) recommendation was 200 mg dm^{-3}, which was split into two applications of 2.22 g pot^{-1} via solution, the first one after the seedling reached 10 cm in height and the other 7 days after the first application. This procedure was repeated at each cut, with the first portion applied on the day of the cut and the second portion 7 days after the first one. The sources of phosphorus, potassium, nitrogen and micronutrients were single superphosphate (P_2O_5), potassium chloride (K_2O), urea and FTE BR 12 (Sulfur: 3.9 %; Boron: 1.8 %; Copper: 0.85 %; Manganese: 2.0 % and Zinc: 9.0 %), respectively.

Variables analyzed

Data collection was performed in three evaluations, each accompanied by a cut, the same method described by Kroth et al. (2015). At 30 days of the treatment installation, the first cut of the plants was performed 5 cm from the soil surface, collecting only the aerial part and leaving a residual height of 5 cm for regrowth. In the second cut, performed 30 days after the first cut, the same procedure of the previous cut was used. In the third and last cut, carried out 30 days after the second cut, the plants were cut close to the soil, and the shoots, roots and a soil sample were collected for pH analysis of each experimental unit.

The variables analyzed were: soil pH ($CaCl_2$), SPAD index (Soil Plant Analysis Development), plant height (cm), leaf area (cm^2 pot^{-1}), shoot dry mass (g pot^{-1}), root dry mass (g pot^{-1}), root volume (dm³ pot^{-1}) water consumption (L pot^{-1}) and water use efficiency (g L^{-1}).

Soil pH analysis was carried out with a digital pH meter, using calcium chloride as a reagent. SPAD reading was performed before each cut, in five diagnostic leaves (+1 and +2) of each pot, with the portable chlorophyll meter SPAD 502-Plus. Bonfim-Silva et al. (2011) reported that this method is important because it is not destructive and is fast and simple, indicating the chlorophyll indices present in the leaves of plants. Plant height was measured with graduated ruler, from the soil surface to the curvature of the last expanded leaf. Leaf area was determined in the leaf area integrator LI-3100 Area Meter (LI-COR Bio-Science).

After the evaluations, the plant samples were dried in a forced ventilation oven at 65 °C for a period of 72 hours or until reaching constant weight. After drying, they were weighed to obtain shoot dry mass.

In the third cut, the roots were washed and the total volume of roots was determined with a graduated cylinder (1000 mL) containing a known volume of water (500 mL). The roots were placed inside the graduated cylinder, and the displaced volume of water was considered to be the volume of roots in cubic millimeters (mm^3). Then, the roots were weighed to obtain the fresh mass, placed in paper bags and dried in a forced ventilation oven at 65 °C for 72 hours or until reaching constant weight, thus obtaining the dry mass.

To determine water consumption and water use efficiency for each cut, every day a scale was used to weigh each pot and the replacement water depths were recorded. The sum of the applied depths was used to obtain water consumption in each cut, while water use efficiency was determined using the method described by Silva et al. (2020), according to the following formula:

$$WUE = \frac{SDM}{\sum WD}$$

Where:

WUE= Water use efficiency (g dm^{-3});

SDM= Shoot dry mass (g);

$\sum LA$= Sum of water depths (dm^3).

Statistical analysis

The collected data were subjected to analysis of variance by Fisher's test at 1% probability level using SISVAR 5.7 software (Ferreira 2019); when significant, the polynomial regression test was applied to verify the fit as a function of the water availability levels.

Conclusions

Water availability in the soil influenced the development of *Panicum maximum* cv. BRS Zuri, with higher results between 67 % and 111 % of the maximum soil water holding capacity.

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