

RESPONSE OF TROPICAL FORAGES TO IRRIGATION IN CERRADO/PANTANAL ECOTONE

RESPOSTA DE FORRAGENS TROPICAIS À IRRIGAÇÃO NO ECÓTONO CERRADO/PANTANAL

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ABSTRACT: This work aimed to evaluate the irrigation influence on the forage production of *Panicum maximum*, *Pennisetum purpureum*, *Urochloa brizantha* and *Urochloa ruziziensis* during the rainy and dry seasons in Cerrado-Pantanal ecotone. Trial was conducted at experimental area of irrigated agriculture of Universidade Estadual de Mato Grosso do Sul, Unit of Aquidauana. We assessed the interaction between irrigation *versus* tropical forage species in the rainy and dry seasons. The first factor is the irrigation or non-irrigation, while the second factor comprises the species. Experimental design used was randomized complete with four replications in factorial scheme 2x4. There were two forage collections during the dry the rainy" interval for standardization cutting and harvest at 45 days after. Traits evaluated dry matter of leaves (DML), dry matter of stems (DMS), total dry matter (DMT) and leaf/stem ratio (L/S) were assessed. Irrigation management influences the production of the assessed forage species only in dry seasons. *Urochloa brizantha* is the most recommended forage for the Cerrado-Pantanal ecotone region, due to its high forage production, especially when it comes to sheets. In dry seasons, *P. purpureum* has increased DMT under an irrigated system, but with lower L/S ratio.

KEYWORDS: *Pennisetum purpureum*. *Panicum maximum* Jacq. *Urochloa Brizantha*. *Urochloa ruziziensis*.

INTRODUCTION

According to IBGE (2012), Brazil has the second largest cattle herd in the world with approximately 212 million heads on a grassland area of 152 million hectares. The State of Mato Grosso do Sul has about 21.5 million heads, being therefore of great importance in the cattle production "ranking", with the municipalities of Corumbá and Ribas do Rio Pardo occupying the first and the third positions, respectively, in cattle production in the country.

In tropical regions, such as Cerrado, forage production is influenced by two distinct periods: the "rainy" periods, from October to March, and the "dry" periods, from June to September. In the rainy periods, high temperatures, long photoperiods and a higher concentration of rainfall favor forage production (TEIXERA et al., 2011). During dry seasons, with the lack of rainfall and other ideal conditions for development, forage suffers from the reduction in uniformity of production, hindering herd food planning and reducing the stocking rate in this period (BRÂNCIO et al., 2003). Water distribution through irrigation can ensure production and enhance forage quality, increasing profitability. Amongst the main forage produced in Brazil, the species *Pennisetum*

purpureum Shun, *Panicum maximum* Jacq and *Urochloa brizantha* (Hoscht ex A. Rich) stand out, both because of their high yield potential as well as their adaptability to Cerrado soil conditions (MOREIRA et al., 2007).

P. maximum cv. Mombaça has a cespitose annual growth cycle, with an average height of 1.65 m and leaves without cerosity, with little hair on the upper surface and slightly purplish stems. It produces around 33 Mg ha⁻¹year⁻¹ of leaf dry matter over 14 days of grazing and 60 days of rest during dry seasons and, 12 days of grazing and 37 of rest during rainy periods (BRÂNCIO et al., 2003). This forage should be well explored during rainy seasons, when growth is more intense and nutritional quality is also better (TORRES et al., 2016).

P. purpureum cv. Napier is a perennial forage with high productive potential, however, it requires suitable climatic conditions and fertile soil for its development. It has open clumps, vigorous tillering, thick stems, large leaves and crude protein contents from 10 to 15% that are obtained from the cutting intervals from 20 to 40 days. If well managed, it can support from 7.0 to 17 animal units ha⁻¹ (LIMA et al., 2010).

U. brizantha cv. Xaraés has a cespitose growth, about 1.5 m in height lanceolate and long sheets with little hair and dark-green color. It is

recommended for areas with rainfall of above 800 mm per year and average fertility soils, reaching a production of up to 21 t ha⁻¹ of dry matter. It has fast regrowth, with leaf growth rates in rainy and dry periods of 28.2 and 9.8 kg ha⁻¹ day⁻¹, respectively (EMBRAPA, 2004).

U. ruziziensis is a perennial undergrowth forage, with a short rhizome and tender leaves, having 6 to 15 mm wide and 10 to 25 cm in length and presence of hair. It is suitable for medium to high fertility soils, with annual rainfall of above 800 mm, and it is quite palatable and well accepted by the animals. It has 8-11% crude protein in the dry matter and production from 10 to 14 t ha⁻¹ of dry matter per year, but it has low regrowth, so appropriate management must be performed (PEDREIRA et al., 2007).

This work aimed to evaluate the irrigation influence on the forage production of *Panicum maximum*, *Pennisetum purpureum*, *Urochloa brizantha* and *Urochloa ruziziensis* during the rainy and dry seasons in Cerrado-Pantanal ecotone.

MATERIAL AND METHODS

Trial was conducted at experimental area of irrigated agriculture of Universidade Estadual de

Mato Grosso do Sul, Unit of Aquidauana (20° 20' S, 55° 48' W and average altitude of 191 meters). Region climate according to the Köppen classification is Aw, defined as sub-humid warm tropical, with the rainy season in the summer and dry in winter and average annual rainfall of 1,200 mm. The soil of the area was classified as Ultisol dystrophic sandy texture.

We assessed the interaction between irrigation *versus* tropical forage species in the rainy and dry seasons. The first factor is the irrigation or non-irrigation, while the second factor comprises the species *P. maximum* cv. Mombaça, *U. brizantha* cv. Xaraés, *U. ruziziensis* and *P. purpureum* cv. Napier. Randomized complete design with four replications was used. The forages *P. maximum*, *U. brizantha* and *U. ruziziensis* were sown in May 5, 2012, the full emergence occurring seven days after sowing, and spending 25 kg ha⁻¹ of seeds, while *P. purpureum* cv. Napier was vegetatively propagated using 10 t ha⁻¹ of seedlings spaced 0.7 m between rows. Table 1 shows the chemical soil analysis of the area. Topdressing was performed 30 days after germination, applying 100 kg ha⁻¹ of nitrogen fertilizer having urea as source.

Table 1. Chemical soil analysis of the área with irrigated and non-irrigated forages in the municipality of Aquidauana, MS.

pH H ₂ O	P mg dm ⁻³	OM g dm ⁻³	K	Ca	Mg	Al	H	SB	T	V %
Irrigated area										
5.44	45.84	20.27	0.19	3.55	0.9	0.15	3.51	4.64	8.3	55.9
Non-irrigated area										
5.15	41.3	19.74	0.2	1.6	0.5	0.0	2.8	2.3	5.1	45.1

P: Mehlich⁻¹.

In weed control, the application of active ingredient 2,4-D, at 1 L ha⁻¹ of the commercial product, at 60 days after emergence (DAE), in addition to periodic hand weeding. During this period, there was the occurrence of *Mocis latipes*, which was controlled by applying the active ingredient deltamethrin, at 0.06 L ha⁻¹ of the commercial product.

We used the sprinkler irrigation, by center pivot, with 87.2% Christiansen's Uniformity Coefficient (CUC) and 78.0% Distribution Uniformity Coefficient (DUC). Irrigated plot consisted of 0.8 ha, where each forage occupied an area of 0.2 ha in "pizza" format with dimensions of 70 m (towards the pivot ray) and 55 m wide at the

end. The non-irrigated forages occupied area of 1170 m², each with 293 m²

Irrigation management started at the date of cultivars emergence using the daily estimate reference evapotranspiration (ET_o) based on Penman-Monteith method (Equation 1). It was considered as water depletion factor 50% the soil water holding capacity. The values related to the effective root zone (Z) and the crop coefficient (K_c) were 40 cm and 1.05, respectively (ALLEN et al., 1998).

$$ET_{o(PM)} = \frac{0,408 \Delta (R_n - G) + \gamma \left(\frac{900 U_2}{T + 273} \right) (e_s - e_a)}{\Delta + \gamma(1 + 0,34 U_2)}$$

Where in:

$ET_{O(PM)}$ is the reference evapotranspiration by Penman-Monteith method, $mm\ day^{-1}$; Δ is the declination of the water vapor saturation curve, $kPa\ ^\circ C^{-1}$; R_n is the net radiation, $MJ\ m^{-2}\ day^{-1}$; G is the heat flow in the soil, $MJ\ m^{-2}\ day^{-1}$; γ is the psychrometric constant (0.0659823); U_2 is the average wind speed 2 m above the soil surface, $m\ s^{-1}$; T is the average air temperature, $^\circ C$; e_s is the vapor saturation pressure, kPa ; e_a is the vapor current pressure, kPa

For carrying out the forage collection, mechanical mowing were made to 25 cm for standardization of forage. After 45 days, there was the collection of samples, which were composed by the shoot and demarcated by a square of 0.5 m side, released at random on the plots by collection of five samples per plot. The first mowing was held on 15 July 2013 and collecting in the dry season on August 31, 2013; the second mowing was conducted on January 7, 2014 and collecting during the rainy season on February 21, 2014. The corresponding climatological data between the range of each mowing and cuts are shown in Table 2.

Table 2. Equivalent climatological balance between mowing and cutting of forage during the rainy and dry seasons.

Season	Irrigation	Average temperature ($^\circ C$)	Relative Humidity (%)	Rainfall (mm)	Applied irrigation depth (mm)
Dry	Irrigated	19.41	62,74	3.60	35.80
	Non-irrigated				-----
Rainy	Irrigated	26.31	79,22	233.80	0.00
	Non-irrigated				-----

After each collection, manual separation of stems, leaves and dead material was performed. For determining dry matter (DM), leaves and stems were taken to an oven with forced air circulation at $65\ ^\circ C$ for 72 hours. After this period, dry matter of leaves (DML), dry matter of stems (DMS), total dry matter (DMT) and leaf/stem ratio (L/S) were assessed.

Initially, the data normality was verified by Shapiro-Wilk test, being it subjected to analyzes of individual variances for each area, and then, assessment of mean squares of the residues was carried out (BANZATTO; KRONKA, 2006) for observing the normal distribution of data. We performed the joint analysis of variance of the areas, and the averages was compared by Tukey test at 5%

probability. All analyzes were performed with Sisvar 5.3 statistical software (FERREIRA, 2011).

RESULTS AND DISCUSSION

For all variables analyzed in this trial, the relationship between the mean square of joint analysis of variance of the experiments did not exceed the ratio 7:1, allowing following implementing the joint analysis of experiments and comparison of irrigation managements (BANZATTO; KRONKA, 2006). In the dry season, there was significance ($p < 0.01$) between the irrigation (I), species (S) and I x S for all variables (Table 3). This indicates that in this period there was differential response of each forage species depending on irrigation management.

Table 3. F values for the variables dry matter of leaves, stems and total (DML, DMS and DMT, respectively) and leaf/stem ratio (L/S) depending on irrigation use (I), tropical forage species (S) and I x S for dry season. Aquidauana, MS, 2014.

Sources of variation	DML	DMS	DMT	L/S
Irrigation (I)	29.82**	25.24**	47.17**	4.29**
Species (S)	4.70**	12.85**	13.30**	9.21**
I x S	10.13**	15.37**	21.24**	4.26**
CV (%)	25.18	31.81	21.41	24.00

** : significant at 1% probability by F-test.

On *P. maximun* e *U. ruziziensis* under irrigation, did not differ for the variable DML

(Table 4), indicating that the leaf production is not adversely affected by the dry season conditions in

the Cerrado/Pantanal ecotone region. Irrigation use in *P. purpureum* and *U. brizantha* provides an increase of 178 and 69%, respectively, in this variable, allowing to infer that these species are highly responsive the irrigation use in this region. With the irrigation use, *P. purpureum* had the highest DML production, while without irrigation there was no difference between tropical forage species.

Evaluating total biomass production, Garcia et al. (2011) found that the Mombaça leaves proportion was higher than that the elephant grass, in disagreement this with work. The authors also observed that this difference is conferred by cultivar tillering characteristic, citing Parsons (1988), asserting that axillary or side tillers of the Napier cultivar favors the stem elongation, contrary to cultivate Mombaça which is basal, resulting in larger sheets.

Table 4. Deployment of significant interaction between irrigation (I) and tropical forage species (S) for the variable dry mass of leaves (DML, kg ha⁻¹), assessed in the dry season. Aquidauana, MS, 2013.

Species	Irrigated	Non-irrigated	Mean	LSD
<i>Panicum maximum</i>	1,900 Ab	2,075 Aa	1,988	886
<i>Pennisetum purpureum</i>	3,618 Aa	1,302 Ba	2,460	
<i>Urochloa brizantha</i>	2,021 Ab	1,199 Ba	1,610	
<i>Urochloa ruziziensis</i>	2,462 Ab	1,853 Aa	2,158	
Mean	2,500	1,607	-----	-----
LSD	666		-----	-----

Means followed by equal uppercase in the line and lowercase letters in the column do not differ by Tukey's test at 5% probability. LSD: least significant difference.

Irrigation enhanced 380% in the production of DMS in *P. purpureum*, but in other species, irrigation management does not influence this variable (Table 5). In irrigated conditions, *P. purpureum* obtained the highest DMS production, however, under rainy season conditions,

P. maximum and *U. ruziziensis* obtained the highest average for this variable. *P. purpureum* obtained the highest DMT, DML and DMS was higher than the other cultivars, corroborating other results (GARCIA et al., 2011; RIBEIRO et al., 2009 e LOPES et al., 2005).

Table 5. Deployment of significant interaction between irrigation (I) and tropical forage species (S) for the variable dry mass of stems (DMS, kg ha⁻¹), assessed in the dry season. Aquidauana, MS, 2013.

Species	Irrigated	Non-irrigated	Mean	LSD
<i>Panicum maximum</i>	1,209 Ac	1,495 Aa	1,352	832
<i>Pennisetum purpureum</i>	3,157 Aa	658 Bb	1,908	
<i>Urochloa brizantha</i>	995 Ac	657 Ab	826	
<i>Urochloa ruziziensis</i>	2,286 Ab	1,752 Aa	2,019	
Mean	1,912	1,141	-----	-----
LSD	625		-----	-----

Means followed by equal uppercase in the line and lowercase letters in the column do not differ by Tukey's test at 5% probability. LSD: least significant difference.

Silva and Nascimento Junior (2008) concluded that tropical and subtropical forages begin the process of regrowth and forage production by tissue accumulation derived from leaves. Only when light restriction occurs (above 95% light interception sward) or when at the flowering the plant beginning the stem elongation, responsible for the shading and senescence of basal leaves, resulting in increased proportion of stems and dead material in the forage mass.

P. purpureum and *U. brizantha* in dry season for DMT (Table 6), unlike the rainy season, which indicates that this condition for the total dry

matter production is not affected. For *P. maximum*, there was no increase in production in relation to the irrigation use compared to without irrigation, allowing to infer that for the others was not different. Irrigation use for *P. purpureum*, *U. brizantha* and *U. ruziziensis* provided increases in total dry matter production. With the irrigation, *P. purpureum* showed higher DMT.

Irrigation did not affect the DMT production in *P. maximum*, however, in *P. purpureum*, *U. brizantha* and *U. ruziziensis* provided, respectively, an increase of 246, 62.5 and 32.7% on DMT production (Table 6), indicating responsiveness of

these forage species to irrigation in dry season. Under irrigation, *P. purpureum* had the highest DMT production, however, under non-irrigated conditions, *P. maximun* and *U. ruziziensis* produced

higher amount of forage, and it is particularly interesting because this is the period of lower forage allowance.

Table 6. Deployment of significant interaction between irrigation (I) and tropical forage species (S) for the variable total dry mass (DMT, kg ha⁻¹), assessed in the dry season. Aquidauana, MS, 2013.

Species	Irrigated	Non-irrigated	Mean	LSD
<i>Panicum maximun</i>	3,109 Ac	3,569 Aa	3,339	1,313
<i>Pennisetum purpureum</i>	6,774 Aa	1,959 Bb	4,367	
<i>Urochloa brizantha</i>	3,016 Ac	1,856 Bb	2,436	
<i>Urochloa ruziziensis</i>	4,748 Ab	3,606 Ba	4,177	
Mean	4,412	2,748	-----	-----
LSD	987		-----	-----

Means followed by equal uppercase in the line and lowercase letters in the column do not differ by Tukey's test at 5% probability. LSD: least significant difference.

Assessing the irrigation influence on *P. purpureum* cv. Napier and *P. maximun* cv. Mombaça, Ribeiro et al. (2009) verified that Mombaça and Napier presented greater DMT availability when submitted to irrigation. They also reported that the Napier DMT availability is related to the higher amount of stem produced by this forage, a fact that can be observed in this work for DMT obtained by Napier regarding the others.

Production capacity of the Xaraés cultivar was evident in this work. Its values are similar to the values of Mombaça cultivar, especially in adopting irrigation system. Studies comparing the productivity of Xaraés with other cultivars are scarce in the literature. In testing sites, it presented high forage production, reaching 21 t ha⁻¹ of dry matter, with 30% of this productivity in the dry season (VALLE et al., 2001). Xaraés can also be an alternative for use even in non-irrigated conditions,

because its adaptation to soils of medium fertility, low water requirement and the good results presented in this study classified it as a good alternative for agricultural regions with lower rainfall (SILVA JUNIOR et al., 2013). Pedreira et al. (2007), assessing Xaraés cultivar under rotational grazing strategies, found that the monthly daily rate of forage accumulation, for the months of October and November, was between 161.7 and 132.1 kg ha⁻¹ day⁻¹, values similar to the observed in this study.

L/S ratio quantifies the number of sheets in the DMT, and since in these organs are the most portion of the digestible crude protein, the analysis of this variable it is necessary for recommending forage species for cultivation. Irrigation influenced only *P. purpureum*, which in irrigated conditions has lower L/S ratio, indicating that the considerable increase in forage production of this species is mainly by the increase in DMT (Table 7).

Table 7. Deployment of significant interaction between irrigation (I) and tropical forage species (S) for leaf/stem ratio (L/S). Aquidauana, MS, 2015.

Species	Irrigated	Non-irrigated	Mean	LSD
<i>Panicum maximun</i>	1.56 Ab	1.41 Ab	1.49	0.54
<i>Pennisetum purpureum</i>	1.21 Bb	1.98 Aa	1.59	
<i>Urochloa brizantha</i>	2.10 Aa	1.83 Aa	1.97	
<i>Urochloa ruziziensis</i>	1.16 Ab	1.05 Ab	1.11	
Mean	1.51	1.56	-----	-----
LSD	0.48		-----	-----

Means followed by equal uppercase in the line and lowercase letters in the column do not differ by Tukey's test at 5% probability. LSD: least significant difference.

When assessing the performance of the species within each irrigation management, we verified that regardless the management adopted, *U. brizantha* obtained the higher L/S ration, but did not differ from *P. purpureum* under non-irrigated condition. In this way, high DMT production by *U.*

brizantha cv. Xaraés allows inferring that this species has a high adaptability to the Cerrado-Pantanal ecotone region, can be recommended to farmers both for irrigated and non-irrigated cultivation.

Pinto et al. (1994), reported that high L/S ratio is a very important attribute from a nutritional point of view, since it represents forage with higher protein content and digestibility. Pedreira et al. (2007) showed that the highest average rates of forage accumulation to Xaraés cultivar were observed in the months of September, October and December, due to post-grazing fertilizing and the

season of high temperature and rainfall availability, reinforcing the high productivity found in this trial, even in non-irrigated area. During the rainy season, irrigation did not influence any of the evaluated variables (Table 8). This occurred due to the rainfall during this period (233.80 mm), which caused no need for irrigation.

Table 8. F values for the variables dry matter of leaves, stems and total (DML, DMS and DMT, respectively) and leaf/stem ratio (L/S) depending on irrigation use (I), tropical forage species (S) and I x S for rainy season. Aquidauana, MS, 2015.

Sources of variation	DML	DMS	DMT	L/S
Irrigation (I)	1.70 ^{ns}	0.01 ^{ns}	1.36 ^{ns}	0.99 ^{ns}
Species (S)	2.41 ^{ns}	15.08**	5.78**	1.97 ^{ns}
I x S	1.40 ^{ns}	1.04 ^{ns}	1.57 ^{ns}	1.34 ^{ns}
CV (%)	18.11	14.72	17.76	15.01

^{ns} and **: not significant and significant at 1% probability by F-test, respectively.

For the rainy season, lack of different results (DML, DMS, DMT and L/S), under irrigated management, is due to two important factors to Forage Crops: temperature and rainfall, especially in the Cerrado region (MULLER et al., 2002). In the averages of these factors, we observed that the levels for the crops requirements were adequate, considering that the temperature and rainfall were

near or above 20°C and 200 mm, respectively, favoring a positive plant development during the assessed period.

There were significant differences between the species for the variables DMS and DMT (Table 9). *P. purpureum* obtained the higher DMS and DMT, but not differed statistically from *P. maximum* and *U. brizantha* for total forage production.

Table 9. Average values of the variables dry matter of stem and total dry matter (DMS and DMT, respectively) depending on the tropical forage species. Aquidauana, MS, 2015.

Species	DMS	DMT
	kg ha ⁻¹	
<i>Panicum maximum</i>	3,681 b	15,122 a
<i>Pennisetum purpureum</i>	11,744 a	16,558 a
<i>Urochloa brizantha</i>	3,844 b	9,984 a
<i>Urochloa ruziziensis</i>	2,313 b	4,830 b
LSD	4,233	10,162

Means followed by equal uppercase in the line and lowercase letters in the column do not differ by Tukey's test at 5% probability. LSD: least significant difference.

According to EMBRAPA (1999), *Panicum maximum* cv. Tanzânia shows good tolerance to drought and cold, and its water requirement varies between 800 and 1500 mm per year. According to Souza Filho (1994), water requirement by *Brachiaria brizantha* (*Urochloa*) cv. Marandu ranges between 800 and 1200 mm per year and shows high resistance to dry. These cultivars belonging to genera very close to those used in this trial, fact that may to explain the absence of statistical difference between the irrigated and non-irrigated systems. Therefore, rainfall was enough to supply the crop water requirement.

CONCLUSIONS

Irrigation management influences the production of the assessed forage species only in dry seasons.

Urochloa brizantha is the most recommended forage for the Cerrado-Pantanal ecotone region, due to its high forage production, especially when it comes to sheets.

In dry seasons, *P. purpureum* has increased DMT under an irrigated system, but with lower L/S ratio.

RESUMO: O objetivo desta pesquisa foi avaliar a influência da irrigação sobre a produção de forragem das espécies *Panicum maximum* cv. Mombaça, *Pennisetum purpureum* cv. Napier, *Urochloa brizantha* cv. Xaraés e *Urochloa ruziziensis*, nas épocas das “águas” e seca na região do ecótono Cerrado-Pantanal. A pesquisa foi desenvolvida na área experimental de agricultura irrigada e fitotecnia da Universidade Estadual de Mato Grosso do Sul, Unidade Universitária de Aquidauana. Foi avaliada a interação entre irrigação *versus* espécies forrageiras tropicais nas épocas das águas e da seca. O primeiro fator consistiu na utilização ou não da irrigação, enquanto o segundo fator foi composto pelas espécies. Foi utilizado delineamento inteiramente casualizados com quatro repetições no esquema fatorial 2x4. Foram realizadas duas coletas de forragem nas épocas seca e das “águas” com intervalo para roçada de uniformização e a colheita 45 dias após, avaliando os caracteres massa seca das folhas (MSF), massa seca dos colmos (MSC), massa seca total (MST) e a relação folha/colmo (F/C). A irrigação influencia a produção de forragem das espécies avaliadas somente na época da seca. A espécie *Urochloa brizantha* é a mais recomendada para a região do ecótono Cerrado-Pantanal devido a sua alta produção de forragem, sobretudo de folhas. Na seca, *Pennisetum purpureum* apresenta maior MST quando irrigado, porém com menor relação F/C.

PALAVRAS-CHAVE: *Pennisetum purpureum*. *Panicum maximum* Jacq. *Urochloa Brizantha*. *Urochloa ruziziensis*.

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