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Chemical composition of *Panicum maximum* 'BRS Zuri' subjected to levels of salinity and irrigation depths[1]

Composição química do capim BRS Zuri submetido a níveis de salinidade e lâminas de irrigação

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ABSTRACT - The study of cultivars with moderate flood tolerance is essential to their use in pastures irrigated with saline water. The aim of this study was to evaluate the chemical composition of *Panicum maximum* 'BRS Zuri' under the effect of different irrigation depths and levels of salinity. A randomised block design of split plots was used with five replications per treatment. The treatments resulted from the combination of three levels of water salinity (S1 = 0.6, S2 = 1.8 and S3 = 3.0 dS m^{-1}) and four levels of irrigation (I1 = 60%, I2 = 80%, I3 = 100% and I4 = 120% of the evapotranspiration). The chemical composition of the grass, *Panicum maximum* 'BRS Zuri', cut at 28 days, was evaluated over two cycles. There was an interaction between the factors (salinity x irrigation depth x cycle) for the dry matter (DM) content. With the increase in irrigation depth, there was a linear reduction in the crude protein (CP) content in both cycles. The neutral detergent fibre (NDF) and cellulose (CEL) content increased linearly as a function of the irrigation depth, while the lignin (LIG) content decreased linearly with irrigation depth. It was concluded that high levels of salinity cause reductions in the dry matter content in response to increased water availability and extension of the cultivar cycles. The reduction in saline levels under low water availability results in a higher CP content. Salinity has a negative effect on the NDF, ADF, HEM, CEL and LIG content as the irrigation depth increases.

Key words: Saline water. Water stress. Dry matter. Pasture.

RESUMO - O estudo de cultivares de moderada tolerância ao alagamento é primordial para sua utilização na irrigação de pastagens com águas salinas. Objetivou-se avaliar a composição química do capim *Panicum maximum* cv. BRS Zuri sob o efeito de diferentes lâminas de água e níveis de salinidade. Utilizou-se delineamento em blocos casualizados com parcelas subdivididas com cinco repetições por tratamento. Os tratamentos foram resultantes da combinação de três níveis de salinidade na água (S1 = 0,6; S2 = 1,8; S3 = 3,0 dS m^{-1}) e quatro intensidades de irrigação (I1 = 60; I2 = 80; I3 = 100; I4 = 120% da evapotranspiração). Avaliou-sea composição química do capim *Panicum maximum* cv. BRS Zuri, cortado aos 28 dias, durante dois ciclos.Houve interação entre os fatores (salinidade x lâmina x ciclo) para os teores de matéria seca (MS). Com o aumento das lâminas de irrigação, houve redução linear nos teores de proteína bruta (PB) nos dois ciclos. O teor de fibra em detergente neutro (FDN) ecelulose (CEL) aumentaram linearmenteem função das lâminas de irrigação, já os teores de lignina (LIG) reduziram linearmente com as lâminas de irrigação. Concluiu-se que os níveis elevados de salinidade causam reduções nos teores de matéria seca, em resposta ao aumentona disponibilidade hídrica e no prolongamento dos ciclos da cultivar. A redução dos níveis salinos sob baixa disponibilidade hídrica proporciona maiores teores de PB. A salinidade afeta negativamente os teores de FDN, FDA, HEM, CEL e LIG com o aumento das lâminas de irrigação.

Palavras-chave: Água salina. Estresse hídrico.Matéria seca. Pastagem.

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INTRODUCTION

The use of pasture as the main source of feed for cattle bred in tropical regions around the world is due to the low cost of production, and is the most economical and practical way of feeding the herd, serving as the basis for cattle farming worldwide (ROJAS-DOWNING; HARRIGAN; NEJADHASHEMI, 2017). The Brazilian semi-arid region includes various microclimates, mainly due to the difference in precipitation that exists between the states. In semi-arid regions, pasture production is most often linked to irrigation systems or water sources that help to reduce losses in production due to drought. However, most of the water sources used for this purpose originate in rivers, dams, and even artesian wells, and have a moderate salt concentration. Compared to other crops, a forage grass cultivar that is tolerant to salinity has the adaptive capacity to withstand conditions unfavourable to plant development. As such, their high efficiency in absorbing water in saline environments stimulates their photosynthetic capacity to accumulate a larger amount of dry matter, an important characteristic of tolerant cultivars (SCHOSSLER *et al*., 2012).

Among forage grasses, the species, *Panicum maximum*, stands out for having productive cultivars of excellent quality, adapted to the different regions and continents of the planet. In February 2014, Embrapa Gado de Corte launched the BRS Zuri cultivar, selected for its productivity, vigour, carrying capacity and animal performance, as well as its moderate tolerance to flooding (SILVEIRA; WANDER, 2015). However, there is little information in the literature about this new cultivar, or data on its use in areas that have water sources with a particular salt concentration.

Within this context, the present work was carried out to evaluate the chemical composition of the forage grass, *Panicum maximum* ‘BRS Zuri’, under the effect of different levels of salinity and irrigation depths.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse, in the Agrometeorology Sector of the Department of Agricultural Engineering at the Federal University of Ceará/UFC, in Fortaleza, Ceará, from March to August 2015. The facility is located at 3°44’44.8” S and 38°34’56.1” W, at an altitude of 30 metres. According to the Köppen classification (1948), the climate is type Aw’ (tropical rainy).

The experimental design was of randomised blocks in an arrangement of split plots, with five replications per treatment. Three levels of water salinity (S1 = 0.6, S2 = 1.8 and S3 = 3.0 dSm^{-1}) and four irrigation depths (I1 = 60%, I2 = 80%, I3 = 100% and I4 = 120%, based on the evapotranspiration measured in the reference treatment, 0.5 dS m^{-1} x 100%), were evaluated, where the levels of salinity corresponded to the main plots and the irrigation depth to the subplots. The grass used was *Panicum maximum* ‘BRS Zuri’.

The soil was a Red-Yellow Argisol, classified as a sandy loam, taken from a homogeneous area at the Federal University of Ceará. A composite soil sample was collected at a depth of 0.20m for characterisation of its physical-chemical attributes (Table 1).

Polyethylene pots with a volume of 11 dm^3 and holes drilled in the base were used. Plates were placed under each pot to collect the irrigation water drained through the holes in the base. The pots were placed in the greenhouse at a height of 20 cm from the ground. Each pot was considered one experimental unit and was properly identified with its respective treatment. The distance between each pot was established at 20 cm in the subplots and 50 cm in the plots. The soil was passed through 4 mm sieve and dried, after which a 2-cm layer of gravel was placed on the bottom of each pot, which was then filled with 10 dm^3 of soil.

From the results of the soil analysis, fertilisation was carried out as recommended by the soil fertility commission of the state of Minas Gerais (ALVAREZ V.; RIBEIRO, 1999). The pH was corrected, together with

Table 1 - Physical and chemical characteristics of the soil collected at a depth of 0.20 m

P	K^+	Na^+	Ca^{2+}	Mg^{2+}	Al^{3+}	SB	CECt	PH	MO
--------mg dm^{-3}--------			-------------------$cmol_c$ dm^{-3}--------------------					H_2O	g kg^1
11.64	54.74	20.7	0.96	0.82	0.05	2.01	2.06	4.8	17.9
Coarse Sand		Fine Sand	Silt	Clay	EC		Overall Particle Density		
------------------------g kg^{-1}-----------------------------					dS m^{-1}		-------------g cm^{-3}-------------		
94	465	298	147	0.59	0.59		1.36		2.66

Phosphorus (P), potassium (K), sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), aluminium (Al^{3+}), sum of bases (SB), effective cation exchange capacity (CECt), hydrogen potential (pH), organic matter (OM) and electrical conductivity (EC). Source: Soil Laboratory/UFC the supply of macro- and micronutrients. Dolomitic limestone (380 mg dm^{-3}) was applied 30 days before planting. At planting, phosphate fertiliser was applied using 75 mg dm^{-3} simple superphosphate, potassium fertiliser using 230 mg dm^{-3} potassium chloride and nitrogen fertiliser using 400 mg dm^{-3} urea; the micronutrients were applied using 40 mg dm^{-3} FTE BR-12. The fertilisers were applied when setting up the plants and during the period of standardisation, the same amount being repeated in each cycle.

Inside the greenhouse, daily measurements were taken by means of a data logger (HOBO U12-012), with the data for temperature (T, ºC) and relative humidity (RH, %) recorded throughout each evaluation cycle. (Table 2).

Table 2 - Maximum, mean and minimum temperature and relative humidity

	Cycle	
	1	2
	Temperature (°C)	
Maximum	37.5	37.5
Minimum	24.2	24.2
Mean	29.0	29.2
	Relative humidity (%)	
Maximum	90.8	86.0
Minimum	41.9	40.1
Mean	72.0	67.3

Source: data logger, model HOBO U12-012

Approximately 50 seeds per pot were sown at a depth of 1.0 cm. Fifteen days after emergence, the plants were thinned, leaving five plants per pot. Before applying the treatments, the plants were irrigated with well-water (ECa = 1.0 dSm^{-1}), to maintain the soil at field capacity.

Forty-five days after planting, the plants were uniformly cut, and the treatments applied to the experimental units. The grass was evaluated every 28 days in each of the two cycles. The cuts were made with pruning shears at a height of 10 cm from the ground. It is worth noting that one experiment had already been carried out with the same plants using four levels of salinity (S_1 = 0.5, S_2 = 2.0, S3 = 4.0 and S_4 = 6.0 dS m^{-1}) at the same irrigation depths. However, after the first cut, plant mortality was seen when applying salinity level S_4 (6.0 dS m^{-1}). The irrigation depth was determined from the evapotranspiration (ET), by means of the difference in the weight of five pots irrigated with water at an ECa of 0.5 dS m^{-1} before and after each irrigation, and the difference between the weight of the volume of replacement water, considering 60%, 80%, 100% and 120% of the obtained value. On the first day of each cycle, immediately after cutting, the pots were irrigated by hand as per the treatments, using a graduated beaker. A two-day irrigation frequency was adopted; when the pots were drained, the water was collected in containers and the volume measured with a beaker.

The saline solutions for irrigation were prepared weekly in tanks with a capacity of 100 L using well-water, distilled water, sodium chloride (NaCl), calcium chloride dihydrate ($CaCl_2.2H_2O$) and magnesium chloride hexahydrate ($MgCl_2.6H_2O$) in the ratio 7:2:1. The salt concentration was calculated from the equation: [Cs ($mmol_cL^{-1}$) = EC x 10], where: Cs = salt concentration; ECa = pre-established electrical conductivity (RHOADES; KANDIAH; MASHALI, 2000).

The chemical composition of the forage was analysed at the Animal Nutrition Laboratory of the Department of Animal Science at the Federal University of Ceará. The forage was harvested on one specific day at the end of each cycle. A representative sample from each plot was placed in paper bags and identified, dried in a forced ventilation oven at temperatures of from 55 to 60ºC for 48 hours (within the usual drying period of from 24h to 72h). After drying, the samples were ground in a Willey-type mill using a 1 mm sieve, then placed in an oven at 105ºC for 24 hours for later chemical analysis.

The dry matter content (DM), crude protein (CP), ether extract (EE), mineral residue (MR), hemicellulose (HEM) and cellulose (CEL), were analysed as per the methodology described by Silva and Queiroz (2002). To determine the fibre content, neutral detergent fibre (NDF) and acid detergent fibre (ADF), the method proposed by Van Soest, Robertson and Lewis (1991) and reported by Silva and Queiroz (2002) was used. The Klason method (VAN SOEST, 1994) was used to determine the lignin content. The mathematical model adopted for the arrangement of subdivided plots in the randomised block design used in the present work was:

$$y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + \varepsilon_{ijkl}$$

where: $y_{ijkl\,=}$ observation of the i-th level of salinity, the j-th irrigation depth, and the k-th cycle in the l-th repetition; μ = overall mean value; $\alpha_{i\,=}$ effect due to the the i-th level of salinity; $\beta_{j\,=}$ effect due to the j-th irrigation depth; $\gamma_{k\,=}$ effect of the k-th cycle; $(\alpha\beta)_{j\,=}$ effect of the double interaction (salinity and irrigation); $(\alpha\gamma)_{i\,=}$ effect of the double interaction (salinity and cycle); $(\beta\gamma)_{j\,=}$ effect of the double interaction (irrigation and cycle); $(\alpha\beta\gamma)_{k\,=}$ effect of the triple interaction (salinity, irrigation and cycle);

ε_{ijkl} = mean error associated with the interaction (salinity, irrigation and cycle).

The data were submitted to analysis of variance, the mean-value comparison test, multiple regression models and descriptive analysis. The interaction between factors was tested at 5% probability by F-test. The quantitative factors were studied using multiple-regression models; the qualitative factors were compared by Tukey's test at 5% probability. The choice of models was based on the significance of the coefficients up to 10% probability and on the coefficient of determination. The Statistical and Genetic Analysis software (SAEG, 2007) was used as an aid in analysing the data.

RESULTS AND DISCUSSION

There was an interaction between the factors (salinity x irrigation depth x cycle) for dry matter content (DM). The second cycle was superior to the first for the irrigation depth of 60% ET at the salinity levels of 1.8 and 3.0 dS m^{-1}, and for the irrigation depths of 80% and 100% ET at the salinity level of 3.0 dS m^{-1} (Table 3).

For the irrigation depth of 60% ET during the first cycle, the greatest DM content was seen at the salinity level of 1.8 dS m^{-1} compared to the other levels. For the irrigation depth of 100% ET during the second cycle, the greatest DM content was seen at the salinity levels of 1.8 and 3.0 dS m^{-1} in relation to the level of 0.6 dS m^{-1}. The DM content increased linearly with the irrigation depth during the first cycle at all levels of salinity, with increases of 0.23, 0.57 and 0.64 g kg^{-1} DM for each 1% irrigation depth above 60% ET.

Consolmagno Neto, Monteiro and Dechen (2007), evaluating the productivity characteristics of Tanzania grass, found a greater DM content during cycle 2 in relation to cycle 1, similar to the results of this study. This occurred in response to the plants producing a higher amount of energy during the first evaluation cycle in order to promote root growth and establishment, whereas during the second cycle, the grasses directed their energy to shoot growth.

There was an interaction between the factors (salinity x irrigation depth x cycle) for crude protein (CP) content (Table 4).

At the irrigation depth of 60% ET, the CP content decreased with the increasing levels of salinity during the first cycle, while during the second cycle, the CP content was greater at the salinity levels of 1.8 and 3.0 dS m^{-1}. At the irrigation depth of 120% ET, the CP content decreased with the increase in salinity during the second cycle. As the irrigation depth increased, there was a linear reduction in CP content during both cycles and for each level of salinity, except during the first cycle at the salinity level of 3.0 dS m^{-1}, which showed a quadratic response, with a maximum value of 94.63 g kg^{-1} DM for the irrigation depth of 80.76% ET.

A reduction in CP content was also found by Vale and Azevedo (2013) when evaluating the productivity and quality of elephant grass and sorghum irrigated with desalinated water, showing that in both crops, there was a reduction in CP content as the salinity of the irrigation

Table 3 - Dry matter (DM) content in g kg^{-1} of *Panicum maximum* 'BRS Zuri' under different salinity levels and irrigation depths

Salinity (dS m^{-1})	Cycle	Irrigation depth (%ET)				Mean	Equation
		60	80	100	120		(Effect of irrigation depth)
Dry matter (DM, g kg^{-1})							
0.6	1	199.85^{Y}	199.21	209.64	211.94	205.16	DM = 184.151 + 0.233425*LAM;R^2 = 0.24
	2	200.07^{M}	204.40	207.27^{L}	248.90	215.16	DM = 325.162 - 3.45027^{Δ}LAM + $0.0233165^{\Delta}$$LAM^2$; R^2 = 0.50
	Mean	199.96	201.80	208.45	230.42	-	
1.8	1	214.20^{BX}	219.01	220.43	252.12	226.44	DM = 174.610 + 0.575886*LAM; R^2 = 0.19
	2	228.01^{AL}	222.82	229.96^{K}	231.23	228.01	DM =228.57 g kg^{-1}
	Mean	221.10	220.91	225.19	241.67	-	
3.0	1	188.30^{BY}	188.19^{B}	209.95^{B}	224.01	202.61	DM = 144.611 + 0.64445*** LAM; R^2 = 0.61
	2	245.29^{AK}	255.23^{A}	236.22^{AK}	233.46	242.55	DM = 267.090 - 0.272645*LAM; R^2 = 0.22
	Mean	216.79	221.71	223.08	228.73	-	

A and B: compare the mean values between cycles 1 and 2, within each irrigation depth, for each level of salinity; X, Y and Z: compare the mean values between levels of salinity at each irrigation depth in cycle 1; K, L and M: compare the mean values between levels of salinity at each irrigation depth in cycle 2; Mean values followed by the same letter in a column do not differ by Tukey's test (P<0.05). *** - significant at 0.1%; ** - significant at 1%; * - significant at 5% and $^{\Delta}$- significant at 10% by F-test

Table 4 - Crude protein (CP) content in g kg^{-1} of *Panicum maximum* ‘BRS Zuri’ under different salinity levels and irrigation depths

Salinity (dS m^{-1})	Cycle	Irrigation depth (%ET)				Mean	Equation
		60	80	100	120		(Effect of irrigation depth)
				Crude protein (CP, g kg$_{-1}$)			
0,6	1	154.31^{AX}	112.04^{X}	91.02^{X}	37.98^{B}	98.84	CP = 265.344 - 1.85010***LAM; R^2 = 0.96
	2	140.08^{BL}	118.64^{K}	90.83^{L}	69.90^{AK}	104.86	CP = 212.121 - 1.19176***LAM; R^2 = 0.97
	Mean	147.20	115.34	90.92	53.94	-	-
1.8	1	97.37^{BY}	83.41^{Y}	57.41^{BY}	38.16	69.09	CP = 160.717 - 1.0181***LAM; R^2 = 0.96
	2	151.17^{AK}	87.86^{L}	74.56^{AM}	35.82^{L}	87.35	CP = 249.062 - 1.79677***LAM; R^2 = 0.92
	Mean	124.27	85.63	65.99	36.99	-	-
3.0	1	72.62^{BZ}	109.88^{BX}	64.82^{BY}	39.25^{A}	71.64	CP = -161.520 + 6.3435 *** LAM - 0.039274***LAM^2; R^2 =0.76
	2	156.23^{AK}	118.48^{AK}	109.05^{AK}	20.84^{BM}	101.15	CP = 288.169 - 20.78***LAM; R^2 = 0.87
	Mean	114.42	114.18	86.94	30.04	-	-

A and B: compare the mean values between cycles 1 and 2, within each irrigation depth, for each level of salinity; X, Y and Z: compare the mean values between levels of salinity at each irrigation depth in cycle 1; K, L and M: compare the mean values between levels of salinity at each irrigation depth in cycle 2; Mean values followed by the same letter in a column do not differ by Tukey’s test ($P<0.05$). *** - significant at 0.1%; ** - significant at 1%; * - significant at 5% and $^{\Delta}$- significant at 10% by F-test

water increased, with a decrease in the nutritional value of the grass as the age increased. Rodrigues *et al*. (2010) also saw a reduction in CP content when evaluating the effect of different levels of irrigation and nitrogen fertiliser on the CP content of the forage grass *Panicum maximum* Jacq. ‘Tanzania’, so that an increase in the level of irrigation gave a linear decrease in the CP content of the forage, with similar results being seen in the present work. This is related to high growth rates under the irrigation conditions, resulting in dilution of the levels of nitrogen produced by the cultivar.

Silva *et al*. (2014) evaluated the use of saline water in maize and sorghum as an alternative for the irrigation and production of forage in the semi-arid region, and found that the CP content was not affected by the salinity of the irrigation water; however, they obtained a mean CP content of 146.2 g kg^{-1} for the maize and 138.2 g kg^{-1} for the sorghum, higher values than those found in this work. The authors noted that the plants were also grown in a Red-Yellow Argisol, in which the higher values are due to the greater facility this type of soil shows for leaching, resulting in a reduction of salts accumulated in the roots.

There was an interaction between the factors under analysis (salinity x irrigation depth x cycle) for the levels of ether extract (EE). A smaller EE content was seen during the second cycle compared to the first cycle for the salinity of 1.8 dS m^{-1} at irrigation depths of 80% and 120% ET, and for the salinity of 3.0 dS m-1 at the irrigation depth of 60% ET (Table 5).

For the irrigation depth of 60% ET during the first cycle, the EE content was greater at salinity levels of 0.6 and 3.0 dS m^{-1} compared to the level of 1.8 dS m^{-1}. The EE content reduced linearly with irrigation depth at the salinity level of 0.6 dS m^{-1} during both cycles, in the second cycle, at the salinity level of 1.8 dS m^{-1} and in the first cycle, at the salinity level of 3.0 dS m^{-1}, with a reduction of 0.16, 0.65, 0.09 and 0.15 g kg^{-1} DM respectively.

Authors such as Al-Soqeer and Al-Ghumaiz (2012), evaluating the productivity and quality of perennial forage grasses under different levels of irrigation and cutting period, found an increase in EE content as the irrigation interval increased, however, for the second cut, they found a reduction in EE value, a fact also seen in this study.

There was an interaction between the factors under analysis (salinity levels x irrigation depth x cycle) for the levels of neutral detergent fibre (NDF) (Table 6).

At a salinity level of 3.0 dS m^{-1}, there was a reduction in the NDF content for the irrigation depths of 60, 80 and 100% ET during the second cycle compared to the first. The NDF content increased linearly with irrigation depth during both cycles at the salinity levels of 0.6 and 1.8 dS m^{-1}, and during the second cycle at the salinity level of 3.0 dS m^{-1}, with an increase of 0.83, 0.64, 0.65, 0.73 and 2.14 g kg^{-1} DM respectively for each 1% irrigation depth above 60% ET.

According to Daur (2016), who evaluated the chemical composition of blue panicum grass (*Panicum antidotale* Retz.) at different growth stages and for changes in the level of humic acid under saline conditions, found that the NDF content of the grass was better when analysed before flowering, obtaining a content of from 540.0 to 588.1 g kg^{-1}, compared to the levels analysed

Table 5 - Levels of ether extract (EE) in g kg^{-1} of *Panicum maximum* 'BRS Zuri' under different salinity levels and irrigation depths

Salinity (dSm^{-1})	Cycle	Irrigation depth (%ET)				Mean	Equation
		60	80	100	120		(Effect of irrigation depth)
Ether extract (EE, g kg^{-1})							
0.6	1	29.98^{X}	26.10	21.82	20.90	24.70	EE = 38.8868 - 0.157647*** LAM; R^2 = 0.63
	2	25.24	22.32	20.64	23.18	22.85	EE = 52.3511 - 0.654327*LAM +0.0034690*LAM^2; R^2 = 0.29
	Mean	27.61	24.21	21.23	22.04	-	--
1.8	1	20.98^{Y}	22.68^{A}	21.42	24.57^{A}	22.41	EE = 22.41
	2	24.96	16.54^{B}	18.28	18.51^{B}	19.57	EE = 27.5006 - 0.0880965 *LAM; R^2 = 0.21
	Mean	22.97	19.61	19.85	21.54	-	--
3.0	1	28.10^{AX}	25.36	21.27	19.51	23.56	EE = 36.9922 - 0.149252*** LAM; R^2 = 0.68
	2	22.57^{B}	22.66	21.62	21.65	22.13	EE = 22.13
	Mean	25.33	24.01	21.44	20.58	-	--

A and B: compare the mean values between cycles 1 and 2, within each irrigation depth, for each level of salinity; X, Y and Z: compare the mean values between levels of salinity at each irrigation depth in cycle 1; K, L and M: compare the mean values between levels of salinity at each irrigation depth in cycle 2; Mean values followed by the same letter in a column do not differ by Tukey's test ($P<0.05$). *** - significant at 0.1%; ** - significant at 1%; * - significant at 5% and $^{\Delta}$- significant at 10% by F-test

Table 6 - Levels of neutral detergent fibre (NDF) in g kg^{-1} of *Panicum maximum* 'BRS Zuri' under different salinity levels and irrigation depths

Salinity (dSm^{-1})	Cycle	Irrigation depth (%ET)				Mean	Equation
		60	80	100	120		(Effect of irrigation depth)
Neutral detergente fibre (NDF, g kg^{-1})							
0.6	1	632.43	635.31	657.47	680.33	651.39	NDF= 576.76 + 0.829176**LAM; R^2 = 0.37
	2	585.02	603.52^{K}	619.98	622.22	607.68	NDF = 550.056 + 0.640317**LAM; R^2 = 0.39
	Média	608.72	619.41	638.57	651.27	-	--
1.8	1	644.14	634.26	644.55	684.00	651.74	NDF = 593.301 + 0.649274ΔLAM; R^2 = 0.16
	2	566.92	628.87^{K}	632.03	614.65	610.62	NDF = 544.772 + 0.731644ΔLAM; R^2 = 0.13
	Média	605.53	631.56	638.29	649.32	-	-
3.0	1	650.89^{A}	657.89^{A}	662.66^{A}	667.45	659.72	NDF = 659.72
	2	531.89^{B}	549.93^{BL}	604.31^{B}	656.70	585.71	NDF = 392.729 + 2.14420 ***LAM; R^2 = 0.75
	Média	591.39	603.91	633.48	662.07	-	--

A and B: compare the mean values between cycles 1 and 2, within each irrigation depth, for each level of salinity; X, Y and Z: compare the mean values between levels of salinity at each irrigation depth in cycle 1; K, L and M: compare the mean values between levels of salinity at each irrigation depth in cycle 2; Mean values followed by the same letter in a column do not differ by Tukey's test ($P<0.05$). *** - significant at 0.1%; ** - significant at 1%; * - significant at 5% and $^{\Delta}$- significant at 10% by F-test

after flowering, which reached levels of from 588.0 to 722.4 g kg^{-1} under saline conditions.

There was no interaction between the factors (salinity x irrigation depth x cycle) for acid detergent fibre (ADF) (Table 7).

However, there was interaction of cycle x salinity, with the greatest FDA content seen during the first cycle at the salinity level of 0.6 dS m^{-1} and the lowest FDA content at the salinity level of 3.0 dS m^{-1}. Mochel Filho *et al*. (2016) studied the productivity and chemical composition of *Panicum maximum* 'Mombasa' under irrigation and nitrogen fertilisation and found that the ADF content varies with the age and stress of the plant as a function of such parameters as soil moisture and precipitation.

A linear increase in ADF content was seen for irrigation depth, with an increase of 1,134 g kg^{-1} DM for each 1% irrigation depth above 60% ET.

There was an interaction between the factors under analysis (salinity levels x irrigation depth x cycle) for the

Table 7 - Levels of acid detergent fibre (FDA) in g kg^{-1} of *Panicum maximum* ‘BRS Zuri’ under different salinity levels and irrigation depths

Salinity (dSm^{-1})	Cycle	Irrigation depth (%ET)				Mean	Equation
		60	80	100	120		(Effect of irrigation depth)
				Acid detergente fibre (ADF, g kg^{-1})			
0.6	1	388.17^{AX}	425.22^{AX}	445.44^{AX}	444.71^{AX}	425.88	
	2	219.59^{B}	249.13^{B}	263.86^{B}	320.27^{B}	263.21	
	Mean	303.88	337.17	354.65	382.49	-	
1.8	1	316.82^{AX}	373.35^{AY}	$406.88A^{Y}$	351.22^{Y}	362.07	
	2	208.34^{B}	289.72^{B}	289.15^{B}	329.85	279.26	
	Mean	262.58	331.53	348.01	681.07	-	
3.0	1	231.03^{Y}	243.39Z	270.35Z	278.65^{Y}	255.85	
	2	235.82	260.64	281.65	291.40	267.38	
	Mean	233.42	252.01	276.00	285.02	-	
	Overall mean	266.63	306.90	326.22	449.53	-	ADF = 206.580+1.13737***LAM ; $R^2 = 0.68$

A and B: compare the mean values between cycles 1 and 2, within each irrigation depth, for each level of salinity; X, Y and Z: compare the mean values between levels of salinity at each irrigation depth in cycle 1; K, L and M: compare the mean values between levels of salinity at each irrigation depth in cycle 2; Mean values followed by the same letter in a column do not differ by Tukey’s test ($P<0.05$). *** - significant at 0.1%; ** - significant at 1%; * - significant at 5% and $^{\Delta}$- significant at 10% by F-test

levels of hemicellulose (HEM). During the first cycle it was found that the highest HEM content occurred in response to a salinity of 3.0 dS m^{-1} at the irrigation depth of 60% ET. Whereas, in the second cycle, an increase in HEM content was seen at all irrigation depths for a saline concentration of 0.6 dS m^{-1}, and at 80% and 100% ET, when submitted to a saline concentration of 1.8 dS m^{-1} (Table 8).

Authors, such as Makarana *et al*. (2017), evaluated growth, yield and grain quality in genotypes of millet (*Pennisetum glaucum* L.) affected by the salinity of the irrigation water in the northwest of India, and found that the hemicellulose content was affected by the different levels of salinity of the irrigation water, the content increasing with the increase in salinity, as was seen in the present study. However, the application

Table 8 - Levels of hemicellulose (HEM) in g kg^{-1} of *Panicum maximum* ‘BRS Zuri’ under different salinity levels and irrigation depths

Salinity (dSm^{-1})	Cycle	Irrigation depth (%ET)				Mean	Equation
		60	80	100	120		(Effect of irrigation depth)
				Hemicellulose (HEM, g kg^{-1})			
0.6	1	244.27^{BX}	210.09^{BY}	212.02^{BY}	235.62^{B}	225.50	HEM = 510.729 - 6.61955*LAM + 3.61084*LAM^2; $R^2 = 0.26$
	2	365.43^{AK}	354.39^{A}	356.12^{A}	301.95^{A}	344.47	HEM = 429.398 - 0.943621 **LAM;$R^2 = 0.48$
	Mean	304.85	282.24	568.14	268.78	-	-
1.8	1	327.32^{Y}	260.91^{BY}	237.67^{BY}	332.77	289.67	HEM = 1059.96 - 18.2050*LAM + 0.100948*LAM2; $R^2 = 0.22$
	2	358.58^{L}	339.16^{A}	342.88^{A}	284.80	331.36	HEM = 429.281 - 1.08806*LAM; $R^2 = 0.28$
	Mean	342.95	300.03	290.27	308.78	-	-
3.0	1	419.86^{AY}	414.50^{AX}	392.30^{AX}	388.80	403.87	HEM = 455.785 - 0.576858ΔLAM; $R^2 = 0.15$
	2	296.06^{BL}	289.29^{B}	322.66^{B}	365.31	318.33	HEM = 209.828 + 1.205 58*LAM; $R^2 = 0.28$
	Mean	357.96	351.89	357.48	377.05	-	-

A and B: compare the mean values between cycles 1 and 2, within each irrigation depth, for each level of salinity; X, Y and Z: compare the mean values between levels of salinity at each irrigation depth in cycle 1; K, L and M: compare the mean values between levels of salinity at each irrigation depth in cycle 2; Mean values followed by the same letter in a column do not differ by Tukey’s test ($P<0.05$). *** - significant at 0.1%; ** - significant at 1%; * - significant at 5% and $^{\Delta}$- significant at 10% by F-test of a salinity of 3.0 dS m^{-1} caused a reduction in HEM content during the second cycle compared to the first cycle, at irrigation depths of 60, 80 and 100% ET. It was found that the HEM content decreased linearly with irrigation depth during the second cycle at the salinity levels of 0.6 and 1.8 dS m^{-1}, with a reduction of 0.94 and 1.09 g kg^{-1} in DM.

There was an interaction between the factors (salinity x irrigation depth x cycle) for cellulose content (CEL). The first cycle was superior to the second cycle at all irrigation depths and levels of salinity (Table 9).

The CEL content was similar at the salinity levels of 0.6 and 1.8 dS m^{-1} for the irrigation depths of 60, 80 and 120% ET. On the other hand, a reduction in CEL content was seen at the salinity of 3.0 dS m^{-1}. A quadratic response to irrigation depth for the CEL content was seen during the first cycle at the salinity of 0.6 dS m^{-1}, with a maximum value of 411.76 g kg^{-1} DM at 85.29% ET. A linear increase in CEL content was seen as a function of irrigation depth at the salinity levels of 1.8 and 3.0 dS m^{-1} during the second cycle, and at the salinity level of 3.0 dS m^{-1} during the first cycle.

Campi *et al*. (2016) evaluated the energy in the biomass of Sorghum irrigated with recovered wastewater and found a Sorghum cellulose content of 325.0 g kg^{-1}. The results showed a higher cellulose content compared to those reported by Zhao *et al*. (2009), but lower than the initial levels seen in this study.

There was interaction between the factors (salinity x irrigation depth x cycle) for the lignin (LIG) content. The first cycle was superior to the second cycle for the irrigation depths of 60% and 120% ET and at the salinity level of 0.6 dS m^{-1}. At the salinity level of 1.8 dS m^{-1}, an increase was seen for the irrigation depth of 60% ET only (Table 10).

During the second cycle, an increase in LIG content was seen at the irrigation depth of 120% ET for the salinity of 1.8 dS m^{-1}, and at an irrigation depth of 60% and 80% ET for the salinity of 3.0 dS m^{-1}. During the first cycle, it was found that the LIG content increased linearly with the irrigation depth at the salinity of 0.6 dS m^{-1}. There was a quadratic response to irrigation depth during the second cycle at the salinity of 0.6 dS m^{-1}. At a salinity of 1.8 dS m^{-1}, the LIG content increased linearly with irrigation depth. On the other hand, with the increase in salinity to 3.0 dS m^{-1}, the LIG content decreased linearly with irrigation depth, showing a reduction of 0.61 and 2.93 g kg^{-1} DM in the LIG content during the first and second cycle respectively.

Mann*et al*. (2009) found a strong relationship between lignin levels in a rapid evaluation of lignin content and structure in Switchgrass (*Panicum virgatum* L.) grown under different environmental conditions. Plants grown in the field had greater levels of lignin in the stem and smaller levels in the leaf biomass, while plants cultivated in growth chambers had a lower lignin content in the stem and a higher content in the leaf biomass (560 and 440 g kg^{-1} respectively). The levels of lignin were greater those found in this study.

Table 9 - Cellulose (CEL) content in g kg^{-1} of *Panicum maximum* ‘BRS Zuri’ under different salinity levels and irrigation depths

Salinity (dSm^{-1})	Cycle	Irrigation depth (%ET)				Mean	Equation
		60	80	100	120		(Effect of irrigation depth)
Cellulose (CEL, g kg^{-1})							
0.6	1	374.00^{AX}	432.13^{AX}	379.72^{A}	361.49^{X}	386.83	CEL= 64.5753 + 8.14125**LAM - 0.0477271**LAM^2; R^2= 0.56
	2	162.51^{BL}	170.84^{BL}	219.60^{B}	333.28^{K}	221.56	CEL = - 30.9210 + 2.80531**LAM; R^2 = 0.38
	Mean	268.25	301.48	299.66	347.38	-	-
1.8	1	373.63^{AX}	405.64^{AX}	349.00^{A}	381.07^{AX}	377.34	CEL = 377.34
	2	197.52^{BK}	232.23^{BK}	261.21^{B}	119.68^{BL}	202.66	CEL = 294.698 - 1.02266ΔLAM; R^2 = 0.17
	Mean	285.57	318.93	305.10	250.37	-	-
3.0	1	162.68^{AY}	196.31^{AY}	237.53^{A}	256.83^{AY}	213.34	CEL = 67.6798 + 1.61842***LAM; R^2 = 0.85
	2	35.21^{BM}	48.21^{BM}	57.27^{B}	73.29^{BL}	53.50	CEL = - 1.98290 + 0.616438***LAM; R^2 = 0.82
	Mean	98.94	122.26	147.40	165.06	-	-

A and B: compare the mean values between cycles 1 and 2, within each irrigation depth, for each level of salinity; X, Y and Z: compare the mean values between levels of salinity at each irrigation depth in cycle 1; K, L and M: compare the mean values between levels of salinity at each irrigation depth in cycle 2; Mean values followed by the same letter in a column do not differ by Tukey’s test (P<0.05). *** - significant at 0.1%; ** - significant at 1%; * - significant at 5% and $^{\Delta}$- significant at 10% by F-test

Table 10 - Lignin (LIG) content in g kg^{-1} of *Panicum maximum* ‘BRS Zuri’ under different salinity levels and irrigation depths

Salinity (dSm^{-1})	Cycle	Irrigation depth (%ET)				Mean	Equation
		60	80	100	120		(Effect of irrigation depth)
				Lignin (LIG, g kg^{-1})			
0.6	1	89.67^{AY}	104.01^{X}	136.56	153.90^{AX}	121.03	$LIG = 19.6777 + 1.12618^{***}LAM$; $R^2 = 0.85$
	2	75.70^{BL}	124.99^{L}	116.32	79.74^{BL}	99.19	$LIG = -310.323 + 9.67943^{\Delta}LAM - 0.0536789^{\Delta}LAM^2$; $R^2 = 0.16$
	Mean	82.68	114.50	126.44	116.82	-	
1.8	1	108.63^{AX}	135.50^{X}	140.24	122.05^{BY}	126.60	$LIG = -107.684 + 5.29422^{**}LAM - 0.0281617^{**}LAM^2$; $R^2 = 0.41$
	2	43.59^{BM}	121.70^{L}	139.94	249.37^{AK}	138.65	$LIG = -147.349 + 3.17779^{***}LAM$; $R^2 = 0.91$
	Mean	76.11	128.60	140.09	185.71	-	
3.0	1	105.17^{BX}	82.29^{BY}	66.61^{B}	69.76^{Z}	80.96	$LIG = 135.809 - 0.609473^{***}LAM$; $R^2 = 0.68$
	2	299.48^{AK}	274.01^{AK}	213.61^{A}	54.44^{M}	192.89	$LIG = 456.365 - 2.92755^{**}LAM$; $R^2 = 0.42$
	Mean	202.32	178.15	140.11	62.10	-	-

A and B: compare the mean values between cycles 1 and 2, within each irrigation depth, for each level of salinity; X, Y and Z: compare the mean values between levels of salinity at each irrigation depth in cycle 1; K, L and M: compare the mean values between levels of salinity at each irrigation depth in cycle 2; Mean values followed by the same letter in a column do not differ by Tukey’s test ($P<0.05$). *** - significant at 0.1%; ** - significant at 1%; * - significant at 5% and $^{\Delta}$- significant at 10% by F-test

CONCLUSIONS

The chemical composition of *Panicum maximum* ‘BRS Zuri’ is affected by increases in salinity level and irrigation depth, with an increase in the dry matter and fibre content, and a reduction in the levels of crude protein, thereby not preventing its use in animal nutrition due to the changes caused by stress.

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