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Evaluation of Water Stress by Irrigation Suspension in Genotypes of Megathyrsus maximus (Jacq.) B.K.Simon & S.W.L.Jacobs

Avaliação de Estresse Hídrico por Supensão de Irrigação em Genótipos de Megathyrsus maximus (Jacq.) B.K.Simon & S.W.L.Jacobs

Suzy Mary Lima de Souza[a]; Liana Jank[b]; Rafael Arruda[c]; Augusto Cury Braff[d]; Valdemir Antônio Laura*[d]

[a]Serviço Social da Indústria. SC, Brasil.
[b]Embrapa Gado de Corte, Grupo de Produção Vegetal. MS, Brasil.
[c]Universidade Federal de Mato Grosso, Instituto de Ciências Naturais, Humanas e Sociais. MT, Brasil.
[d]Universidade Anhanguera Uniderp, Programa de Pós-Graduação em Agronegócio Sustentável. MS, Brasil
*E-mail: valdemir.laura@embrapa.br

Abstract

Water scarcity is the main abiotic factor responsible for the low productivity of plants, and climate change will have impacts on society and biodiversity, causing a decrease in agricultural production, an increase in the vectors of diseases and extinction of animals and plants. Therefore, we aim to evaluate seven genotypes and two cultivars of Megathyrsus maximus (Jacq.) B.K.Simon & S.W.L.Jacobs for drought tolerance through irrigation suspension to identify genotypes more tolerant to water stress. At the time of water supply suppression and on days multiple of three until the 18th day of evaluation, the chlorophyll content in leaves, the number of leaves, height of stems and the degree of leaf loss were estimated. Also, the rate of photosynthesis, transpiration, stomatal conductance and leaf temperature were obtained with an infrared gas analyzer. We also determined the dry biomass of the aerial part after the stress and after the plants' rehydration by irrigation. Data were submitted to Anova and Tukey's test (5%). Cultivar Massai and BRS Tamani and genotypes PM19, PM20 and PM21 were the most tolerant; only height and stomatal conductance were not significant in relation to stress duration and stress duration x genotype interaction.

Keywords: Panicum maximum. Drought. Stress tolerance.

Resumo

A escassez hídrica é o principal fator abiótico responsável pela baixa produtividade das plantas, e as mudanças climáticas terão impactos na sociedade e na biodiversidade, causando diminuição da produção agrícola, aumento dos vetores de doenças e a extinção de animais e plantas. Portanto, objetivamos avaliar sete genótipos e duas cultivares de Megathyrsus maximus (Jacq.) B.K.Simon & S.W.L.Jacobs quanto à tolerância à seca por meio da suspensão da irrigação para identificar genótipos mais tolerantes ao estresse hídrico. No momento da supressão da irrigação e em dias múltiplos de três até o 18º dia de avaliação, foi estimado o teor de clorofila nas folhas, o número de folhas, a altura dos colmos e o grau de perda foliar. Também foram obtidas a taxa de fotossíntese, a transpiração, a condutância estomática e a temperatura foliar com um analisador de gases infravermelho. Determinamos a biomassa seca da parte aérea após o estresse e após a reidratação das plantas por irrigação. Os dados foram submetidos aos testes Anova e Tukey (5%). A cultivar Massai e BRS Tamani assim como os genótipos PM19, PM20 e PM21 foram os mais tolerantes ao estresse hídrico; apenas a altura e a condutância estomática não foram significativas em relação à duração do estresse e à interação duração do estresse x genótipo.

Palavras-chave: *Panicum maximum. Seca. Tolerância ao estresse.*

1 Introduction

The Intergovernmental Panel on Climate Change (IPCC, 2014) showed that there may be an increase in global atmospheric CO_2 concentration of up to 720 µmol mol^{-1}, which may cause a temperature increase of up to 3 °C, with a direct effect on changes in the hydrological patterns (Grandis et al., 2010; Zandalinas et al., 2018). Water scarcity is the main abiotic factor responsible for low productivity and low plant growth and is the most common cause of severe food shortages in the world (Baldoni et al., 2015). This shortage can be even more severe due to climate change.

Climate change will have an impact on society and on biodiversity, causing a decline in agricultural production in Latin America, an increase in the vectors of various diseases and the extinction of animals and plants due to long periods of drought and changes in water regimes (Maroun, 2007; Freitas, 2018). With this, it is expected in the future, a more extreme climatic scenario with more frequent droughts, floods and heat waves. These changes in the climate will cause negative impacts on agricultural productivity and quality of life, since the combination of several stresses will be greater than initially predicted (Ryan, 1991; Zandalinas et al., 2018).

Plant stress is defined as "a significant deviation from the normal conditions for the life of the plant, which can lead to changes and responses at the organism level" (Seixas et al., 2015) and Lambers et al. (2008) define it as "a change in environmental factors that reduce the rate of physiological processes".

That is why plants can respond to stress in a variety of ways, ranging from seconds to days, which can result in decline in growth and development. This decline will lead to acclimatization, in which the plant will adjust to the environmental modifications to survive, thus demonstrating its tolerance to stress. It is different from adaptation because it is considered as an evolutionary scale because it causes genetic changes (Lambers et al., 2008). Larcher (2006) explains that this adjustment depends on the plants, and the most common are leaf blade decrease, stomatal opening control, increase in leaf solutes to prevent water loss to the environment and decrease in the number of leaves, amongst others.

Megathyrsus maximus (Jacq.) B.K.Simon & S.W.L.Jacobs is a Poaceae also known by its synonym Panicum maximum Jacq. (Filgueiras, 2015) and is one of the most recommended forage grasses for ranching systems in tropical and subtropical regions due to its high productivity, quality and palatability. In addition, it is a pioneer of deforested areas and in forest margins, and due to its high genetic adaptability, has more than 12 cultivars registered in the Ministry of Agriculture, Livestock and Supply in Brazil. In addition, Embrapa (Brazilian Agricultural Research Corporation) holds the germplasm bank with more than 426 accessions (Jank, 1995; Valentim, et al., 2001; Victor et al., 2015). The species is widely used in pasture areas in Brazil, and some studies on light tolerance and flooding had been already done (Silva et al., 2009; Victor et al., 2015), for example, in which cultivars of M. maximus tolerant to flooding (cv. Massai and cv. Mombaça) and to 50% decrease in light were identified, indicating a broad plasticity. Therefore, we aim to evaluate drought tolerance by suspending irrigation in nine genotypes of M. maximus (accessions from Africa, hybrids and commercial cultivars) in order to identify the most tolerant to water stress. The irrigation suspension method is indicated to determine tolerance to water stress because it simulates environmental conditions, but in a controlled environment, without the influence of climatic variations, guaranteeing a more precise evaluation (Blum, 2011; Blum, 2017). Our hypothesis is that the variables height, number of leaves, SPAD index of chlorophyll (chlorophyllometer), physiological data (photosynthesis, transpiration, stomatal conductance and leaf temperature) will be differentially affected by the period of suspension of irrigation, and that M. maximus genotypes more tolerant to water stress may be identified.

2 Material and Methods

The experiment was carried out in greenhouse at Embrapa Beef Cattle (20º27’04” S and 54º42’57” W), with daily maximum temperature control (33 ºC ± 2 ºC) and minimum relative humidity (35% ± 1%). The experimental design was a factorial scheme with nine genotypes x seven water stress duration levels from the time of suspension of the individual irrigation (zero, three, six, nine, 12, 15 and 18 days), with four replications and plots of three plants per pot, with irrigation and individual identification. The pots used were 15.0 cm high, with a capacity of 0.7 L, with 8.0 cm x 8.0 cm of upper opening and 6.5 cm x 6.5 cm at the base.

Seeds of each genotypes, from the Embrapa Genetic Improvement Program, were germinated in expanded polystyrene trays filled with sand and, ten days after emergence, seedlings standardized for size of aerial part and root system were selected and transplanted to the plastic pots, with soil in the field capacity, determined by the funnel method (Luchese et al., 2001). The soil obtained at Embrapa was air dried, previously sieved in a 2.0 mm diameter sieve and stowed in the pots. This soil was fertilized, and its acidity was corrected according to the soil analysis result. The daily irrigation time, for the establishment of seedlings, were five minutes, by dripping in each pot at 08:00 a.m.

Seedlings, after transplantation to pots, were fertilized weekly with 100 mL of nutrient solution Hoagland and Arnon (1950) until the beginning of the irrigation suspension (Mattos et al., 2005; Freitas, 2018; Martins et al., 2018). The soil in the pots was maintained at 90% field capacity up to 60 days from establishment, when water supply was suspended in the water stress treatments which were randomly assigned to the pots. Soil in the pots without water stress was maintained throughout the period at 90% of field capacity (Melo et al., 2007).

At the time of suppression of the water supply and at days multiple of three, i.e. at days zero (control), three, six, nine, 12, 15 and 18, the chlorophyll content in leaves was estimated with a chlorophyll meter (SPAD-502 - Soil Plant Analysis Development), and leaf numbers and stem heights were evaluated.

We also evaluated the rate of photosynthesis, transpiration, stomatal conductance and leaf temperature obtained with an Infra-Red Gas Analyzer (IRGA, LICOR - 6400) measured in the period from 09:30 am to 12:00 a.m., with photosynthetic light flux at 1,000 μmol of photons $m^{-2}s^{-1}$ and 400 μmol of carbon dioxide (CO_2) up to the 15 days of irrigation suspension (Freitas, 2018).

Above ground dry biomass was determined by cutting the plants close to the soil. The fresh material was packed in paper bags for drying in an air-forced drier for 72 hours at 65°C until reaching constant weight (Mattos et al., 2005; Pezzopane et al., 2014). To evaluate the regrowth, we reestablished irrigation, which Freitas (2018) called rehydration, of root part after removal of the above ground biomass. After the period of 23 days, we determined again the above ground dry biomass produced after the rehydration (regrowth biomass).

We constructed ANOVA models to identify significant mean differences for each variable chosen to represent water stress. These variables were all considered as answers in our models. ANOVA was chosen for modeling because the experimental design was relatively simplified in the control of the variables of interest, and mainly by the number of replications to guarantee degrees of freedom to control possible errors. All the response variables were standardized for mean zero and unit variance with the decostand function ("standardize" method) by the Vegan Package (Oksanen et al., 2017). For ANOVA we used the function "aov" of the R's Basic "Stats" Package (R Core Team, 2018). All analyzes and charts (ggplot function, package ggplot2) were done in the environment R (Wickham, 2009).

3 Results and Discussion

All seven genotypes and two cultivars evaluated showed visual severe stress symptoms and used several mechanisms to delay senescence and cell death. The results corroborate our hypothesis, being possible to verify that water stress influenced directly the physiological parameters evaluated (Table 1).

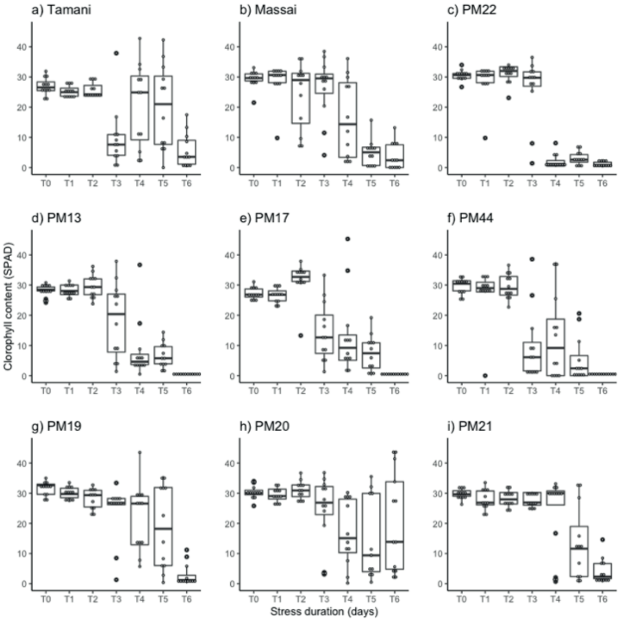
Table 1 - Probabilities of significance associated with physiological variables as a function of genotypes and stress duration

Variables	Source of Variation	dF	F	P	
Chlorophyll content (SPAD)	Genotype	8	10.53	$5.19e^{-14}$	***
	Stress Duration	6	171.67	$< 2e^{-16}$	***
	Genotype x Duration	48	4.67	$< 2e^{-16}$	***
	Residue	693			
Photosynthesis	Genotype	8	8.94	$4.09e^{-10}$	***
	Stress Duration	5	101.24	$< 2e^{-16}$	***
	Genotype x Duration	40	1.92	0.002	**
	Residue	162			
Transpiration	Genotype	8	11.04	$2.21e^{-12}$	***
	Stress Duration	5	88.80	$< 2e^{-16}$	***
	Genotype x Duration	40	2.11	< 0.001	***
	Residue	162			
Leaf Temperature	Genotype	8	30.16	$< 2e^{-16}$	***
	Stress Duration	5	1550.66	$< 2e^{-16}$	***
	Genotype x Duration	40	16.26	$< 2e^{-16}$	***
	Residue	162			
Stomatal conductance	Genotype	8	2.01	0.039	*
	Stress Duration	5	5.58	$9.11e^{-05}$	***
	Genotype x Duration	40	1.02	0.437	ns
	Residue	162			
Stem height	Genotype	8	101.46	$< 2e^{-16}$	***
	Stress Duration	6	0.40	0.88	ns
	Genotype x Duration	48	0.63	0.98	ns
	Residue	680			
Number of Leaves	Genotype	8	20.43	$< 2e^{-16}$	***
	Stress Duration	6	124.41	$< 2e^{-16}$	***
	Genotype x Duration	48	4.56	$< 2e^{-16}$	***
	Residue	680			
Dry Biomass after Stress	Genotype	8	25.76	$< 2e^{-16}$	***
	Stress Duration	6	9.55	$4.21e^{-10}$	***
	Genotype x Duration	48	1.75	0.002	**
	Residue	692			
Dry Biomass of regrowth	Genotype	8	28.57	$< 2e^{-16}$	***
	Stress Duration	6	9.80	$2.37e^{-10}$	***
	Genotype x Duration	48	12.77	$< 2e^{-16}$	***
	Residue	645			

Caption: P value: ***< 0.001 / **< 0.01 / *< 0.05 / ns- non-significant.
Df = Degrees of Freedom
Source: research data.

The chlorophyll content estimated by SPAD index (Table 1) was significant for all the evaluated genotypes; however, PM22, PM13 and PM44 obtained indices close to zero at 18 consecutive days of stress (Figure 1), while PM21 at 18 days was the genotype with the highest index; cv. Massai and BRS Tamani, PM19 and PM21 also presented the highest levels at 18 days, inferring that the photosynthetic apparatus was still active and that the 18-day period was not enough to reach the severe stress, i.e. the Permanent Wilting Point and the death of leaf cells (Figure 1).

Figure 1 - Estimate of chlorophyll content along the stress duration periods for each genotype



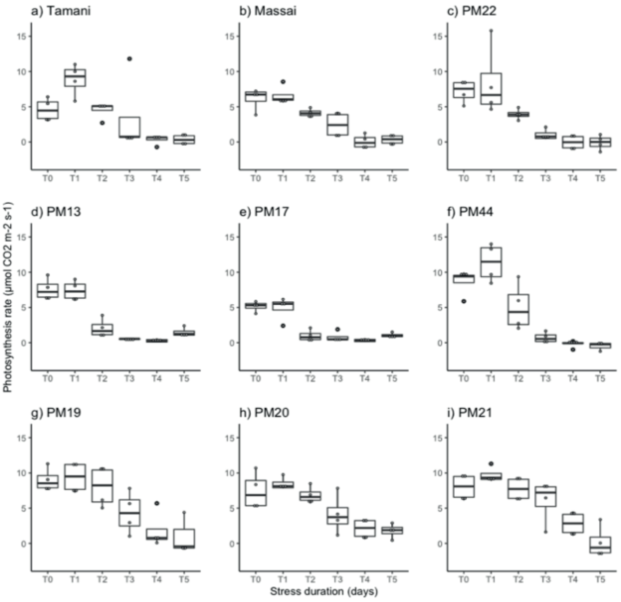
Source: research data.

The chlorophyll content in leaves is directly related to photosynthesis, because photosynthesis is the process by which autotrophic organisms fix CO_2 with the use of energy from sunlight, with O_2 being the residue released together with the synthesis of carbohydrates, source of energy for autotrophs (Larcher, 2006; Lambers, 2008). In plants, in general, 40% of their dry biomass consists of carbon fixed directly from photosynthesis, a process that allowed life on earth as we know it (Kramer and Boyer, 1995; Lambers, 2008). In drought-susceptible cotton genotypes (Gossypium hirsutum (L.), the net photosynthetic rate fell while the leaf temperature increased, and RUBISCO (ribulose-1,5-bisphosphate carboxylase oxygenase enzyme) showed lower activity compared to the drought-tolerant ones, tested under the same conditions (Zandalinas et al., 2018), further reducing the fixation of atmospheric CO_2.

In Lippia alba the estimated chlorophyll content obtained by the chlorophyllometer (SPAD Index) at 15 days of stress did not differ from the control (Freitas, 2018). However the same did not occur in our data because the chlorophyll contents in our experiment were significant for both genotypes and stress duration. Genotype PM20 presented the highest index, followed by cv. Massai, BRS Tamani, PM19 and PM21 at 18 consecutive days of irrigation suspension (Figure 1). on the other hand Freitas (2018) evaluating L. alba at zero, five, ten and 15 days of suspension of water supply, noticed that the duration that most affected them was 15 days, while for us, it was 18 days; however, the highest leaf temperature was recorded at nine days while in L. alba, this record occurred at 15 days.

There were differences among genotypes, duration of stress and their interaction for the rate of photosynthesis, transpiration and leaf temperature (Table 1), however for stomatal conductance there were only differences among genotypes and duration. The photosynthesis rate at nine days of stress approached zero for most genotypes (Figure 2), except for PM19, PM20 and PM21.

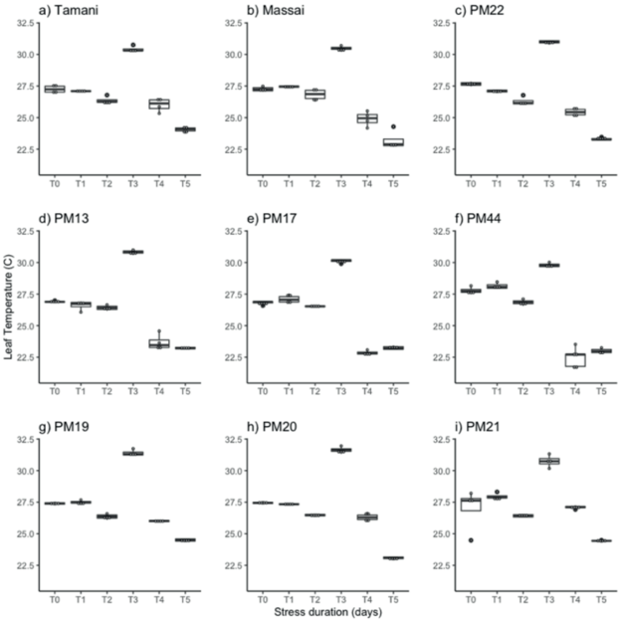
Figure 2 - Photosynthesis rate (µmol CO_2 m^{-2} s^{-1}) along the stress duration periods for each genotype



Source: research data.

Leaf temperature is indicated as being a good indicator of water stress since it tends to increase when the plant detects stress. It can be seen that at nine days of consecutive irrigation suspension the genotypes showed a response to stress with the increase in temperature (Figure 3), higher than the maximum mean of the environment (28 °C) in the period of the treatments development (obtained from IRGA-6400 and Climatempo, 2019) and from there on they sought other ways to overcome water scarcity, saving it, as well as nutrients and energy, reducing their metabolic activities and protecting the photosynthetic apparatus, considered the framework of stress adjustment.

Figure 3 - Leaf temperature (°C) along the stress duration periods for each genotype



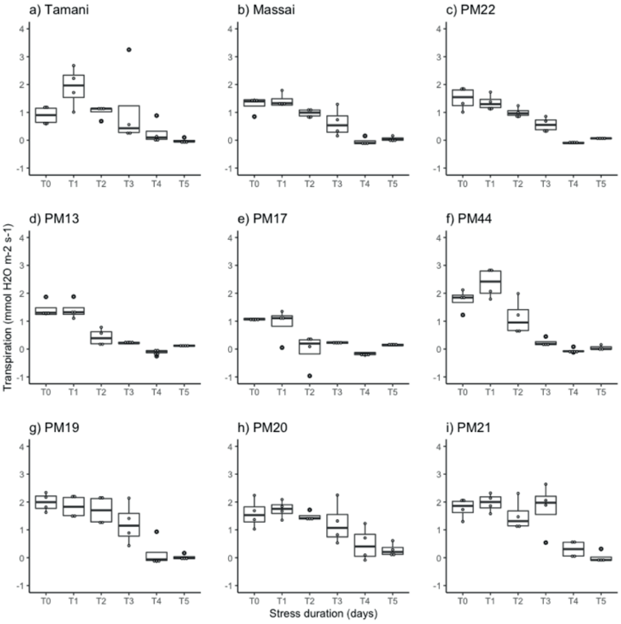
Source: research data.

With the decrease in the chlorophyll content (Figure 1), the pigment responsible for the sunlight capture, the rate of photosynthesis also declines and thus the rate of transpiration (Larcher, 2006; Lambers et al., 2008) as were sawn to water stress in L. alba also caused a reduction in the rate of photosynthesis, transpiration and stomatal conductance, causing an almost five-fold decrease in the period of 15 days in relation to the control (Freitas, 2018). However, Araújo et al. (2010) evaluating three genotypes of dwarf elephantgrass observed a decrease in stomatal conductance and transpiration due to water unavailability, however the photosynthetic rate was higher compared to the nine genotypes of M. maximus evaluated in this work, which may be explained by the control of temperature and humidity as well as by the decrease in solar radiation that enters the greenhouse.

As observed in Figure 3, comparing the genotypes in the different stress durations, PM19, PM20, PM21, BRS Tamani and cv. Massai were those that presented higher leaf temperature at 15 days of stress duration, as well as chlorophyll content, indicating the presence of metabolic activities, while PM22, PM13, PM17 and PM44 values were close to zero, that is, at a critical point of stress, indicating to be sensitive to water deficit.

In Figure 4 we can see the transpiration data in the period of evaluation and ratifies the responses obtained for the rate of photosynthesis, leaf temperature and chlorophyll content, and demonstrates the effect of the suspension of irrigation on the plants, with the decrease in transpiration throughout the time. It is possible to emphasize that at nine days of irrigation suspension it is possible to identify genotypes that are more sensitive to water deficit, i.e., PM13, PM17 and PM44, which already presented transpiration rates close to zero.

Figure 4 - Transpiration (mmol H_2O m^{-2} s^{-1}) along the stress duration periods for each genotype



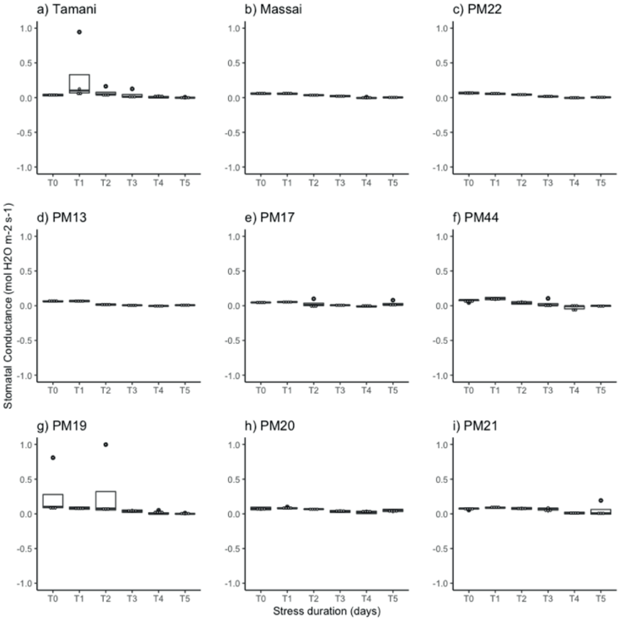
Source: research data.

The transpiration rate (Figure 4) is directly related to the plants' water balance, whose concept was proposed by Montfort (1922) and Maximov (1929), defined as the relation between the amount of water absorbed by the roots and the water rate lost in transpiration. This is then related to the whole plant's homeostatic balance and its deficit may directly or indirectly affect its growth and development and may even cause death (Larcher, 2006; Araújo et al., 2010). The reduction in transpiration occurs as a strategy to save water, stomatal closure being the main one, however, there is a metabolic cost, as it reduces transpiration, decreasing the cooling capacity of the leaf and increasing the leaf temperature, as well as reducing the photosynthetic rates and, therefore, the production of nutrients and energy (Larcher, 2003; Kramer and Boyer, 1995). Ahmed et al. (2013) in a study with barley (Hordeum vulgare L.) under water stress reported decreases in growth, chlorophyll content and photosynthetic rate, which are metabolically interrelated.

In our experiment the stomatal conductance of M. maximus was affected by water stress differently from what was reported by Freitas (2018) for L. alba. In M. maximus, there was a significant variation of the stomatal conductance among the genotypes, but not between the treatments, whereas for L. alba, at 15 consecutive days of stress there was a drastic fall in comparison to the control. Winter (1976) argues that the main response of plants to drought (water stress) is the change in stomatal opening aiming to control the CO_2 flow, leaf temperature and water loss through evaporation to the environment. However, this did not occur in genotypes of M. maximus, whose change in stomatal conductance although significant among genotypes did not vary throughout the stress period.

Figure 5 presents the comparison between the stomatal conductances recorded by each genotype during the stress evaluation period, in which the interaction between these two factors was not significant (Table 1). Again, the results by genotype and in relation to stress duration were significant, the same being found for chlorophyll content, photosynthesis and transpiration.

Figure 5 - Stomatal conductance (mol H_2O m^{-2} s^{-1}) along the stress duration periods for each genotype



Source: research data.

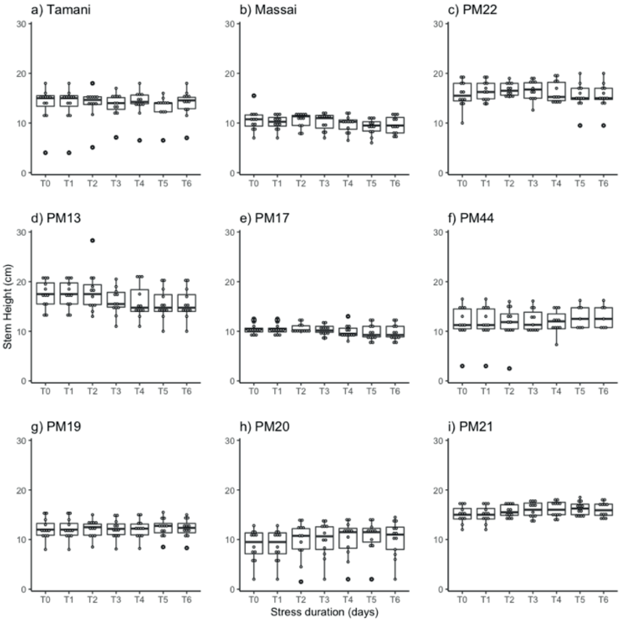
Sanchéz et al. (2016) evaluating Arundo donax L., a plant of C_3 metabolism and Panicum virgatum, a plant of C_4 metabolism, did not find differences in the photosynthetic rates of both, however, a decrease in the rate of photosynthesis and stomatal conductance was found, as in our work (Figure 5), and the chlorophyll content in A. donax was not significant. This differs from our data since the chlorophyll content was significant ($p<0.05$) except for the interaction of genotype by the stress duration for stomatal conductance, which may help explain the stress tolerance of these genotypes. Seixas et al. (2015) mention the experiments of Mattos et al. (2005) who evaluated the morphogenic, physiological and productive characteristics of Urochloa species, in which the photosynthetic rates of all species were reduced, the same found in all M. maximus genotypes evaluated in this work.

Our data differ from the studies by Carlin and Santos (2009) on physiological stress indicators in sugarcane

(Saccharum sp.), because they realized that the growth was drastically reduced, even with the detection of solutes increase in the cells. A highlight, however, is that cv. Massai, BRS Tamani, PM19, PM20 and PM21 produced more regrowth dry biomass after a stress suspension of 18 days (regrowth after the stress) than the control and the plants subjected to only three days of stress, for example. A possible explanation is a tolerance of these genotypes to periods without water, with the occurrence of osmotic adjustment, as explained by Turner (2018), in which the plants reallocate nutrients and solutes in the cells to respond to the water deficit, conserving the cellular turgor and therefore the organs, such as roots and leaves.

In relation to the height of the stem, there were differences among genotypes (Figure 6), but not in relation to the time of suspension of irrigation (Table 1). This was distinct from the number of leaves that was affected by the time of suspension of irrigation.

Figure 6 - Height of the stem (cm) along the stress duration periods for each genotype



Source: research data.

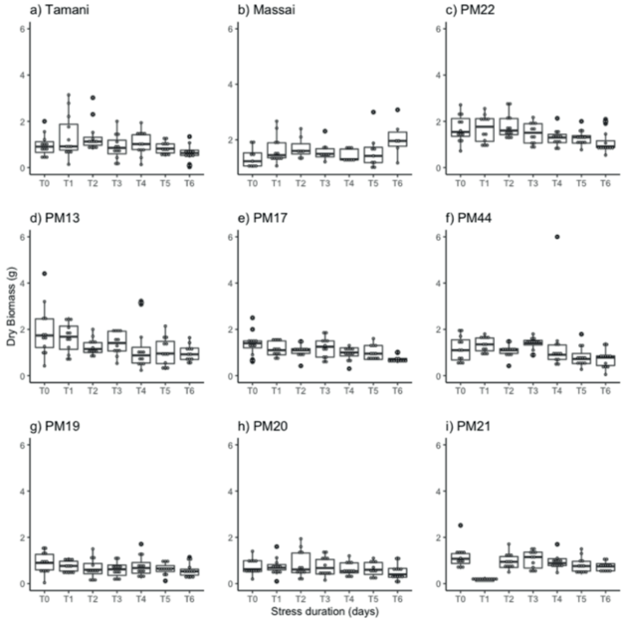
The number of leaves per main plant (disregarding the other tillers) was significant and accompanied the water deficit, as well as the chlorophyll content decrease and other physiological rates. This is due to foliar curling, which has been observed and is a mechanism used to reduce the loss of water to the environment.

Above ground dry biomass was obtained after irrigation suspension (Figure 7), which varied significantly among genotypes, stress duration period and their interaction (Table 1).

The number of leaves per main plant (disregarding the other tillers) was significant and accompanied the water deficit, as well as the chlorophyll content decrease and other physiological rates. This is due to foliar curling, which has been observed and is a mechanism used to reduce the loss of water to the environment.

Above ground dry biomass was obtained after irrigation suspension (Figure 7), which varied significantly among genotypes, stress duration period and their interaction (Table 1).

Figure 7 - Production of Dry Biomass (g) along the stress duration periods for each genotype



Source: research data.

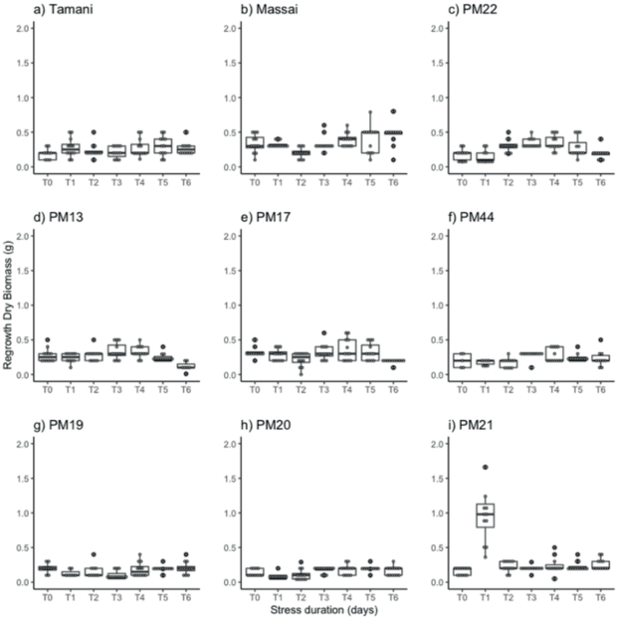
Martins et al. (2018) in a work with legumes of forage potential, with suspension of irrigation for 18 days found increase content of total sugars, proline and extravasation of electrolytes, mechanisms described as stress compensators (Turner, 2018), as they prevent the loss of water to the environment by saving it. Therefore, Macroptilium lathyroides (L.) Urb, Vigna luteola Jacq. and Desmodium incanum DC can tolerate water restriction by accumulating sugars, soluble sugars and proline in roots and leaves.

The suspension of irrigation also affected the dry biomass since this is directly related to the rate of photosynthesis, showing the need to produce species less sensitive to climatic changes (Mattos et al., 2005; Pezzopane et al. 2014).

There was also variation in the production of dry biomass of regrowth after 23 days of irrigation reestablishment (Figure 8), however, the results were significant only for the genotypes. Nevertheless, cv. Massai presented greater dry biomass of regrowth after 18 days of stress than the control (without stress) and three-day stress, for example, which can be explained as a tolerance factor of these genotypes to periods without water. Although there were no differences in the survival of the plants, since the regrowth was 100% in six genotypes, when irrigation was restored at 18 days of irrigation suspension.

Therefore, comparing Figures 7 and 8, we noticed that the genotypes were significantly affected by the period of irrigation suspension, however, they were able to survive and resume growth after the stress ceased, that is, they tolerated stress, and cv. Massai, BRS Tamani, PM19, PM20 and PM21 may be considered the most suitable to withstand the drought conditions here simulated.

Figure 8 - Production of dry biomass of regrowth (g) after suspension of the stress in different stress periods for each genotype



Source: research data.

However, in the treatments performed by Mattos et al. (2005), considering that the complete recovery of stress in physiological terms did not occur, it is possible to infer that the species of Urochloa (sin. Brachiaria) studied by them, when reestablishing their normal photosynthetic activities, were able to tolerate the lack of water in the soil, and therefore, the plants have a point where they can completely reestablish after suffering a water stress. The same may be considered for the M. maximus genotypes, which after the suspension of the stress, regrew 100% except for genotype PM44, considered one of the most sensitive, where approximately 20% of the plants did not regrow.

The photosynthetic rates of three elephantgrass genotypes evaluated by Araújo et al. (2010), decreased after the fifth day of irrigation suspension, which our data corroborates with, since there is evidence that water stress damages the metabolism of the mesophyll, and is often more important than the limitation of water in the plant tissue (Carlin; Santos, 2009). This may have been the case of the PM44 genotype, which showed lower regrowth after the stress, but there was no damage in the other evaluated genotypes, indicating that they may have reallocated organic and mineral nutrients in the roots to wait for better survival conditions (Larcher, 2006), precisely because the roots are the main sensors of water stress (Chaves, 1991). However, L. alba rehydrated for 24 hours already recovered its photosynthetic activities demonstrating its rapid stomatal regulation (Freitas, 2018), as observed with the genotypes here studied. As for rehydration, Blum & Tuberosa (2018) showed that the survival trait of plants to dissection (or dehydration), the basis of the evolutionary success, is the conservation of the photosynthetic apparatus, which in resurrection plants is a particularly remarkable characteristic, since they recover after rehydration, returning very quickly to CO_2 fixation and other metabolic activities.

So, the genotypes cv. Massai and BRS Tamani stood out, and although they were affected by water stress, they obtained 100% regrowth and retained all their metabolic activities, which allows us to infer that these plants relocated their nutrients to the roots to wait for better survival conditions.

The genotypes PM19, PM20 and PM21 stood out, since they showed no reduction in chlorophyll content after 18 days of stress and, therefore, no damage to the photosynthetic apparatus and neither reached the point of permanent wilt.

4 Conclusion

According to our results we identified the genotype PM44 as the most sensitive to water stress, while other genotypes (BRS Tamani, cv. Massai, PM19, PM20 and PM21) were most tolerant and showed higher adaptation to stress. Eighteen days of suspension of irrigation were sufficient to differentiate the genotypes into tolerant and non-tolerant to water deficit. Thus, we could identify the most tolerant and the most sensitive ones in the period evaluated. We believe that a longer evaluation period on the field is necessary to ensure that the tolerance was not only relative to the conditions evaluated by us.

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