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CARACTERÍSTICAS ESTRUTURAIS E ACÚMULO DE FITOMASSA DO MILHETO SOB DIFERENTES REGIMES DE IRRIGAÇÃO COM ÁGUA RESIDUÁRIA E ADUBAÇÃO ORGÂNICA

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1 RESUMO

A utilização de água residuária pode aumentar a oferta hídrica e de alimentos em regiões semiáridas. Assim, objetivou-se estudar a dinâmica temporal das características estruturais e acúmulo de fitomassa do milheto irrigado com diferentes lâminas de água cinza, com e sem adubação orgânica. A pesquisa foi conduzida em ambiente protegido em esquema fatorial (4 x 2) + 1, com três repetições, sendo os fatores: níveis de água disponível do solo (25, 50, 75 e 100%) e doses de esterco (0 e 34 Mg ha^{-1}), mais o tratamento controle (irrigação com água potável e sem adubação). Foram realizadas avaliações semanais das características estruturais: comprimento e diâmetro do colmo e número de perfilhos, folhas totais, folhas vivas e folhas mortas, sendo ajustados modelos matemáticos para descrever o comportamento dessas características ao longo do ciclo da cultura. Após 60 dias de aplicação dos tratamentos o milheto foi colhido e determinou-se o acúmulo de fitomassa e massa de raízes. O modelo sigmoidal é o que melhor explica a dinâmica da maioria das características estruturais. A irrigação com águas cinzas não afetou as características estruturais, massa de raízes e o acúmulo de fitomassa do milheto, sendo indicado adubação a fim de melhorar o seu desempenho.

Palavras-chave: *Pennisetum glaucum*, águas cinzas, dinâmica do crescimento, manejo de irrigação

SILVA, J. R. I.; SOUZA, E.; LEITE, M. L. M. V.; BARROS JUNIOR, G.; LIMA, J. R. S; SALES, A. T.
STRUCTURAL CHARACTERISTICS AND PHYTOMASS ACCUMULATION OF MILLET UNDER DIFFERENT IRRIGATION REGIMES WITH WASTEWATER AND ORGANIC FERTILIZATION

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2 ABSTRACT

The use of wastewater can increase the water and food supply in semi-arid regions. Thus, the objective was to study the temporal dynamics of structural characteristics and the accumulation of phytomass in millet irrigated with different depths of greywater, with and without organic fertilization. The research was conducted under greenhouse conditions in a factorial scheme (4 x 2) + 1 with three replications, the factors being levels of water available from the soil (25, 50, 75 and 100%) and manure doses (0 and 34 Mg ha^{-1}), plus control treatment (irrigation with drinking water and without fertilization). It was performed weekly evaluations of structural characteristics: stem length and diameter, and number of tillers, total leaves, live leaves and dead leaves. Mathematical models were adjusted to describe the behavior of these characteristics throughout the cycle. After 60 days of the application of the treatments, millet was harvested and the accumulation of phytomass and root mass was determined. The sigmoidal model best explains the dynamics of most structural features. The irrigation with greywaters did not affect the structural characteristics, root mass and phytomass accumulation of millet, and fertilization is indicated to improve its performance.

Keywords: *Pennisetum glaucum*, greywaters, growth dynamics, irrigation management

3 INTRODUCTION

The semiarid region of Brazil is characterized by high evapotranspiration and variability in the spatiotemporal distribution of rainfall, compromising the recharge of water bodies and causing instability in agricultural production (SILVA et al., 2017). Water limitation throughout the plant cycle promotes water stress, which is one of the main abiotic stresses that limits crop production and may become even more severe in future climate scenarios (REDDY et al., 2017).

The use of domestic sewage water for irrigation is a management alternative that seeks to minimize water scarcity in regions experiencing water deficit throughout the year (LARSEN et al., 2001). Furthermore, reducing the irrigation depth tends to promote more rational use of water resources. However, restricting the water supply can have significant impacts on crop yields, as water stress causes various types of damage to plant metabolism, such as reduced photosynthesis, reduced cell division, increased energy expenditure, and the production of reactive oxygen species (FAROOQ et al., 2019).

To minimize the impacts of water stress, some authors have dedicated themselves to the study of fertilization, as plants with adequate nutritional balance have high water use efficiency (WARAICH et al., 2011). Fertilization is also recommended for crops irrigated with wastewater, as the nutrients dissolved in this type of water may not be sufficient for full crop development (SANTOS JÚNIOR et al., 2015; LARSEN et al., 2001).

Millet culture (*Pennisetum glaucum*) has gained prominence in recent years because of its adaptability to high temperatures, water deficit, and salinity (NELSON et al., 2018; SILVA et al., 2018). Furthermore, it can replace corn (the species with the highest water and nutrient demands) in animal diets (SILVA et al., 2020). To understand plant responses to environmental management, various structural characteristics (plant height, number of live and dead leaves, and stem diameter, among others) have been evaluated throughout the plant life cycle (ALMEIDA et al., 2021). However, this type of study generates a large amount of information, as these analyses are often performed weekly. Therefore, techniques that reduce this amount of information without compromising the understanding of plant growth dynamics are necessary.

Studying growth curves via nonlinear models allows us to reduce the information present in the dataset, summarizing it into just a few parameters or curves with practical interpretations (NASCIMENTO et al., 2017). Understanding the dynamics of interactions between plant structural traits and irrigation management is essential, as these traits are correlated with grain and forage yields. Changes in the structural traits of millet are indicative of stress, so assessing these traits is efficient for identifying responses to environmental management in a short period of time (ALMEIDA et al., 2021).

Given this context, the objective was to study the temporal dynamics of the structural characteristics, root mass and phytomass accumulation of millet (*Pennisetum glaucum*) irrigated with different levels of wastewater (gray water), with and without organic fertilization, in a semiarid region of the state of Pernambuco.

4 MATERIALS AND METHODS

The research was conducted in a protected environment at the Federal Rural University of Pernambuco, Serra Talhada Academic Unit, semiarid region of Pernambuco (altitude: 429 meters, latitude: 7° 56' 15" S and longitude: 38° 18' 45" W). According to the Köppen classification, the climate of the region is BShw - semiarid, hot and dry. The meteorological conditions (daily averages) of the protected environment during the experiment were an air temperature of 30.09 ± 1.57 °C and a relative humidity of 44.00 ± 5.48%.

A randomized block design was adopted, with a factorial scheme (4 × 2) + 1 with three replications. The first factor studied was the irrigation depth with gray wastewater as a function of the available water (AD) fraction of the soil (25, 50, 75 and 100%), and the second factor was the organic fertilization conditions (with and without the application of cattle manure). The control treatment received irrigation with water from the urban supply at a depth equivalent to 100% of the available water in the soil and did not receive fertilization. Thus, the experiment included nine treatments (T1 - 25% AD without fertilization, T2 - 50% AD without fertilization, T3 - 75% AD without fertilization, T4 - 100% AD without fertilization, T5 - 25% AD with fertilization, T6 - 50% AD with fertilization, T7 - 75% AD with fertilization, T8 - 100% AD with fertilization and T9 - control treatment).

The wastewater (Table 1) was collected from a graywater collection system used for bathing, cooking, and laundering in a rural residence. After collection, the graywater was treated by a filtration system consisting of a grease trap and a filtration tank formed by a surface layer of charcoal, followed by a layer of coarse gravel, coarse sand, fine sand, and fine gravel, whose functions are to retain larger particles of grease, soap residue, and organic matter that were not retained in the grease trap, respectively. Finally, the water was directed to a stilling tank, where it was later collected and used for millet irrigation.

Table 1. Chemical analysis of urban supply water (UA) and gray wastewater (GR) used for millet irrigation.

Components	AA	AIR	Components	AA	AIR
Calcium (mmol L^{-1})	0.64	2.2	Chlorine (mmol L^{-1})	0.60	9.60
Magnesium (mmol L^{-1})	0.48	0.68	Copper (mg L^{-1})	0.04	0.06
Sodium (mmol L^{-1})	0.32	17.04	Iron (mg L^{-1})	0.08	0.08
Potassium (mmol L^{-1})	0.07	0.46	Manganese (mg L^{-1})	0.03	0.05
Carbonate (mmol L^{-1})	0.00	0.24	Zinc (mg L^{-1})	0.05	0.05
Bicarbonate (mmol L^{-1})	0.40	4.00	pH	7.20	7.75
Sulfates (mmol L^{-1})	0.04	0.17	CE (dS m^{-1})	0.20	0.98
RAS	0.27	8.69	Water classification*	C1S1	C3S2

*Classification according to the risk of salinization and sodification proposed by Richards (1954): C1S1 – low risk of salinization and sodification, C3S2 – high risk of salinization and moderate risk of sodification. RAS – sodium adsorption ratio, CE – electrical conductivity.

The pots used in the test had a capacity of 18 dm^3 and were filled with soil until a density of 1.30 g cm $^{-3 \text{ was reached}}$. The soil, classified as the Cambisol Haplic, was collected from the 0–20 cm depth layer. After being broken up and sieved (4 mm mesh), the chemical and physical characteristics of the soil were determined and are presented in Table 2. For the treatments that received organic fertilizer, organic fertilizer was added to the soil and homogenized for later filling of the pots, with 645 g of cattle manure being added per pot, equivalent to 34 Mg ha^{-1}, a dose sufficient for the full growth of millet (NICOLAU SOBRINHO et al., 2009). The chemical characteristics of the manure are also presented in Table 2.

Table 2. Chemical and textural characteristics of the Cambisol Haplic collected from the 0–20 cm thick layer and the chemical composition of the cattle manure used as organic fertilizer in millet cultivation.

Soil analysis (0-20 cm)										
Chemical								Texture		
pH	P	K	In the	Here	Mg	H+Al	MO	Sand	Silt	Clay
	mg dm^{-3}	-------------- cmol$_c$ dm^{-3} -------------					%	------------- % ------------		
7.1	40.0	0.88	0.11	1.20	0.10	1	1.24	73.6	15.9	10.5
Manure analysis										
		N	P	K	Her e	Mg	W	C/N		
		---------------------- g kg^{-1} ----------------------								
		10.4	5.28	10.5	11.2	6.8	113.3	10.8		

pH - hydrogen potential, P - phosphorus, K - potassium, Na - sodium, Ca - calcium, Mg - magnesium, H - hydrogen, Al - aluminum, MO - organic matter, N - nitrogen, and C - carbon.

To define available soil water (AD), soil moisture was determined at the maximum vessel retention capacity (MRC), following the methodology of Casaroli and Jong van Lier (2008), and the permanent wilting point (PMP), subjecting the undisturbed soil samples to a pressure of 15 ATMs in a Richards extractor. AD was determined by the difference between the CRV and PMP. The procedures described for determining AD were performed for soil samples with and without manure, obtaining the following results: for the soil without manure, 0.18 g g $^{-1}$ and 0.03 g g $^{-1}$ refer to CRV and PMP, respectively; and for the soil with manure, 0.20 g g $^{-1}$ and 0.05 g g $^{-1}$ refer to CRV and PMP, respectively.

millet seeds (*Pennisetum glaucum* (L.) R. Br.), cultivar IPA-Bulk-1 BF, per pot. From sowing to the fifteenth day, the stand formation period was considered. All the pots were irrigated daily with potable water, and the soil was maintained at field capacity. After this period, thinning was performed, leaving only one plant per pot. The application of different levels of wastewater (graywater) then began on the basis of the available soil water fractions (25, 50, 75, and 100% AD). Irrigation was carried out daily, and the water mass lost through evapotranspiration was replaced by weighing the pots.

After the start of treatment (DAT), the experiment was conducted for 60 days. Weekly measurements were taken of the following structural characteristics of the millet: stem length (measured from the base of the plant to the last node); number of live leaves (a leaf being considered live if it was fully expanded and had more than 50% of the leaf area not compromised by senescence); number of dead leaves (leaves that had more than 50% of the leaf area compromised by senescence); number of total leaves (sum of the number of live leaves plus the number of dead leaves); stem diameter (measured with a caliper at 3.0 cm from the soil surface); and the number of tillers per plant.

For each structural characteristic evaluated, nonlinear mathematical models, quadratic (Equation 1) and sigmoidal (Equation 2), were adjusted to describe the behavior of the structural characteristics throughout the experimental period (CRUZ; REGAZZI; CARNEIRO, 2014). The day of evaluation was considered the independent variable (considering day zero as the start of treatment application), and the structural characteristics were considered the dependent variable.

$$Y_i = b_0 + b_1 X_i + b_2 X_i^2 \quad (1)$$

$$Y_i = \frac{a}{1 + \exp\left(-\left(X_i - X0\right)/b\right)} \quad (2)$$

where Y_i = the dependent variable; X_i = the independent variable; b_0, b_1 and b_2 = the adjustment coefficients of the second-degree equation; and *a*, X0 and b = the adjustment coefficients of the sigmoidal model.

At the end of the experiment (60 DAT), the plants were cut close to the ground to determine the phytomass. The roots of each experimental plot were also collected, and the soil was removed from the pot, broken, passed through a sieve (4 mm mesh) to retain the roots, and then washed in running water. To determine dry matter, after these procedures, the aerial parts and roots were placed in an oven at 65 °C until they reached a constant weight (DETMANN et al., 2012).

The data were initially subjected to Shapiro–Wilk normality and Cochran homoscedasticity tests. To evaluate the influence of treatments on mass accumulation in the shoot and root, analysis of variance (5% F test) was applied, and regression adjustment was performed for quantitative factors and Tukey's test (5%) for qualitative factors. The program used to perform the statistical analyses, adjust the mathematical models, and create the graphs was R (TEAM CORE R, 2017).

5 RESULTS AND DISCUSSION

The variables stem length (CL), stem diameter (CL), number of tillers (NL), number of total leaves (NLT), and number of dead leaves (NLM) fit the sigmoidal model, whereas the number of live leaves (NLV) was the only variable to fit the quadratic model. Table 3 presents the coefficients of the models adjusted to their respective treatments. The parameter 'a *' of the* sigmoidal model (Equation 2) is related to the maximum value that the structural characteristic reached. Thus, for the characteristics CL, NL, NTL, and NLM, the treatments that received organic fertilization and were irrigated with the highest fractions of available soil water (100%, 75%, and 50%) presented higher values for this parameter, indicating greater plant growth under these treatments.

Table 3. Coefficients of the sigmoidal and quadratic regression models adjusted from data measured on millet plants under different gray wastewater depths, with and without organic fertilization (0 and 34 Mg ha $^{-1}$ of cattle manure).

	Culm length (CL)			**Culm diameter (DC)**			**Number of tillers (NP)**		
Trat.	the	X0	b	the	X0	b	the	X0	b
T1	89.01	23.93	6.28	9.07	11.76	5.17	3.00	14.36	0.50
T2	83.50	19.95	4.25	8.12	11.21	7.19	2.28	6.09	0.98
T3	86.44	22.18	4.58	8.53	10,10	8.36	2.57	6.32	1.36
T4	76.87	21.07	4.88	8.55	10.54	3.52	2.71	6.57	1.41
T5	114.0	19.07	4.36	10.19	7.27	3.72	4.15	9:30	4.31
T6	95.19	15.43	4.56	9.02	8.79	3.49	5.34	14.51	5.00
T7	93.16	17.51	4.92	9.93	10.22	2.90	3.79	10.72	4.89
T8	76.44	18.43	5.70	9.05	11.68	3.17	3.10	8.63	4.54
T9	82.26	23.60	7.50	8.42	10.74	5.05	2.92	9.93	4.82
	Total number of sheets (NFT)			**Number of living leaves (NFV)**			**Number of dead leaves (NFM)**		
	the	X0	b	b 0	b 1	b 2	the	X0	b
T1	15.49	11.49	6.19	1.36	0.58	-0.006	11.57	83.69	7.98
T2	20.04	15.64	9.47	3.04	0.45	-0.005	8.54	33.91	7.48
T3	19.41	13.76	7.56	2.35	0.59	-0.007	7.88	32.43	7.31
T4	18.13	11.51	6.65	3.04	0.58	-0.009	12.10	35.49	7.60
T5	30.56	15.60	6.39	2.67	0.81	-0.009	13.93	30.05	6.15
T6	32.66	15.54	6.00	1.93	1.07	-0.013	13.74	29.46	4.56
T7	29.04	14,14	5.63	2.18	0.97	-0.013	12.75	29.86	5.02
T8	25.03	14.71	5.81	1.08	0.96	-0.014	13.36	32.06	5.66
T9	19.44	13.92	6.35	1.47	0.70	-0.009	8.12	33.21	7.39

a, X0 and b - coefficients of the sigmoidal model; b0, b1 and b2 – coefficients of the second-degree model; AD – available soil water; T1 – 100% AD without manure; T2 – 75% AD without manure; T3 – 50% AD without manure; T4 – 25% AD without manure; T5 – 100% AD with manure; T6 – 75% AD with manure; T7 – 50% AD with manure; T8 – 25% AD with manure; and T9 – control.

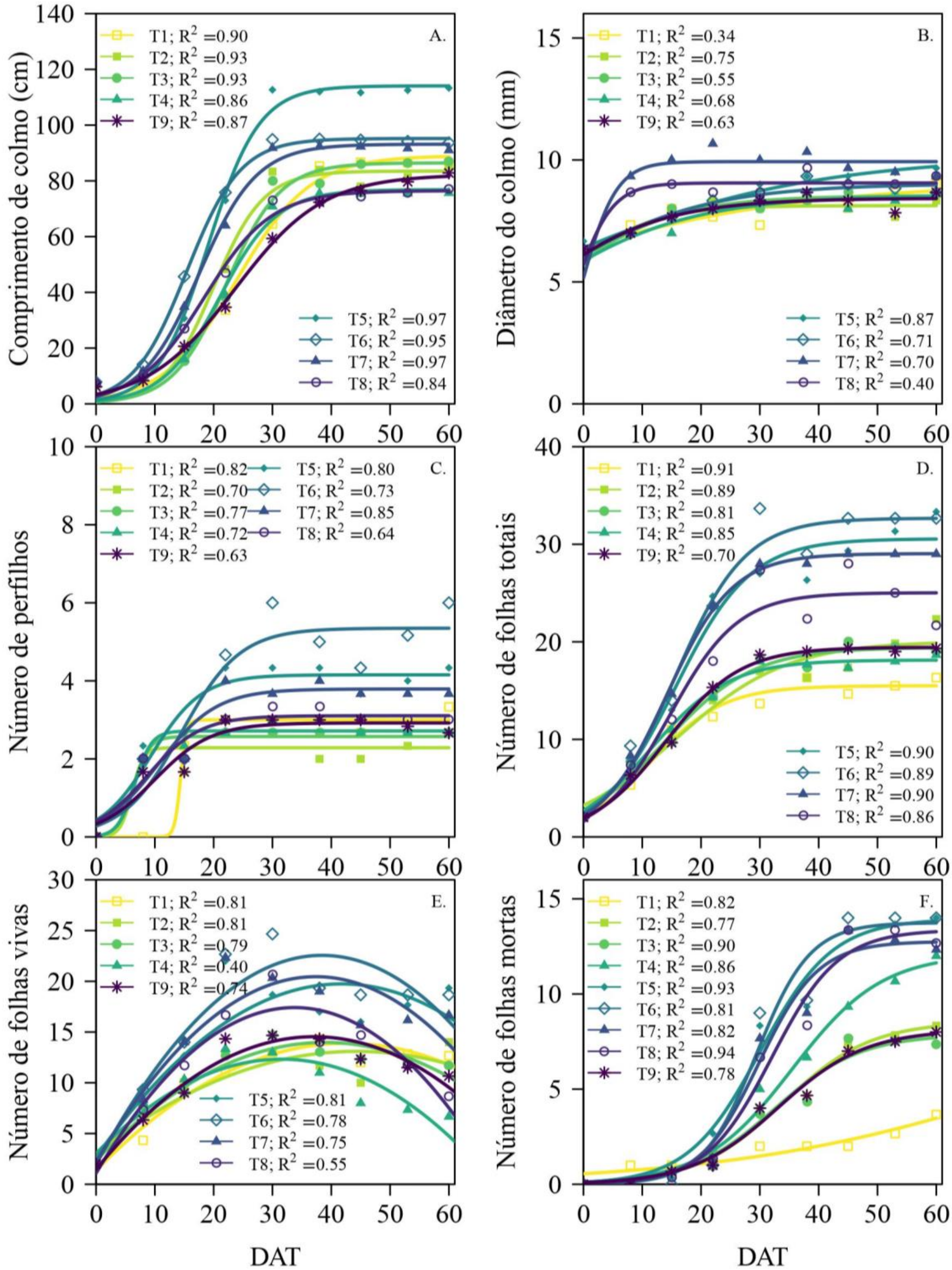
The parameter 'X0' indicates how many days it takes for millet plants to reach 50% of the maximum value of the structural trait; the lower this value is, the faster the plants reach the reproductive phase. Plants irrigated with 100, 75, and 50% soil AD presented lower values for this parameter for the structural traits CC, NP, NFT, and NFM. These findings suggest that well-hydrated millet plants grow faster and can reach the reproductive cycle faster than plants under water restriction.

The number of live leaves (NLL) best fit the quadratic regression (Table 3), which allowed, after derivation of the regression, X_{max} (the day on which the highest NLL occurred) to be obtained. The plants without fertilization presented the highest NLL at 48, 45, 42, and 32 days, with soil DA fractions of 100, 75, 50, and 25%, respectively. In fertilized plants, the highest NLL was reached at 45, 41, 37, and 34 days, following the decreasing order of the soil DA fractions. Regardless of the presence or absence of fertilization, the $X_{max\ values}$ decrease due to the reduced water supply. These findings indicate that millet plants under water deficit tend to reach the maximum NLL peak more quickly throughout the crop cycle. Therefore, millet crops with water limitations must be constantly monitored so that the number of dead leaves does not reach a proportion that could harm the quality of the forage.

The prediction efficiency of the models was assessed via the coefficient of determination (R^2) (Figure 1); most fits were satisfactory, with R^2 values above 0.8. Stem length (SL) accelerated growth between 10 and 35 DAT and stabilized after this period (Figure 1A). Compared with the unfertilized treatments, the fertilized treatments had greater SL values at all evaluation times. Fertilized plants exhibit greater growth, as an adequate nutrient supply accelerates the differentiation process and, consequently, tissue expansion (LI et al., 2013). SL decreased with decreasing irrigation depth, and this reduction was more drastic for the fertilized treatments, reaching a 34% reduction when the average results obtained for the highest irrigation depth (100% AD) were compared with those for the lowest irrigation depth (25% AD). Water deficit promotes less cellular differentiation and a smaller number of cells, compromising the expansion of plant tissues (TARDIEU; GRANIER; MULLER, 2011).

For plants irrigated with 75% and 50% AD, there was only a 15% reduction in stem length compared with those irrigated with 100% AD. In contrast, in the treatments that received no fertilizer, the CC showed little variation (<4%) among the three highest irrigation depths (100%, 75%, and 50% AD). These results suggest that pearl millet is tolerant to water deficit, with a reduction of up to 50% in available soil water without significantly compromising stem length. This tolerance of pearl millet to water stress may be associated with increased expression of certain genes and proteins that determine patterns of water regulation and transport in the plant (REDDY et al., 2017). Additionally, the accumulation of compatible osmosolutes (proline, free amino acids and soluble sugars) contributes to osmotic adjustment in millet, reducing the cellular water potential and facilitating water absorption by the plant even under deficit (MARVIYA; VAKHARIA, 2016).

Figure 1. Temporal dynamics of the structural characteristics of millet under different levels of gray wastewater, with and without organic fertilization (0 and 34 Mg ha $^{-1}$ of cattle manure); DAT – days after application of treatments; AD – soil available water; T1 – 100% AD without manure; T2 – 75% AD without manure; T3 – 50% AD without manure; T4 – 25% AD without manure; T5 – 100% AD with manure; T6 – 75% AD with manure; T7 – 50% AD with manure; T8 – 25% AD with manure; and T9 – control.



Stalk diameter (SC) was the variable that responded least to the applied treatments, as no significant differences were observed depending on water limitation or fertilization, which stabilized at 20 DAT (Figure 1B). The stalk diameter is an important structural component and is associated with the plant damping-off index, with a higher SC indicating lower damping-off rates (COSTA et al., 2016). Therefore, deficit irrigation and graywater did not affect this crucial structural characteristic.

The number of tillers remained stable after 10 DAT in unfertilized plants and at 30 DAT in fertilized plants (Figure 1C). The soil available water (AD) level did not influence the dynamics of tiller number in the unfertilized treatments. In the fertilized treatments, the number of tillers decreased with increasing soil AD. The total leaf number (TLN) of the plants stabilized after 30 DAT (Figure 1D). In the unfertilized treatments, the TLN dynamics did not significantly change as a function of soil AD; however, fertilized plants presented a decrease in TLN due to the reduction in AD.

Like other structural characteristics, the number of live leaves (NLL) was greater in the fertilized treatments (Figure 1E). A greater number of leaves per unit area tends to increase CO_2 absorption and maximize productivity (THARANYA et al., 2018). When subjected to the highest level of water restriction (25% of AD), the plants presented a more pronounced reduction in NLL (mainly in the fertilized treatment – T8). Fertilized millet plants show a significant increase in leaf area; however, when subjected to water stress, they tend to suffer more from the effects of water restriction (leaf senescence), as they have a larger transpiring surface. (AFFHOLDER, 1995).

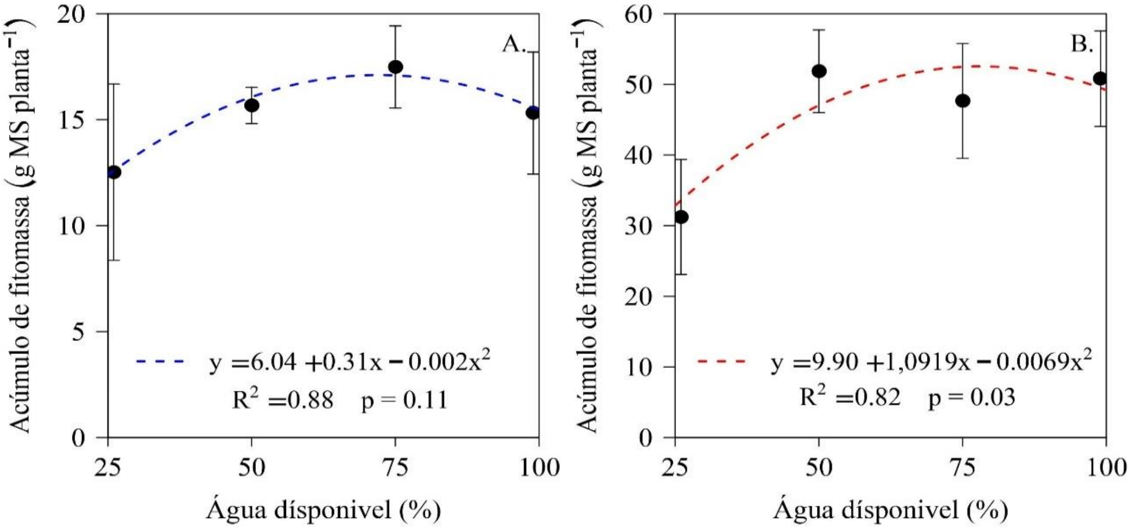
The number of dead leaves (NFM) tended to stabilize after 45 DAT (Figure 1F). The fertilized plants, regardless of the soil water level, presented the highest NFM values, which was a consequence of greater NFV emission in the initial growth phase (Figure 1E). The leaf development process ends with senescence, and its speed and intensity are influenced by environmental factors (air temperature and water availability), harvest management, soil nitrogen availability, and genetic factors (PEREIRA et al., 2011).

Organic fertilization increased millet phytomass by more than 100%, regardless of the soil water availability (Figure 2). Phytomass accumulation in millet irrigated with the urban water supply (T9 - control) was equal to that of plants irrigated with gray water and not receiving fertilization (15.22 g DM plant $^{-1}$). This finding demonstrated that gray water did not compromise phytomass accumulation; however, it also did not provide nutrients to increase millet yield.

Graywater generally has a low amount of dissolved nutrients due to its origin, which does not include wastewater from residential latrines (LARSEN et al., 2001). In an experiment with millet irrigated with wastewater, the addition of 4.5% human urine to the volume of this water resulted in phytomass accumulation similar to that of plants under mineral fertilization and irrigated with high-quality water (SANTOS JÚNIOR et al., 2015). Although millet grows well in sandy, low-fertility soils, it responds to fertilization because of its nutrient translocation capacity (UPPAL et al., 2015).

Unfertilized millet plants were not significantly influenced by soil AD levels on phytomass accumulation, and no meaningful mathematical model could be fitted (Figure 2A). When millet is fertilized, the leaf area increases in the early growth stages. However, the larger the leaf area is, the greater the degree of water stress, as millet plants require more water (AFFHOLDER, 1995). The effects of water stress also depend on irrigation management, and the shorter the interval between irrigation events is, the smaller the effect of this stress (ISMAIL; EL - NAKHLAWY; BASAHI, 2018). Furthermore, the treatments without fertilization tended to have similar leaf areas, as indicated by the dynamics in the number of live leaves (Figure 1D), and consequently, they tended to have similar transpiration rates.

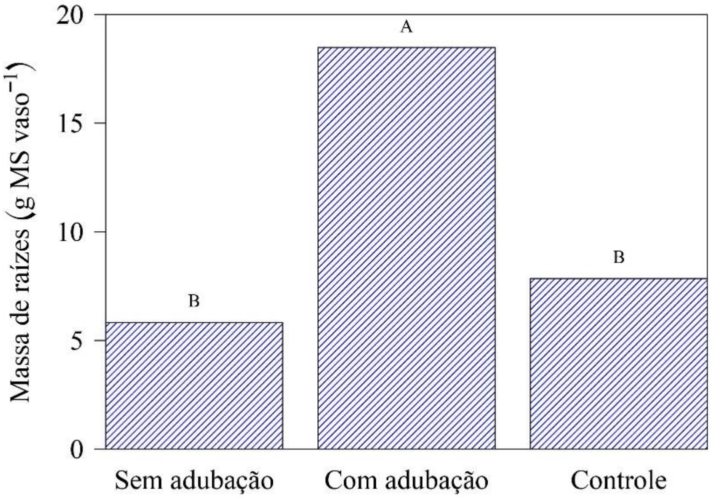
Figure 2. Dry matter production as a function of available soil water in millet fertilized with 34 Mg ha $^{-1}$ cattle manure (A) and without fertilization (B).



When millet plants were fertilized, there was a significant effect on the available soil water level, and the second-degree polynomial equation best described this behavior (Figure 2B). Derivating the polynomial equation, the maximum phytomass accumulation was found at 79% AD, with a decreasing trend occurring from this point onward (Figure 2B). The reduction in phytomass accumulation was most significant in the plants irrigated with 25% AD. However, irrigation with up to 50% AD did not significantly reduce the millet phytomass. The response of millet to deficit irrigation is associated with plant metabolism, which regulates stomatal opening and closure, osmotic pressure, and the expression of drought tolerance genes (GHATAK et al., 2015).

Similar to structural characteristics and shoot dry matter accumulation, root dry matter did not significantly benefit from graywater irrigation (Figure 3). However, compared with no fertilization, cattle manure fertilization favored root growth, increasing root dry matter by 3.6 times. The increase in root mass is important because it is strongly associated with the grain yield, phytomass accumulation, and transpiration of millet plants (THARANYA et al., 2018).

Figure 3. Dry mass of roots of millet plants irrigated with residue (gray water) with and without organic fertilization (0 and 34 Mg ha $^{-1}$ of cattle manure) and the control treatment (irrigated with water from the supply and without fertilization).



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6 CONCLUSION

phytomass accumulation and root mass. However, when irrigation with gray water is associated with organic fertilization, better structural characteristics and biomass accumulation occur.

Millet, when fertilized, can be irrigated with up to 50% of the available soil water without significantly compromising crop performance.

Despite their lower growth and yield, millet plants without fertilization can be irrigated, maintaining up to 25% of the soil's available water without compromising crop development.

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