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Irrigation management, light interception, and nitrogen in Tanzania grass cultivation

Manejo de irrigação, interceptação luminosa e nitrogênio no cultivo do capim Tanzânia

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ABSTRACT - Management of nitrogen fertilization and light interception of pastures contributes to forage production in regions with low water availability. Therefore, the objective was to evaluate the effect of different nitrogen doses and light interception levels on the growth of *Panicum maximum* cv. Tanzania under different irrigation managements. The experiment was carried out in a greenhouse, using a factorial scheme (5 x 2 x 2), corresponding to five irrigation depths (40, 60, 80, 100, and 120% of actual evapotranspiration), two canopy light interception levels (90 and 95%), and two nitrogen doses (300 and 600 kg N ha^{-1} $year^{-1}$). The highest biomass production occurs under irrigation with 120% of evapotranspiration. However, the best structural characteristics (tillering and number of leaves) occur with 100% of evapotranspiration, regardless of nitrogen dose and light interception level. Interruption of growth with 95% of incident light and fertilization with 600 kg N ha^{-1} $year^{-1}$ promoted greater tillering, number of leaves and leaf length, regardless of the irrigation level. Tanzania grass management with an interruption of growth with 95% of incident light, 600 kg N ha^{-1} $year^{-1}$, and irrigation with 80% of actual evapotranspiration led to tillering and number of leaves only 11% lower than the values found in the other treatments irrigated with 100% of actual evapotranspiration. Interruption of growth with 95% of incident light and fertilization with 600 kg N ha^{-1} $year^{-1}$ improve the performance of Tanzania grass under deficit irrigation.

Keywords: *Panicum maximum*. Actual evapotranspiration. Nitrogen fertilization. Tropical grass.

RESUMO - O manejo da adubação nitrogenada e interceptação luminosa das pastagens contribuem para produção de forragem em regiões com baixa disponibilidade de água. Portanto, objetivou-se avaliar o efeito de diferentes doses de nitrogênio e níveis de interceptação luminosa no crescimento do capim *Panicum maximum* cv. Tanzânia sob diferentes manejos de irrigação. O experimento foi conduzido em casa de vegetação, em esquema fatorial (5 x 2 x 2), relativo a cinco lâminas de irrigação (40, 60, 80, 100 e 120% da evapotranspiração real), dois níveis de interceptação de luz pelo dossel (90 e 95%) e duas doses de nitrogênio (300 e 600 kg N ha^{-1} ano^{-1}). A maior produção de biomassa ocorre com 120% da evapotranspiração. Porém as melhores características estruturais (perfilhamento e número de folhas) ocorrem com 100% da evapotranspiração, independente da dose de nitrogênio e nível de interceptação luminosa. A interrupção do crescimento com 95% de luz incidente e a adubação com 600 kg N ha^{-1} ano^{-1} proporcionaram maior perfilhamento, número e comprimento de folhas do capim, independentemente da lâmina de irrigação. O capim Tanzânia com interrupção do crescimento com 95% da luz incidente, 600 kg N ha^{-1} ano^{-1} e irrigação com 80% da evapotranspiração obteve perfilhamento e número de folhas apenas 11% inferior aos outros tratamentos irrigados com 100% da evapotranspiração. A interrupção do crescimento com 95% da luz incidente e adubação com 600 kg N ha^{-1} ano^{-1} melhoram o desempenho do capim Tanzânia sob irrigação deficitária.

Palavras-chave: *Panicum maximum*. Evapotranspiração real. Adubação nitrogenada. Grama tropical.

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INTRODUCTION

Using grasses with high production and responsiveness to growth factors has contributed to animal production in pastures in Brazil, increasing the productivity and profitability of agricultural systems (SILVEIRA, 2020). The cultivation of *P. maximum* grass, cv. Tanzania, is widespread in several regions of the country, as it has accelerated growth, high productivity and good nutritional value (BUMBIERIS JUNIOR et al., 2021). However, in regions where the water deficit condition predominates, reductions in productivity are noticeable (LEMOS et al., 2019). Water deficit is common in semi-arid regions, leading to seasonality in the production of forage species throughout the year, causing food shortages to animals (ARAÚJO JÚNIOR et al., 2020). Thus, Tanzania grass cultivation becomes viable most of the year with the use of irrigation (ARAÚJO JÚNIOR et al., 2019).

Determining water depths suitable for Tanzania grass cultivation can improve its production in semi-arid environment (LIMA et al., 2018). The use of increasing irrigation depths has promoted higher yields of leaf fresh and dry mass, number of tillers and height of the grass (LEMOS et al., 2019). When the availability of irrigation water is lower than the volume required by forage species, it causes a reduction in the structural characteristics and nutritional value of pastures (MOMBACH et al., 2019; COUTINHO et al., 2020). However, information on management strategies for Tanzania grass under deficit irrigation, such as the association of nitrogen fertilization management and light interception, is scarce in the literature.

Tanzania grass is demanding in terms of soil fertility and management, so fertilization and defoliation intensity are important for optimizing its production (LAGE FILHO et al., 2021). Forage species of the genus *Panicum* respond positively to increasing doses of nitrogen fertilization, which promote a shorter cycle, greater number of tillers, greater fresh and dry biomass, and higher crude protein content (COSTA et al., 2016; RODRIGUES et al., 2017; SILVA et al., 2017; SILVA et al., 2018; SOUZA; BITTAR, 2021). Nitrogen fertilization is a key management strategy for increasing Tanzania grass production (LINS et al., 2015).

The productivity of a grass results from the continuous emergence of leaves and tillers, so knowledge on the structural characteristics of forage plants, such as stem height, number of tillers, leaf length, leaf area index, among others, is fundamental for proper management, enabling a perennial pasture (CARDOSO et al., 2019; LEMOS et al., 2019; CAMILO et al., 2020). Light interception is a fundamental characteristic for decision-making about the appropriate moment for the defoliation or grazing of grasses (BARBERO et al., 2014). Studies demonstrate that the adequate light interception for Tanzania grass is approximately 95%; above this value, plants modify their dry matter accumulation, reducing the formation of leaf blades and increasing the accumulation of stalks and senescent matter (MACEDO et al., 2017; CAMILO et al., 2020; LAGE FILHO et al., 2021).

Thus, understanding morphogenetic characteristics and using appropriate management techniques, such as irrigation, nitrogen fertilization and light interception, are fundamental to promote higher technical-economic yields of this grass in the region. Thus, the objective of this study was to evaluate the effect of different nitrogen doses and light interception levels on the growth of *Panicum maximum* grass cv. Tanzania under different irrigation managements.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse from August 2017 to January 2018, at the Academic Unit of Agricultural Sciences, Center for Sciences and Agri-Food Technology (CCTA) of the Federal University of Campina Grande (UFCG), located in the municipality of Pombal, PB, Brazil, whose geographical coordinates are: 6º48'16" S latitude and 37º49'15" W longitude, at an altitude of 194 m. According to the classification of Köppen (1948), the climate is BSh, characterized as hot and dry semi-arid, with average precipitation of 750 mm and average annual evapotranspiration of 2000 mm.

The experimental design adopted was randomized blocks, in a factorial scheme (5 x 2 x 2), relative to five irrigation depths (40, 60, 80, 100, and 120% of actual evapotranspiration - ETR) combined with two levels of light interception (period of time required for the canopy to reach 90 and 95% of incident light interception) with cutting height of 30 cm (adapted from ZANINE et al., 2011) and two nitrogen doses (300 and 600 kg N ha^{-1} year^{-1}), with 4 replicates, totaling 80 experimental plots.

The experiment was installed in 20-dm^3 pots, filled with 1 dm^3 of crushed stone (number zero) covering the base, followed by 16 dm^3 of soil (*Neossolo Flúvico Ta Eutrófico* (RYve) Entisol (Fluvent), Table 1) and 3 dm^3 of cattle manure (aged for 20 days, Table 2).

Table 1. Physical-chemical attributes of the soil used in the experiment.

pH	P	K^+	Na^+	$H^+ + Al^{3+}$	Al^{3+}	Ca^{2+}		Mg^{2+}	SB	CEC	OM
	-------------- mg kg^3 --------------		---------- cmol$_c$/dm^3 ----------								g/kg
6.5	148.9	263.70	0.07	1.34	0.0	3.0		1.34	5.09	6.42	7.1
Sand	Silt	Clay	DC	DF	BD	PD	TP	Moisture			Textural class
2-005mm	0.06-0.002 mm	<0.002 mm	--					0.01	0.33 MPa	1.50	
-------------------- g/Kg --------------------			g/kg	kg/dm^3	g/cm^3	kg/dm^3	m^3/m^3	-------------- g/kg --------------			Loamy sand
801	140	59	0.0	1000	1.54	2.65	0.42	118	125	24	

SB: sum of bases; CEC: cation exchange capacity; OM: organic matter; DC: dispersible clay; DF: degree of flocculation; BD: bulk density; PD: particle density; TP: total porosity.

Table 2. Chemical attributes of the cattle manure used in the experiment.

N	P	K	S	OM
-------------------- g kg^{-1} --------------------				%
17.87	3.95	5.72	3.09	28.5

OM = Organic matter.

Sowing was carried out by planting 10 seeds of Tanzania grass per pot and, after the seedlings reached 5 cm in height, thinning was performed, leaving a stand of 3 plants per sampling unit. At 46 days after sowing, the standardization cut was performed. Then, when the seedlings reached an average height of 65 and 75 cm (90 and 95% of light interception, respectively), based on the inflection of the highest leaf of the plant, measured with a tape measure, the plants were cut to 30 cm height from the ground using grass shears.

During the experiment, doses of 300 and 600 kg of N ha^{-1} were top-dressed in the form of urea according to treatment, considering the soil depth of 0-20 cm, corresponding to 150 and 300 mg N dm^{-3} of soil, respectively. The N doses were split into three portions and applied during the experimental period, with the first application after the standardization cut and the others at 14 and 28 days after the standardization cut. Basal fertilization consisted of 60 kg $P_2O_5^-$ ha^{-1} in the form of single superphosphate as source of P and 60 kg of K_2O ha^{-1} in the form of potassium chloride as source of K, corresponding to 30 mg $P_2O_5^-$ dm^{-3} and 30 mg K_2O dm^{-3} of soil.

Irrigation was performed daily at 4 p.m., using a graduated beaker, to leave the soil with moisture content close to its maximum holding capacity, using the weighing lysimetry method, based on the depth equivalent to 100% of the actual evapotranspiration - ETR, as indicated in Equation 1. The other treatments received water replacement equivalent to the percentages of actual evapotranspiration. The differentiation of the irrigation depths began at 46 days after sowing, soon after the standardization cut.

$$Va = Wfc - Wc \quad (1)$$

Where: Va = volume applied; Wfc = weight of the container at maximum water holding capacity; Wc = current weight of the container.

When the plants individually reached the management goals (90 and 95% LI), they were evaluated for: stem height from the standardization cut (STH), total number of tillers per pot (TNT), total number of leaves per tiller (TNL), number of living leaves per tiller (NLL), number of senescent leaves per tiller (NSL), length of living leaves (LLL), and length of senescent leaves (LSL). STH, LLL, and LSL were measured with a tape measure, whereas TNT, TNL, NLL, and NSL were counted manually. After determining the structural characteristics, a cut was made at 5 cm from the soil surface, and the harvested biomass was weighed on a digital scale to obtain the fresh mass (FM) and then placed in paper bags and dried in a forced air circulation oven at a temperature of 65 ºC until obtaining constant weight of the dry mass (DM).

The data were subjected to analysis of variance; in case of significance ($p < 0.05$), Student's t test was used for the irradiation and nitrogen dose factors and polynomial regression analysis was used for the irrigation depth factor, both at 5% probability level ($p<0.05$). In case of interaction between irrigation depth and the other factors, it was decided to decompose each these other factors within the irrigation depth factor, by means of polynomial regression analysis. SISVAR® software, version 5.6, was used for the analyses (FERREIRA, 2019).

RESULTS AND DISCUSSION

There were significant ($p < 0.05$) effects of the irrigation depths x light interception x nitrogen doses interaction for the variables: total number of tillers, total number of leaves, number of living leaves and average length of living leaves. For stem height, number of senescent leaves, fresh mass and dry mass of Tanzania grass, a significant ($p < 0.05$) individual effect of irrigation depths was observed. For the average length of senescent leaves, a significant individual effect of nitrogen doses was observed.

Stem height increased linearly with the increase in irrigation depths, by 1.25 cm for each 20% increment in the actual evapotranspiration (ETR) in the irrigation depth, ranging from 23.49 cm in plants irrigated with 40% ETR to 28.56 cm in plants irrigated with 120% ETR (Figure 1A). Thus, it is verified that the heights of plants irrigated with the depths of 60 and 80% ETR were reduced by 4.59 and 9.17% compared to those of plants irrigated with 100% ETR, respectively (Figure 1A). The increase in stem height observed in the present study, due to the increase in irrigation depth, has also been observed by Lopes et al. (2014), Luz et al. (2008) and Alencar et al. (2009), when studying grasses of the genera *Brachiaria* (Xaraés grass), *Panicum* (Tanzania grass and Mombaça grass), *Pennisetum* (Pioneiro grass), and *Cynodon* (Estrela grass), respectively. Tropical forage species are efficient in using water, which implies greater production potential (MOMBACH et al., 2019).

Greater availability of water favors the absorption, solubilization and transport of nutrients in plants, resulting in increments in the structural characteristics of forage species (LIMA et al., 2018; COUTINHO et al., 2020; MOMBACH et al., 2019; ARAÚJO JÚNIOR et al., 2019; BRANDÃO et al., 2017). However, the linear increase in stem height as a function of increasing irrigation depths should be carefully evaluated, as stem height restricts intake by cattle due to the physical barrier it imposes on the grazing process. It is important to highlight that the increase in stem height and lower leaf elongation negatively influence forage quality, since the greatest amount of nutrients is found in the leaves (LAGE FILHO et al., 2021).

The total number of tillers showed a quadratic behavior for plants in the treatments: 90% of incident light interception + 300 kg N ha^{-1} $year^{-1}$ (I1N1), 90% of incident light interception + 600 kg N ha^{-1} $year^{-1}$ (I1N2), and 95% of incident light interception + 300 kg N ha^{-1} $year^{-1}$ (I2N1), with the highest number of tillers found under irrigation with depths of 99.0, 101.5, and 88.7% ETR, respectively (Figure

1B). For plants managed with 95% of incident light interception + 600 kg N ha^{-1} $year^{-1}$ (I2N2), there was an increasing linear behavior as a function of the increase in irrigation depth, with estimated increments of 6 tillers for each 20% increment in ETR, which corresponds to a reduction of 18 tillers when comparing plants irrigated with 100% ETR with plants irrigated with 40% ETR (Figure 1B).

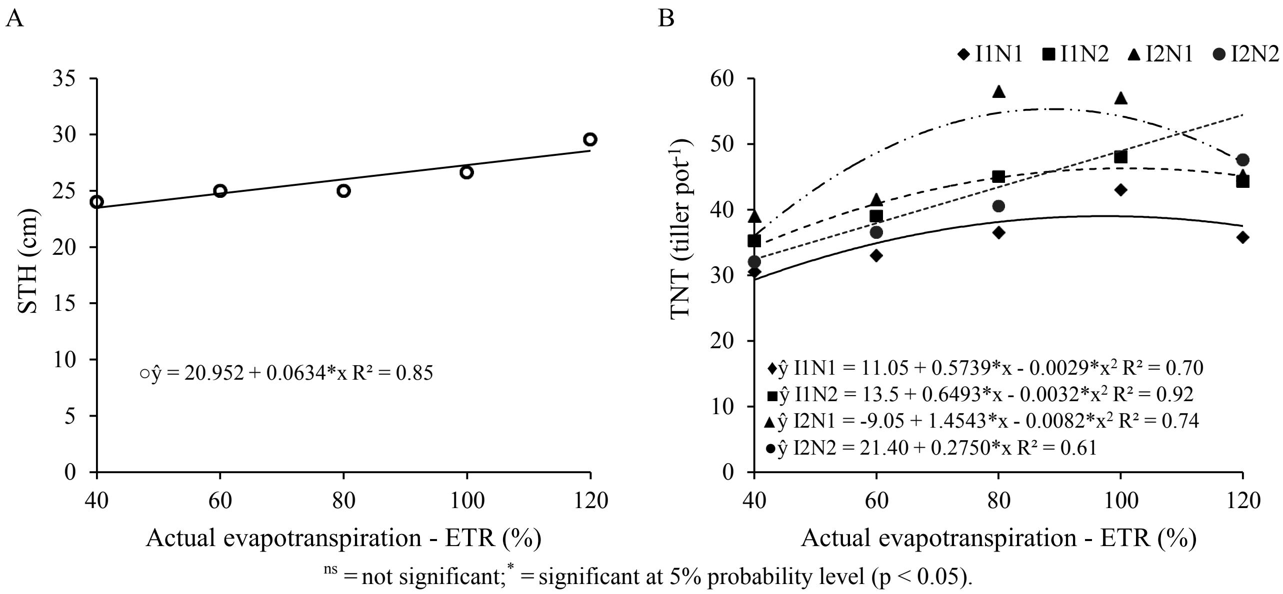
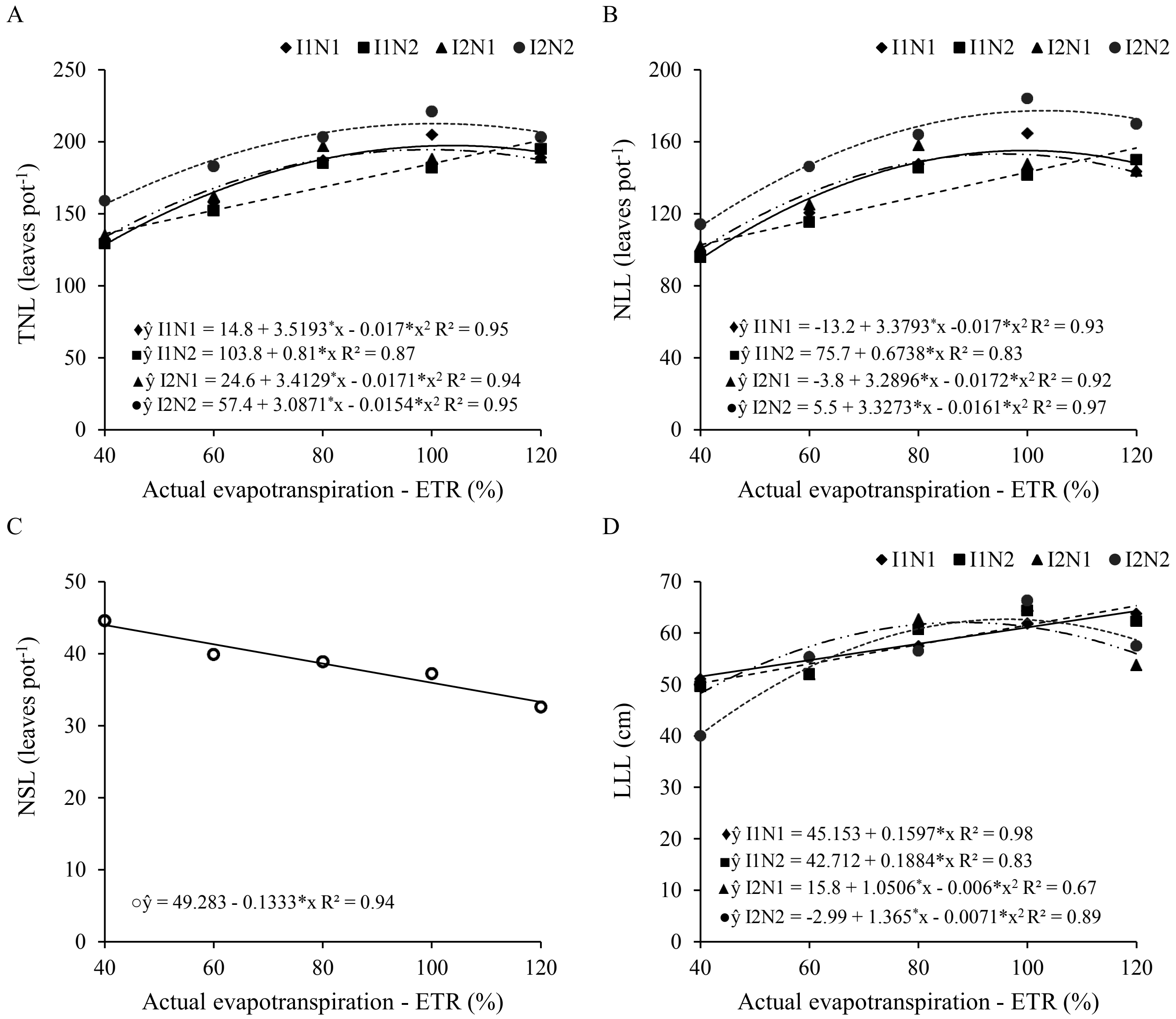


Figure 1. Stem height – STH (A) and total number of tillers – TNT (B) of Tanzania grass plants under different irrigation depths, light interception levels (I1 = 90 and I2 = 95% of incident light interception) and nitrogen doses (N1 = 300 and N2 = 600 kg N ha^{-1} $year^{-1}$).

The reduction in the number of tillers observed in the present study when plants were irrigated with 40% ETR suggests that this depth is below the volume required by the crop to express its maximum tillering. Reducing the number of tillers under water stress conditions is a way for the plant to reduce its growth rate caused by water deficit, due to the reduction in soil water potential. Under water deficit condition, Tanzania grass plants reduce the number of tillers, as a form of adaptation. The reduction in the production of tillers by this forage species causes a decrease in its biomass production, compromising the supply of food for the animals (LAGE FILHO et al., 2021).

Plants that received the highest doses of nitrogen require higher water depths for tillering (Figure 1B). However, when in excess, nitrogen can cause reduction in the osmotic potential of the soil and phytotoxicity effects, which can impair plant growth. Thus, the use of higher water depths favors the efficiency of nitrogen use by plants when excessive N doses are applied to the soil, improving the osmotic potential, besides eliminating part of it by leaching, as observed with the 120% ETR depth.

In the total number of leaves and number of living leaves, a quadratic behavior was observed in all treatments, except for I1N2 (90% LI + 600 kg N ha^{-1} $year^{-1}$). However, plants of the I2N2 treatment (95% LI + 600 kg N ha^{-1} $year^{-1}$) obtained the highest number of leaves under all irrigation depths, except for 120% ETR, with values of 156, 187, 206, and 212 leaves per pot for the depths of 40, 60, 80, and 100% ETR, respectively (Figures 2A and B). As for the irrigation depths, the highest total numbers of leaves were observed under the depths of 103.5, 99.8, and 100.2% ETR, and the highest numbers of living leaves were observed at the depths of 99.4, 95.6, and 103.3% ETR for the treatments I1N1 (90% LI + 300 kg N ha^{-1} $year^{-1}$), I2N1 (95% LI + 300 kg N ha^{-1} $year^{-1}$), and I2N2 (95% LI + 600 kg N ha^{-1} $year^{-1}$), respectively (Figures 2A and B). It is worth mentioning that in all treatments, except I1N2, reductions of total and living leaves when comparing the estimated optimal depths with 80% ETR were lower than 11%, so this depth can be used in the irrigation of the species with small losses, aiming at water saving (Figures 2A and B). This increase in TNL is justified by the adequate water supply to the forage, given that under appropriate conditions, water is responsible for maintaining cell turgor, favoring the performance of high photosynthetic rates and high leaf elongation rate, which is extremely sensitive to water availability (BOYER, 1970). Lage Filho et al. (2021) also found that adequate water availability favors leaf growth and elongation in Tanzania grass plants. Similar results were found by Lopes et al. (2014) and Coutinho et al. (2020), for Brachiaria and Massai grass plants, respectively.



^{ns} = not significant; * = significant at 5% probability ($p < 0.05$)

Figure 2. Total number of leaves – TNL (A), number of living leaves – NLL (B), number of senescent leaves – NSL (C) and average length of living leaves – LLL (D) of Tanzania grass plants under different irrigation depths, light interception (I1 = 90 and I2 = 95% of incident light interception) and nitrogen doses (300 and 600 kg N ha^{-1} year^{-1}) at 90 days after the standardization cut.

Plants of the treatment with 90% LI + 600 kg N ha^{-1} year^{-1} responded in an increasing linear way to the increase in irrigation depth, with the highest total number of leaves and number of living leaves obtained under 120% ETR (Figures 2A and B). Under the other irrigation depths, the results of the treatment with 90% LI + 600 kg N ha^{-1} year^{-1} for these variables were lower than those of the other treatments (90% LI + 300 kg N ha^{-1} year^{-1}, 95% LI + 300 kg N ha^{-1} year^{-1}, and 95% LI + 600 kg N ha^{-1} year^{-1}). The association of 90% LI with 600 kg N ha^{-1} year^{-1} was detrimental to the growth of Tanzania grass plants, and the best responses obtained under 120% ETR occur due to the elimination of nitrogen from the soil via leaching.

The increase in water availability to Tanzania grass plants linearly reduced the number of senescent leaves, with the lowest number (33 leaves/tiller) obtained in plants irrigated with 120% ETR and the highest number (44 leaves/tiller) obtained in plants irrigated with 40% ETR (Figure 2C). This result indicates that the increase in water availability prolongs the leaf longevity of Tanzania grass. According to Ferrari, Paz and Silva (2015), if the soil has low water availability, there will be a decrease in growth rates, dry matter and cell expansion.

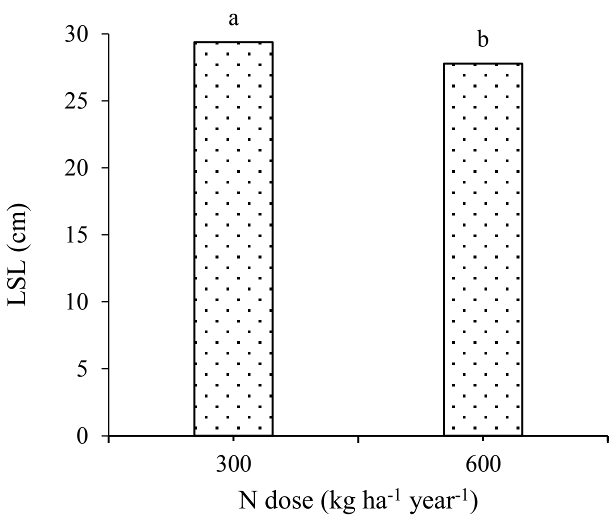
There was a significant ($p < 0.05$) interaction between irrigation depths, light interception and nitrogen doses for the length of living leaves, and it was verified that the average length of living leaves for the treatments I1N1 and I1N2 increased linearly as a function of the increase in water supply, with the longest lengths obtained under 120% ETR (Figure 2D). For the treatments I2N1 and I2N2, the average length of living leaves showed a quadratic behavior as a function of the increase in irrigation depth, with the longest lengths observed under the depths of 87.6 and 96.1% ETR, respectively (Figure 2D). It can be seen that plants of the treatment I2N1 obtained better results for the length of living leaves, with a lower water requirement. It is worth mentioning that, under the depth of 80% ETR, growths at most 10% lower were found when compared to the optimal depths estimated in the treatments I2N1 and I2N2 (Figure 2D).

The concept of critical leaf area index, in which 95% light interception is used for the management of temperate climate grasses, is valid and can be applied to the tropical grasses *P. maximum* Mombaça (CARNEVALLI et al., 2006) and Tanzania (BARBERO et al., 2014; MACEDO et al., 2017; LAGE FILHO et al., 2021) and with the cultivars *B. brizantha* Xaraés (PEDREIRA; PEDREIRA; SILVA, 2007) and Marandu (GIACOMINI et al., 2009). It was found here that the interruption of growth with 90% of the incident light reduces the production of tillers (Figure 1B) and the production, longevity and length of the leaves (Figures 2A, B and D) of Tanzania grass plants, making the regrowth less vigorous. Therefore, this condition is not suitable for Tanzania grass management, as the interruption of growth limits the production potential of the forage.

The light intensity of 95% is considered adequate for Tanzania grass, as plants accumulate more biomass (MACEDO et al., 2017). In the present study, the light interception of 95% corresponded to the average height of 75 cm, which is considered adequate for the defoliation of this forage (BARBERO et al., 2014). The height of Tanzania grass plants can vary according to the purpose of production and management; according to Silveira (2020), the recommended grazing height for Tanzania grass subjected to continuous stocking regime is between 40 and 60 cm and, for the rotational grazing condition, the ideal is the entry with a height between 65 and 70 cm. The management of Tanzania grass with heights between 60 and 80 cm promotes accumulations of leaf blades, being indicated when the objective is the use of pastures in the dry season (BARBERO et al., 2014).

Associating the interruption of growth with 95% LI with nitrogen dose of 600 kg N ha^{-1} year^{-1} promoted more vigorous regrowth, with a higher number of total and living leaves. When defoliation management and nitrogen fertilization are adequate, they promote growth in forage species, reducing their cycle and increasing production (SOUZA; BITTAR, 2021). Efficiency in the use of nitrogen promotes greater tillering and more vigorous regrowth, as it favors cellular recovery (SOUZA; BITTAR, 2021; OLIVEIRA et al., 2022).

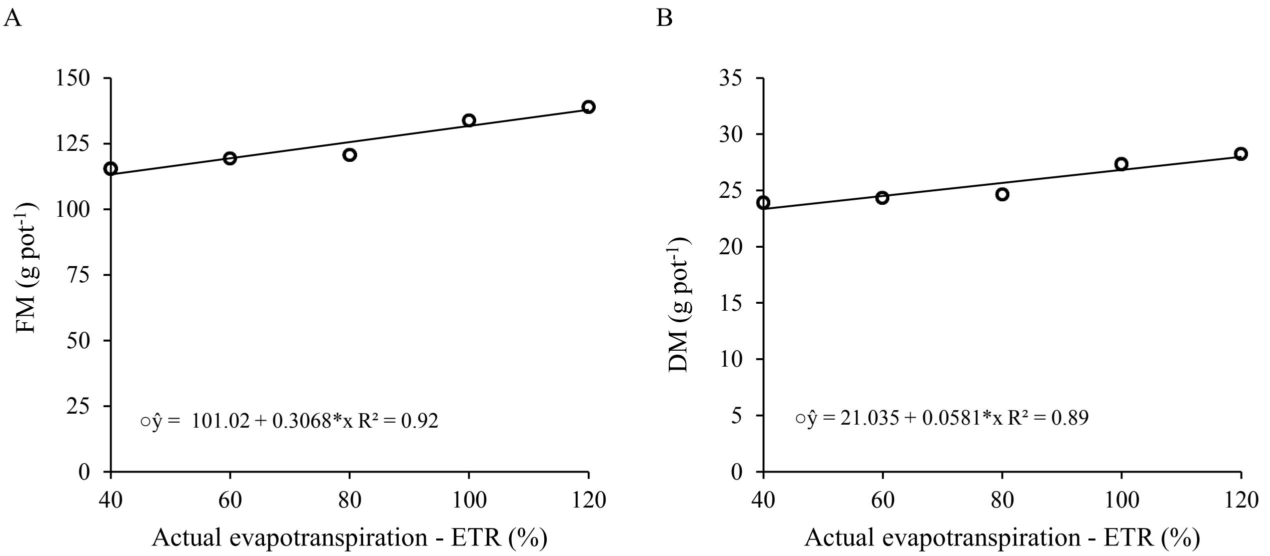
Tanzania grass plants fertilized with 300 kg N ha^{-1} year^{-1} obtained higher average length of senescent leaves, 29.4 cm, which is 5.76% higher than the average length of dry leaves of plants fertilized with 600 kg N ha^{-1} year^{-1}, respectively (Figure 3). Similarly, Costa et al. (2016) found a quadratic effect of nitrogen fertilization (0, 80, 160, 240 and 320 kg N ha^{-1} year^{-1}) on the average length of leaves of *P. maximum* cv. Massai, estimating the maximum values with the application of 302 kg N ha^{-1} year^{-1}. It can be concluded that the response of plants to nitrogen was variable in relation to species and cultivars of the same species, but in both experiments the best dose is close to 300 kg N ha^{-1} year^{-1}.



Equal letters do not differ by Student's t-test at 5% probability level (p<0.05)

Figure 3. Average length of senescent leaves (LSL) of Tanzania grass plants under different nitrogen doses (300 and 600 kg N ha^{-1} year^{-1}) at 90 days after standardization cut.

FM and DM increased with the increase in irrigation depth, with increments of 21.7 and 19.9%, when comparing plants irrigated with 40 and 120% ETR, which had 137.84 and 28.01 g of FM and DM under the 120% ETR depth, respectively (Figures 4A, B). This is possible due to the fact that the increase of water available in the soil is related to the higher biomass production in forage plants, a condition that is indispensable for the solubilization and transport of nutrients, favoring plant development (LIMA et al., 2018). Lima et al. (2018) observed a significant effect of the irrigation depth of 100% on shoot dry mass, root dry mass and total dry mass, but the irrigation depth corresponding to 50% caused reductions of 46.88, 46.52, and 46.81% in these variables, respectively. Similar results for dry and fresh mass have been found by Coutinho et al. (2020) and Brandão et al. (2017), for Massai and Mombaça grass plants, respectively. The FM and DM under the 100% ETR depths were 131.7 and 26.8 g, while in plants irrigated with 80% ETR the values were 125.6 and 25.7 g, indicating reductions of 4.6 and 4.1% in the FM and DM of Tanzania grass plants, respectively. These results indicate that the 80% ETR depth is viable for Tanzania grass production, with small production losses (4.1-4.6%) (Figures 4A, B).



^{ns} = not significant; * = significant at 5% probability ($p < 0.05$)

Figure 4. Fresh mass – FM (A) and dry mass – DM (B) of Tanzania grass plants under different irrigation depths, light interception (I1 = 90 and I2 = 95% of incident light interception) and nitrogen doses (300 and 600 kg N ha^{-1} year^{-1}).

CONCLUSIONS

Irrigation depth of 80% ETR is suitable for Tanzania grass cultivation, with biomass losses of less than 5%.

Interruption of growth with 95% of incident light and fertilization with 600 kg N ha^{-1} year^{-1} improve the structural characteristics, such as tillering and number of leaves, of Tanzania grass under deficit irrigation.

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