Growth and physiological responses of young plants of *Dendrocalamus asper* (Poaceae: Bambusoideae) under water stress

Crescimento e respostas fisiológicas de plantas jovens de *Dendrocalamus asper* (Poaceae: Bambusoideae) submetidas a estresse hídrico

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ABSTRACT
Understanding how water stress impacts the growth and physiology of young bamboo plants is important to define management strategies and successful field establishment of

the species. In this study, young plants of *Dendrocalamus asper* were evaluated to determine the effects of water availability in the initial phase of growth and the physiological behavior of the species under these conditions. Four water deficit conditions (0%, 25%, 50% and 100% of field capacity) were applied in a completely randomized design. The plants were grown in pots under a tunnel-type greenhouse environment. At 7 and 30 days of imposition of treatments, growth characteristics and gas exchange were evaluated, and at 30 days, Chl *a* fluorescence, pigment concentration and dry mass were analyzed. Water stress affected the growth and gas exchange of young *D. asper* plants. Under lower water availability (25%), the plants had a significant reduction in the dry mass of leaves and stems at 30 days and, interestingly, a greater number of shoots was observed. Although photosynthetic efficiency did not differ statistically, *D. asper* plants have reduced stomatal conductance (g_s) and transpiration (E) under higher water restriction (50% and 25%), and higher P_N (net photosynthesis) under 50% of the field capacity. The behavior observed in young plants of *D. asper* shows tolerance to the level and period of imposed water stress. In addition, shoot emission seems to be the main survival strategy when cultivated under 25% of water availability. This study provides an initial analysis of the impact of water deficit on clonal plantlets of *Dendrocalamus asper*, and further research is needed to identify the physiological and biochemical mechanisms of this species under greater stress period.

Keywords: bamboo, water deficit, abiotic stress, gas exchange.

RESUMO

Compreender como o estresse hídrico impacta o crescimento e a fisiologia de plantas jovens de bambu é importante para definir estratégias de manejo e o sucesso no estabelecimento em campo de espécies cultivadas. Neste estudo, plantas jovens de *Dendrocalamus asper* foram avaliadas para determinar os efeitos da disponibilidade de água na fase inicial do crescimento e comportamento fisiológico da espécie. Para tanto, quatro tratamentos hídricos foram aplicados (0%, 25%, 50% e 100% da capacidade de campo), em delineamento inteiramente ao acaso. As plantas foram cultivadas em vasos sob ambiente de estufa tipo túnel. Aos 7 e 30 dias de imposição dos tratamentos, foram avaliadas características de crescimento e trocas gasosas, e aos 30 dias analisada a fluorescência da Chl*a*, e concentração de pigmentos e a massa seca. Verificou-se que o estresse hídrico afetou o crescimento e as trocas gasosas de plantas jovens de *D. asper*. Sob menor disponibilidade de água (25% cc), as plantas tiveram redução significativa da massa seca de folhas e colmo aos 30 dias e, interessantemente, maior número de brotos. Apesar da eficiência fotossintética não diferir estatisticamente, plantas de *D. asper* têm redução da condutância estomática (gs) e transpiração (E) sob maior restrição hídrica (50% e 25% cc), e maior P_N (fotossíntese líquida) sob 50% da capacidade de campo. O comportamento observado em plantas jovens de *D. asper* evidencia tolerância ao nível e período de estresse hídrico imposto. Além disso, a emissão de brotações parece ser a principal estratégia de sobrevivência quando cultivada sob 25% da disponibilidade hídrica. Este estudo fornece uma análise inicial do impacto do déficit hídrico em mudas clonais de *Dendrocalamus asper*, sendo necessárias pesquisas para identificar os mecanismos fisiológicos e bioquímicos dessa espécie sob maior período de estresse.

Palavras-chave: bambu, déficit hídrico, estresse abiótico, trocas gasosas.

1 INTRODUCTION

Global food security and the sustainability of plant production are constantly threatened by the dynamics of climatic factors such as temperature, light intensity and rainfall (SELEIMAN et al., 2021). Among them, the occurrence of water stress is the most limiting factor due to the negative impacts on the survival, distribution and productivity of cultivated plants. Water is essential in virtually all plant physiological processes, from cell expansion and division, absorption and transport of nutrients and metabolites, and maintenance of photosynthetic efficiency (SCHARWIES; DINNENY, 2019).

In response to low water availability, plants reduce primary processes such as cell expansion and division, increase stomatal closure and thermal dissipation mechanisms and antioxidant defenses (LAXA et al., 2019). As a consequence, there are changes in the dynamics of root and shoot growth to optimize biomass allocation. Furthermore, water stress alters chlorophyll production, photochemical activity and damages cell membranes (LIU et al., 2017).

Bamboos are plants of socioeconomic and environmental importance, distributed in tropical, subtropical and temperate regions (FELISBERTO et al., 2017) and represent an important resource for sustainable forest development (MUSTAFA et al., 2021). The species *Dendrocalamus asper* (Schult. & Schult.f.) Baker ex K. Heyne, known as giant bamboo or *bambu balde*, is the bamboo with the largest diameter and stalk length cultivated in Brazil, used as raw material for construction, industry and ornamental use (TOMBOLATO; GRECO; PINTO, 2012), and one of the most versatile and commercially cultivated species (MUSTAFA et al., 2021)

The impact of water stress on the growth and physiology of bamboo plants is reported for species such as *Phyllostachys heterocycla* (WU et al., 2019) and *P. edulis* (WU et al., 2018), *Dendrocalamus membranceus* (CHAN et al., 2018), *Fargesia ruga* (dwarf bamboo) (LIU et al., 2017), *Bambusa vulgaris,* and *Bambusa blumeana* (DIERICK et al., 2010). Short-term moderate water stress induced by PEG-6000 increased the resistance of *D. membranaceus*, for example. Research also shows that the application of phosphorus (P) in *Fargesia ruga* plants promotes improvements in the CO_2 assimilation rate by regulating energy dissipation and increasing the production of antioxidant enzymes under water stress.

Interestingly, research conducted with *Phyllostachys heterocycla*, a sprawling bamboo species (with interconnected ramets), showed different water use strategies under water restriction (WU et al., 2019). According to the authors, young culms tolerate drought, while old culms tend to adopt the drought avoidance as a strategy. It was also observed that both types of stem are able to maintain the sap flux density relatively stable through structural and physiological adjustments. Despite the advances made on water use strategies by bamboo, the impact of water stress on young plants is poorly understood and there are no studies with the species *Dendrocalamus asper*. In addition, phyto technical management during the establishment of plants in the field depends on research that contributes to the effective use of water resources, especially under conditions of excess or scarcity of water.

In this study, young plants of *Dendrocalamus asper* were evaluated to determine the effects of water availability on the growth and physiological behavior of the species and, with that, to support management strategies and success in the cultivation of this plant. According to the results, the imposition of water restriction for 30 days reduces biomass production, without significantly impacting the photosynthetic efficiency of young plants of *D. asper*.

2 MATERIAL AND METHODS

2.1 PLANT MATERIAL AND GROWING CONDITIONS

The experiment was carried out with young plants of *Dendrocalamus asper* obtained by micropropagation. For this, shoots maintained *in vitro* were cultivated in liquid MS medium (MURASHIGE; SKOOG, 1962), supplemented with sucrose (30 $g.L^{-1}$) and without the addition of phyto regulators, for 45 days in growth room conditions at a temperature of 25±4ºC and photoperiod of 16 hours under 100 $\mu mol.m^2.s^{-1}$ (LED/Decorlux TL-1216 / 10W lamps; 940lm – 6500K).

Then, the plants were removed from the culture flasks, standardized and their roots were washed in running water. Soon after, they were transferred to transparent polyethylene cups (500 mL capacity), perforated at the bottom and filled with a mixture of sand and commercial substrate (Vivatto Technes – Cabreúva, SP), at a ratio of 1:1 (v/v), being kept in a humid chamber system for 7 days in the growth room (pre-acclimatization). Subsequently, the plants were transferred to a greenhouse environment for another 115 days for acclimatization.

After acclimatization, they were transplanted into polystyrene pots with a capacity of five liters, filled with substrate of the same composition. Then, the pots were placed on benches in a tunnel-type greenhouse environment, where they remained for 60 days.

During this period, the plants were kept at 100% of the field capacity (fc), previously established as the mass of water retained by the dry substrate after suffering saturation and subsequent drainage of the excess. In addition, localized fertilization was performed using 50 g of Basacote@ mini fertilizer.

2.2 WATER TREATMENTS

To evaluate water stress, four treatments were applied (0%, 25%, 50% and 100% of field capacity). The water treatments of 25% and 50% of the fc were established by calculating the respective percentages of the water mass retained at 100% field capacity. Water maintenance was carried out by weighing the vessels daily and with the appropriate replacement of the transpired water mass, with the aid of a digital scale. The 0% of the fc treatment did not receive irrigation during the period of water stress.

2.3 VARIABLE GROWTH RESPONSES

The evaluations were carried out at 7 and 30 days of the water treatments and included: stem diameter (mm), shoot length (cm) and number of expanded leaves and shoots. At 30 days, the dry mass of leaves, stem and roots was also quantified, after drying in an oven with forced air circulation at 65 °C, until reaching constant mass.

2.4 GAS EXCHANGE

The measurement of gas exchange was performed with the aid of a portable infrared gas analyzer (IRGA, model LI-6400 XT, LI-COR Inc., CA, USA), between 8 am and 11 am. For this, the central region of the blade of the youngest and fully expanded leaf was chosen. The following parameters were evaluated: net photosynthesis (P_N, μmol m^{-2} s^{-1}), stomatal conductance (g_s, mol of H_2O $m^{-2}s^{-1}$), leaf transpiration (E, mmol of H_2O m^{-2} s^{-1}) and partial pressure of CO_2 (Ci, μmol $m^{-2}s^{-1}$). During measurements, conditions in the IRGA chamber were controlled, with temperature maintained at 30 °C, 400 ppm CO_2 and photon flux density (PPFD) of 1200 μmol photons $m^{-2}s^{-1}$.

The water use efficiency (WUE) was calculated by the ratio P_N/E, while the carboxylation efficiency (CE) was evaluated by the ratio P_N/Ci. The intrinsic water use efficiency (iWUE) was determined by the ratio P_N/g_s.

2.5 CHLOROPHYLL *A* FLUORESCENCE

Chlorophyll *a* fluorescence analysis was performed with the aid of a fluorometer (LI-400-40) coupled to the IRGA, on the same leaves used for the gas exchange. The following parameters were analyzed: current quantum efficiency of photosystem II ([ΔF/Fm' = (Fm'-Fs) / Fm'], photochemical quenching [qP = (Fm' - Fs) / (Fm' - Fo')] and electron transport rate [ETR = ((Fm' - Fs) / Fm') x PPFD x 0.4 x 0.85]. For ETR evaluation, 0.4 was used as the fraction of excitation energy distributed to photosystem II in C4 plants and 0.85 as the fraction of light absorbed by the leaves and PPFD as the photosynthetic photon flux density.

Then, the leaves were dark-adapted for at least 25 min, covering the entire leaf blade area with aluminum foil. Afterwards, the potential quantum efficiency of photosystem II [Fv/Fm = (Fm - Fo) / Fm] and non-photochemical quenching [NPQ = (Fm - Fm') / Fm'] were analyzed. Fm and Fo are maximum and minimum fluorescence of dark-adapted leaves; Fm' and Fs are maximal fluorescence and in dynamic equilibrium in light-adapted leaves and Fo' is the minimum fluorescence after far-red illumination of leaves previously exposed to light.

2.6 RELATIVE WATER CONTENT (RWC)

The RWC was determined considering 0.1 g of leaf tissue (LT), which was transferred to a petri dish containing filter paper moistened with 10 ml of reverse osmosis water, being kept for 24 hours in a refrigerated environment (4 °C) and protected from light. After this period, the excess of water in the tissue was removed using paper towels to obtain the turgid mass (TM). Subsequently, the leaf tissue was transferred to a paper bag and taken to an oven with forced air circulation at 65 °C until constant mass was reached. At that moment, the dry mass (DM) was determined. The RWC was obtained by the formula: RWC = [(LT - DM) / (TM - DM)] x 100 (WEATHERLEY, 1950).

2.7 MEMBRANE DAMAGE (MD)

Cell membrane integrity was estimated from electrolyte leakage (AVILA et al., 2020), with modifications. For this, 100 mg of tissue extracted from the medial region of the leaf blade was transferred to a test tube containing 18 mL of reverse osmosis water for 24 hours at room temperature. The conductivity (C_1) of the aqueous solution was then measured with a conductivity meter (Digimed DM-32). Then, the samples were submitted to a water bath at 100 °C for 1 h and, after cooling to room temperature, the electrical conductivity was measured again (C_2). Membrane damage was estimated by the formula: MD = (C_1/C_2) x 100

2.8 CHLOROPHYLL AND CAROTENOID CONTENTS

The quantification of pigments was performed using 50 mg of fresh leaf blade, which after being fragmented, was transferred to a test tube containing 5 ml of 80% acetone (v/v), kept in the dark for 48 h. The absorbance measurements in a spectrophotometer were performed at three wavelengths: 470 ηm, 644.8 ηm and 661.6 ηm. The levels of chlorophyll *a* (Chl_a), chlorophyll *b* (Chl_b), total chlorophyll (Chl_{total}) and carotenoids (C_{x+c}), in µg/ml of solution, followed Lichtenthaler (1987).

2.9 EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS

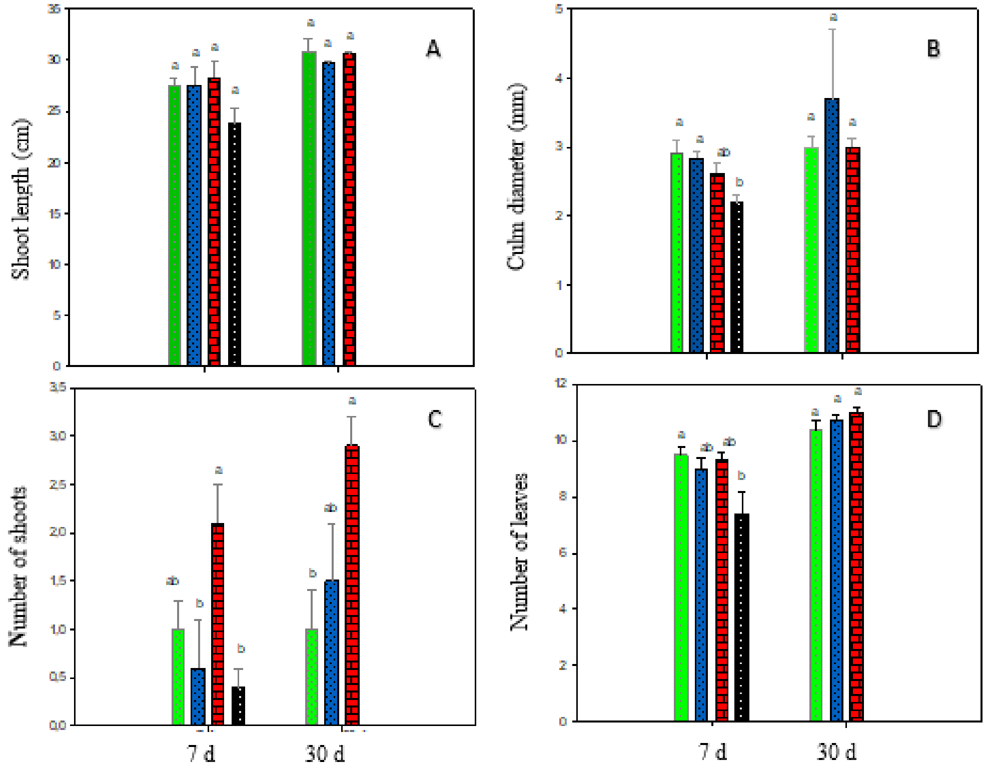
Four water treatments were imposed with 5 replications (n=20), in a completely randomized design, with each experimental unit represented by a pot with one plant. The variables were analyzed using ANOVA, and the means were compared using the Tukey test ($p < 0.05$), with the aid of the SISVAR 5.6 software (FERREIRA, 2011).

3 RESULTS

The growth and physiology of young plants of *Dendrocalamus asper* were influenced by exposure time and water stress intensity. In addition, plants submitted to the absence of irrigation did not survive the 30 days of the treatment imposition. Most plants died after 15 minutes of stopping irrigation. At 7 and 30 days, the plants did not show statistically significant differences for the variable length of the shoot (Figure 1A).

As for the diameter, it was found that in the period of 7 days, the bamboo plants submitted to 0 and 25% fc, in general, presented smaller diameter, not differing statistically from each other, while those that were in 25% fc did not differ ($p<0.05$) from plants grown under 100 and 50% fc (Figure 1B). At 30 days, plants submitted to 100, 50 and 25% fc treatments did not show statistically significant differences in plant diameter.

Figure 1. Growth of young plants of *Dendrocalamus asper* under water stress conditions, at 7 and 30 days after treatments.



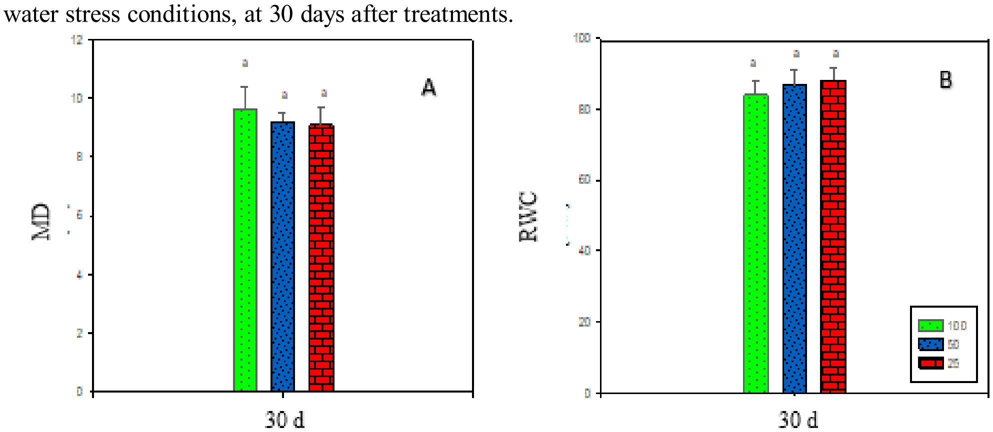
Legend: A - shoot length (cm); **B -** culm diameter (mm); **C -** number of shoots; **D -** number of leaves. Green bars – irrigation with 100% of the pot capacity; Blue bars - irrigation with 50% of the pot capacity; Red bars – irrigation with 25% of pot capacity; Black bars – no irrigation. Different letters within each assessment period indicate significant differences between treatments.

Interestingly, for the number of shoots variable, at 7 days, the plants that were at 100 and 25% fc had the highest number, not statistically different from each other, but differing from the other treatments (Figure 1C). At 30 days, it can be observed that plants treated at 25% fc had a higher number of shoots, statistically different from plants that were at 100% fc, which had a lower number of shoots (Figure 1C). The plants in the 50% fc treatment did not differ compared to the 25% fc treatment, nor those that were in 100% fc.

Although not statistically evaluated, the plants that were at 100% fc were quite homogeneous in terms of the number of shoots between the 7th and 30th day of the experiment (approximately 1 shoot), different from the plants of the other treatments where there was clearly an increase in the number of shoots with the time of cultivation, with the exception of plants submitted to the absence of irrigation, which did not survive. For the variable number of leaves at 7 days it was found that significant differences were only observed between treatments 0 and 100% fc. At 30 days of the experiment, the plants showed no differences in the number of leaves formed due to the treatment used (Figure 1D).

After 30 days from the beginning of the experiment, data on membrane damage, relative water content, total chlorophyll, chlorophyll *a* and *b* ratio, carotenoid, and plant dry mass were also evaluated. In the evaluations, the control treatment (0% fc) could only be evaluated for the dry mass variable. For the other variables, it was not possible to evaluate this treatment because the plants died. Figure 2 shows the results regarding membrane damage (MD) and relative water content (RWC) of plants at 25, 50 and 100% fc, which did not differ statistically in face of the water availability.

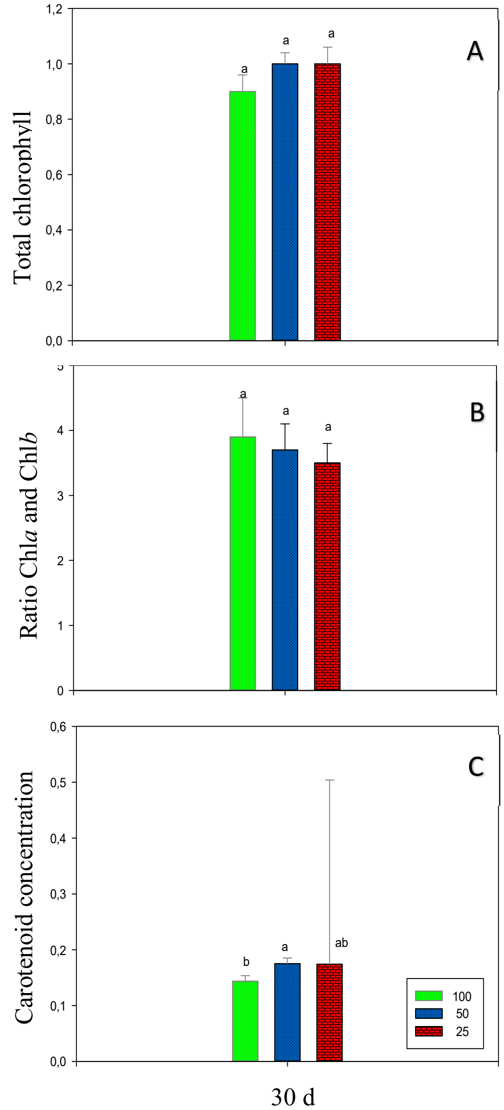
Figure 2. Membrane damage and relative water content of young plants of *Dendrocalamus asper* under water stress conditions, at 30 days after treatments.



Legend: A - Membrane damage (MD) and **B -** Relative water content (RWC). Green bars – irrigation with 100% of the pot capacity; Blue bars - irrigation with 50% of the pot capacity; Red bars – irrigation with 25% of pot capacity. Different letters within each assessment period indicate significant differences between treatments.

The total chlorophyll concentration and the chlorophyll *a* and *b* ratio also showed no statistically significant differences among the water stress treatments tested (Figure 3). However, it can be observed that the average for total chlorophyll of the 100% fc treatment was lower than that of the 50 and 25% fc treatment, which had a lower average for the chlorophyll ratio *a* and *b* (Figura 3B). On the other hand, when carotenoids were evaluated, it was verified that the leaves of the plants of the 100% fc treatment presented, in general, lower values than those of the other treatments.

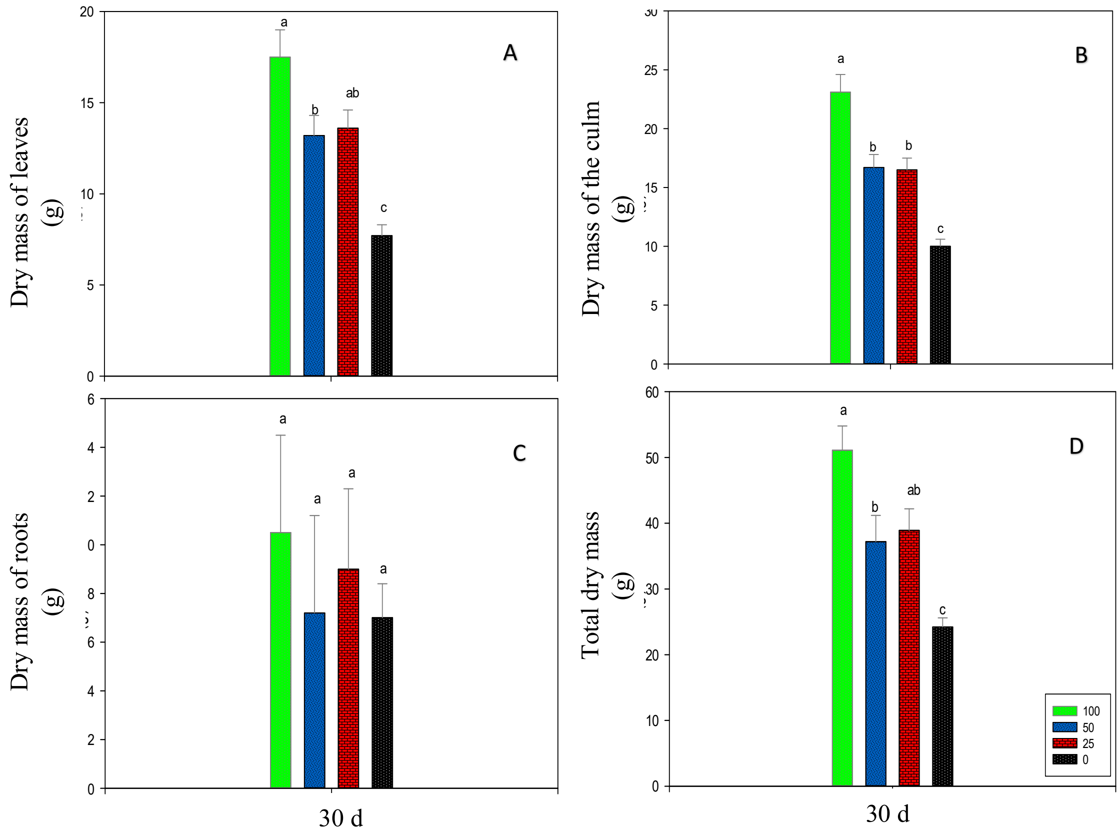
Figure 3. Total Chlorophyll, Chl*a*/Chl*b* and concentration of carotenoids from young plants of *Dendrocalaums asper* under water stress conditions, at 30 days after treatments.



Legend: A - Total chlorophyll; **B -** Ratio Chl*a* and Chl*b* and **C** – Carotenoid concentration. Green bars – irrigation with 100% of the pot capacity; Blue bars - irrigation with 50% of the pot capacity; Red bars – irrigation with 25% of pot capacity. Different letters within each assessment period indicate significant differences between treatments.

The dry mass data of *D. asper* plants at 30 days of experiment are shown in Figure 4. In general, it was verified that the plants of the 100% fc treatment had higher dry mass in all the analyzed characteristics (leaf, stem and total dry mass), with the exception of the variable root dry mass, where no differences were observed among the water treatments (Figure 4A-D). In the evaluation, it was also possible to verify that the plants of the treatments 50 and 25% did not differ among themselves for any variable studied, suggesting a similar behavior of the plants in both cultivation conditions. Furthermore, it was found that when it was possible to evaluate, the plants of the treatment without irrigation were always the ones that presented the lowest values for the variables, with the exception of the dry weight of the roots, which did not present significant differences between the treatments (Figure 4A-D). Still, the average root mass was higher in plants grown under 100% and 25% of the field capacity.

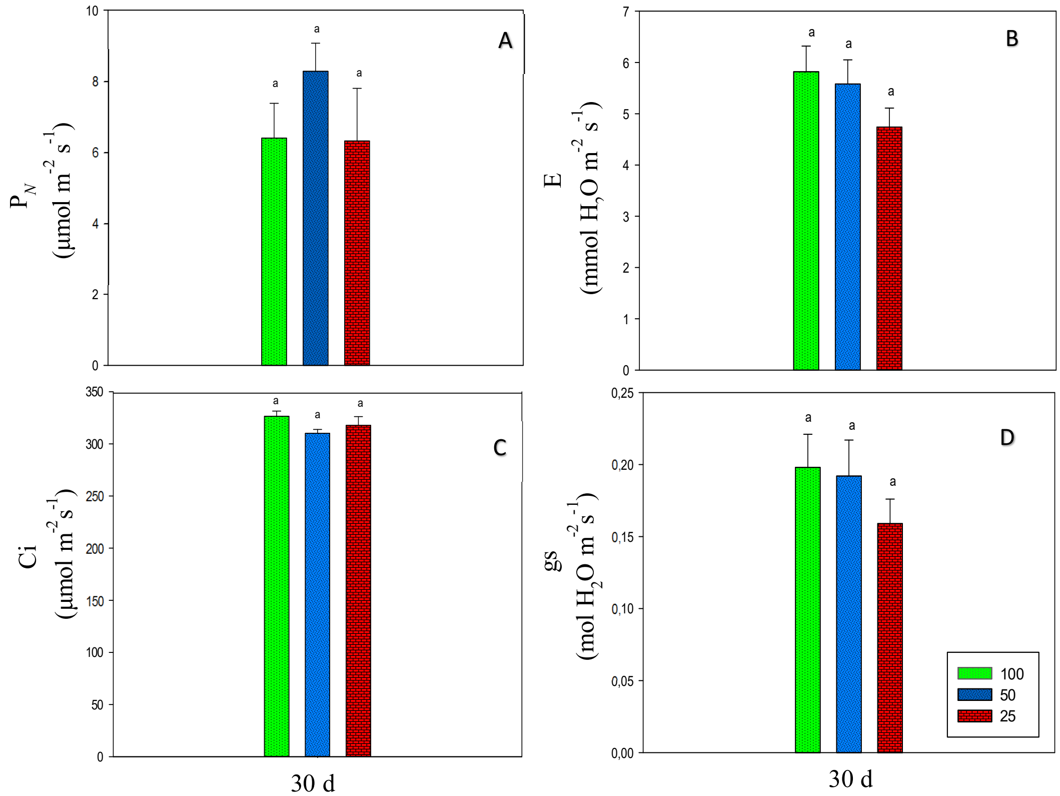
Figure 4. Production of dry mass of leaves, stems, roots and total young plants of *Dendrocalaums asper* under water stress conditions, at 30 days after treatments.



Legend: **A -** Dry mass of leaves (g); **B -** Dry mass of the culm (g); **C -** Dry mass of roots (g) e **D -** Total dry mass (g). Blue bars - irrigation with 50% of the pot capacity; Red bars – irrigation with 25% of pot capacity; Black bars – no irrigation. Different letters within each assessment period indicate significant differences between treatments.

The variables net photosynthesis (P_N), transpiration (E), partial pressure of CO_2 (Ci) and stomatal conductance (g_s) of the plants showed no statistically significant differences at 30 days in any of the water treatments studied (Figure 5). However, it can be observed that the plants submitted to 50% fc showed higher averages for photosynthesis than the plants submitted to the treatments of 100 and 25% fc and that, from then on, for all other variables, the plants of the 100% fc treatment showed the highest means compared to the other treatments (Figure 5A-C).

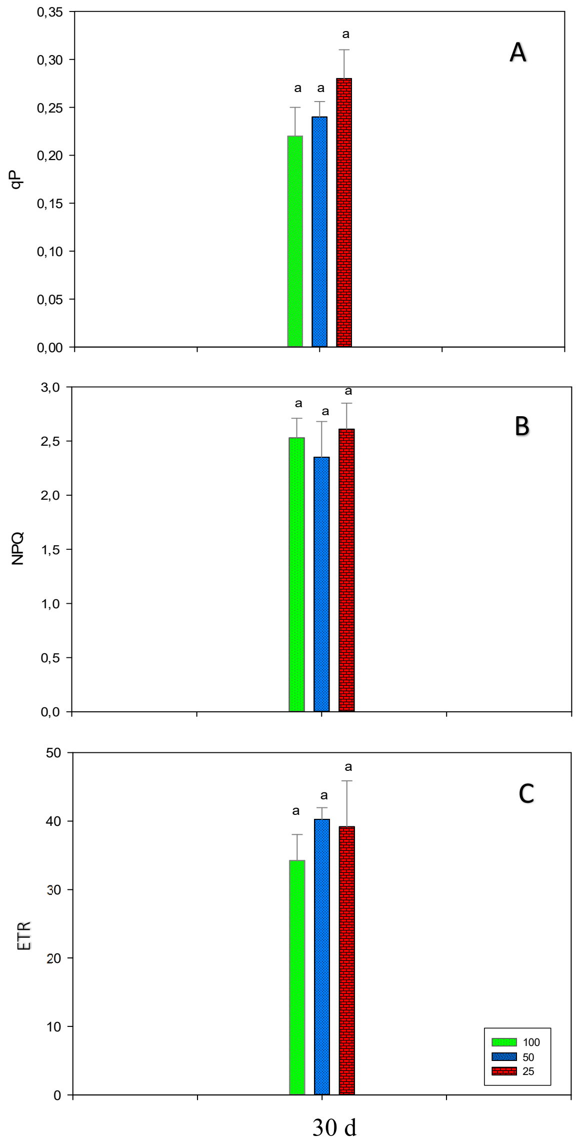
Figure 5. Net photosynthesis (P_N) and Gas exchange of young plants of *Dendrocalamus asper* under water stress conditions, at 30 days after treatments.



Legend: A - Liquid photosynthesis (P_N); **B -** transpiration (E); **C -** partial pressure of CO_2 (Ci) and **D -** stomatal conductance (g_s). Blue bars - irrigation with 50% of the pot capacity; Red bars – irrigation with 25% of pot capacity. Different letters within each assessment period indicate significant differences between treatments.

Regarding the chlorophyll *a* fluorescence analysis, there were no statistically significant differences for photochemical (qP) and non-photochemical (NPQ) quenching, rate of electron transport (ETR), effective quantum efficiency (ΔF/Fm’) and potential quantum efficiency of photosystem II (Fv/Fm) (Figure 6). In spite of that, it was verified that when submitted to 25% fc, the plants of *D. asper* presented, on average, values of qP and NPQ slightly higher than the plants of the other treatments, while for ETR the means observed were slightly lower than those at 50%.

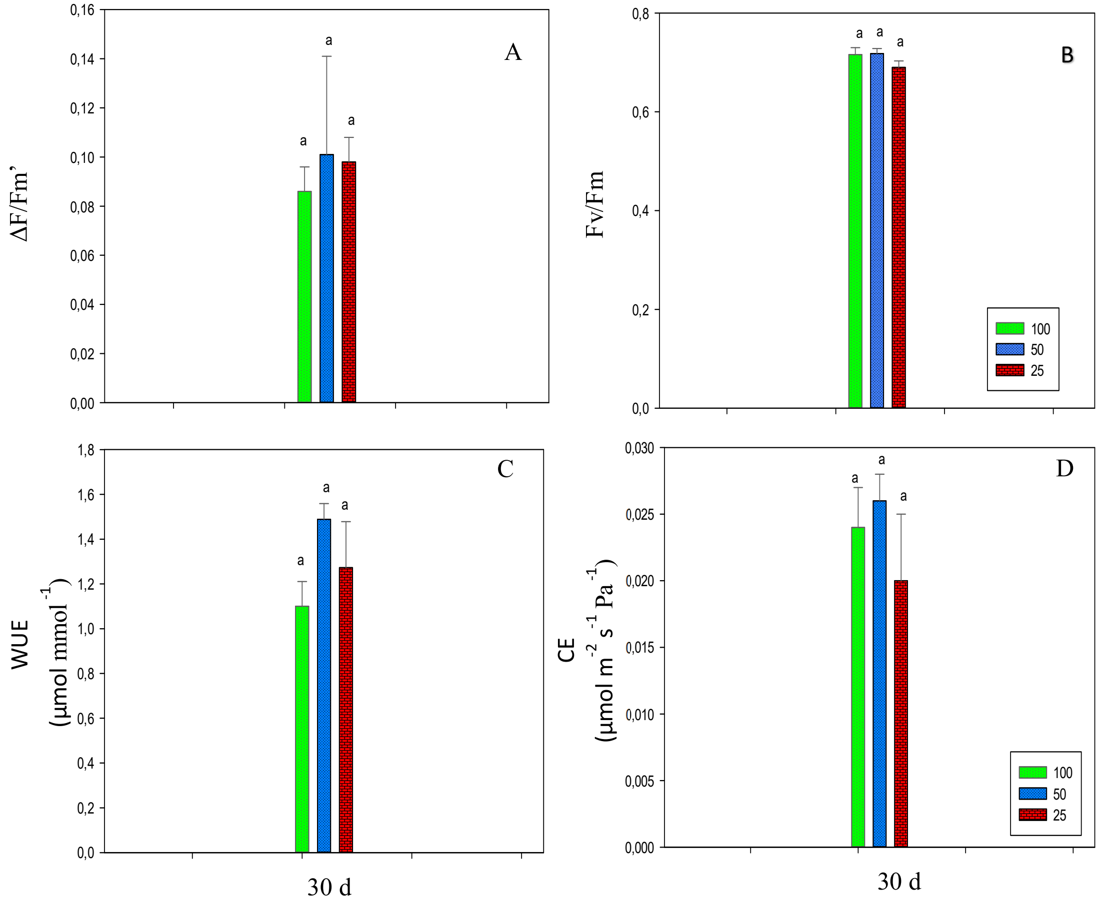
Figure 6. Photochemical (qP) and non-photochemical (NPQ) quenching and electron transport rate (ETR) of young *D. asper* plants under water stress conditions, at 30 days after treatments.



Legend: A - photochemical quenching (qP); **B -** non-photochemical quenching (NPQ); **C -** electron transport rate (ETR). Blue bars - irrigation with 50% of the pot capacity; Red bars – irrigation with 25% of pot capacity. Different letters within each assessment period indicate significant differences between treatments.

As observed for most of the physiological variables described above, both for the effective quantum efficiency (ΔF/Fm'), as for the potential quantum efficiency of photosystem II (Fv/Fm), water use efficiency (WUE) and carboxylation (CE), the plants in the different treatments did not present statistically significant differences (Figure 7A-D). Although they did not differ statistically, the water use (WU) and carboxylation efficiency (CE) were higher in plants submitted to 50% irrigation.

Figure 7. Effective quantum efficiency (ΔF/Fm'), potential quantum efficiency of photosystem II (Fv/Fm), Water use efficiency (WUE) and carboxylation efficiency (CE) of young *Dendrocalamus asper* plants under water stress conditions, at 30 days after treatments.



Legend: A - Effective quantum efficiency (ΔF/Fm'); **B -** Potential quantum efficiency of photosystem II (Fv/Fm); **C** - Water use efficiency (WUE); **D -** Carboxylation efficiency (CE). Blue bars - irrigation with 50% of the pot capacity; Red bars – irrigation with 25% of pot capacity. Different letters within each assessment period indicate significant differences between treatments.

4 DISCUSSION

Plants respond directly to changes in the environment by altering their morphophysiology and biochemical processes to ensure survival and reproduction under adverse environmental conditions (LAXA et al., 2019; FANG, XIONG, 2015). Under drought stress, these processes include improvements in the root system, leaf structure, relative water content and stomatal regulation, in addition to cellular and molecular mechanisms. Thus, to mitigate the effects of water deficit, it is very important to determine plant responses and the mechanisms involved in drought tolerance (ILYAS et al., 2021).

In the present study, young plants of *Dendrocalamus asper* were evaluated to determine the effects of water availability on the growth and physiological behavior of the species and, with that, to support management strategies and success in the cultivation of this plant. According to the results, the imposition of water restriction for 30 days significantly reduces the dry biomass of leaves, stems and total, without, however, affecting the dry mass of roots. Still, plants submitted to 25% of the water capacity seem to use the higher production of shoots as an adaptation strategy to the low availability of water in the soil.

Changes in water and nutrient availability impose on plants the need to optimize growth and biomass allocation by altering root and shoot growth dynamics. As a consequence, increased root growth (in absolute terms or in relation to the aerial part of the plant) is a common response to reduced water availability (KUDOYAROVA et al., 2015). When evaluating the tolerance of *Bambusa vulgaris* seedlings to water and saline stress, Souza et al. (2019) concluded that the species under study is more sensitive to water deficit, and that the absence of irrigation for periods longer than 14 days causes the death of seedlings. In the present study, young plants of *D. asper* tolerated the lack of water for up to two to three weeks, after which the seedlings died completely.

Interestingly, the water treatments studied did not significantly impact the photosynthetic efficiency of *D. asper*. In this study, plants grown at 50% of field capacity had the highest means of net photosynthesis (P_N), water use efficiency (WUE) and carboxylation efficiency (CE). The lowest carboxylation efficiency was observed under severe deficit (25% fc).

Plant acclimatization to moderate stress factors involves numerous morphophysiological adjustments, being stomatal closure one of the first. In this way, the plant reduces excessive water loss through transpiration, avoids cavitation of the xylem vessels and prevents the rapid reaching of critical levels of water potential (BRODRIBB; McADAM, 2017; AVILA et al., 2020). In the present research, *D. asper* plants reduced stomatal conductance (gs) as the water was reduced (100, 50 and 25% fc), a response also verified for stomatal transpiration (T).

Chl*a* fluorescence analysis, as well as the determination of the concentration of chlorophylls *a* and *b* and carotenoids, are important physiological indicators of the photosynthetic potential in response to environmental conditions imposed on plants. In the present study, despite not differing (p<0.05) among treatments, plants grown under 25% fc had a greater reduction in the maximum efficiency of photosystem II (Fv/Fm) and a lower ratio Chl *a*/Chl *b*, showing a decrease in the content of Chl *a*. In this water condition, higher values for photochemical quenching (qP), non-photochemical quenching (NPQ) and electron transport rate (ETR) were also observed.

The decrease of P_N, g_s and Fv/Fm was observed in plants of *Fargesia rufa* (dwarf bamboo) under water stress (equivalent to 30% of the soil water content considered for well-irrigated plants, 80%) (LIU et al., 2017). According to these authors, photosynthesis is among the physiological processes most sensitive to water stress, partially due to the simultaneous decrease in g_s and C_i (intercellular concentration of CO_2), a consequence of stomatal closure. Similar to what was observed for *F. rufa*, the lower net photosynthesis under 25% fc may also be associated with impaired PSII (photosystem II) function, as confirmed by the decrease in Fv/Fm and lower Chl*a* content.

NPQ, an indicator of dissipation of excitation energy in the antenna system of PSII, was also increased in stressed plants of *F. rufa* (LIU et al., 2017). In this research, the increase in thermal dissipation capacity was verified in *D. asper* plants under 25% of the field capacity, evidencing a non-stomatal strategy. Decrease in total biomass, net photosynthesis, stomatal conductance and photosystem II efficiency were also observed for *Phyllostachys edulis* (mosso bamboo) under water deficit (WU et al., 2018). However, nutrient application mitigated the drastic effects of low water availability, as evidenced by greater water use efficiency and membrane integrity.

Another indicator of water status and plant adaptation to drought is the relative water content (RWC) which, in this study, did not differ among the treatments studied. Even so, higher values for RWC were verified in *D. asper* plants submitted to 25% and 50% fc. Chen et al. (2016) state that the ability of plants to maintain a high water potential, chlorophyll content and Fv/Fm under drought stress contributes to their adaptability. According to the authors, the maintenance of water status is crucial for the optimal physiological functioning and growth of plants. The reduction of transpiration losses caused by the change in stomatal conductance, the curling of leaves by bulliform cells and the dynamics in the production of shoots and roots are strategies of plants submitted to a water deficit condition (SELEIMAN et al., 2021).

The results observed in the present study contribute to the understanding of the responses of bamboo species in the initial phase of establishment. However, further research is needed to assess the impact of the extent of water deficit, not only on growth, but also to elucidate the biochemical and anatomical strategies of *D. asper* plants. This is because the exposure of plants to water stress causes morpho anatomical, physiological changes and increased biochemical defenses to mitigate the negative impacts of excess or deficiency of water. Such responses, however, depend on the intensity and time of exposure to the limiting abiotic factor and, therefore, differences may or may not be observed depending on the species and stage of plant development.

5 CONCLUSIONS

This study provides an initial analysis of the effects of water stress on the growth and physiological responses of young plants of *Dendrocalamus asper*.

The imposition of water stress for 30 days does not significantly affect the photosynthetic efficiency of plants.

The behavior observed in young plants of *D. asper* shows tolerance under 50% of the field capacity.

Plants subjected to 25% of the substrate's water capacity have higher shoot emission and lower leaf and stem dry mass.

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