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EFFECTS OF DIFFERENT IRRIGATION DEPTHS ON THE CONTENT OF TSH1188 COCOA SEEDLINGS PHOTOSYNTHETIC PIGMENTS

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Abstract: This study aimed to evaluate the effect of different irrigation depths on the levels of photosynthetic pigments in seedlings of TSH 1188 genotype cocoa and indicate the best irrigation depth for seedling production based on these characteristics. For this purpose, five irrigation depths were applied, corresponding to 4, 6, 8, 10 and 12 mm day^{-1}. The experimental design was completely randomized with 20 seedlings per treatment. At 55 days after sowing, photosynthetic pigments were extracted and quantified, and the content of chlorophyll a, chlorophyll b, total chlorophyll and carotenoids was determined. The results were submitted to analysis of variance by the F test at 5% probability. Regression models that best applied to the effects of the irrigation depth on the evaluated characteristics were adjusted. The irrigation depth of 7.74 mm d^{-1} had the highest total chlorophyll content, being the most recommended for the production of TSH 1188 cocoa seedlings.

Keywords: *Theobroma cacao* L.*;* Irrigation management; chlorophyll content

1 INTRODUCTION

Cacao (*Theobroma cacao* L.) is a plant typical of the tropical climate, native to the basins of the Amazon River, Mexico and Central America, where there are forests with hot and humid characteristics (NAKAYAMA *et al*., 1996). Its use is in the most diverse forms, for human consumption

and can be raw material in the production of chocolate, cocoa powder, jellies, juice pulp, honey and butter.In animal handling, it is associated with the manufacture of feed and can also be used agricultural production as the use of fertilizers (LIMA *et al*., 2018; LAHIVE *et al*., 2019).

In 2019, Brazil had 581,997 hectares for the planting or harvesting of cocoa, with a produced quantity of 259,425 t throughout the Brazilian territory. Nationally, the states of Pará, Bahia and Espírito Santo stand out in cocoa productivity, with their respective production of 128,961, 113,039 and 11,051 t, being responsible for more than 97% of all national production (IBGE, 2021).

For the success of perennial crops, such as cacao, one of the most important steps is the production of seedlings, since those that do not have good quality can affect the longevity of the crop. Therefore, one of the factors that directly influence the obtainment of seedlings with a high standard of quality is the proper management of water through irrigation (TATAGIBA et al., 2015), and often the application of water to the plants is done in such an empirical way, without technical knowledge, resulting in water deficit, compromising plant production and development (RONG-HUA *et al*., 2006).

Among all leaf pigments, chlorophyll a, chlorophyll b and carotenoids are involved in the photosynthesis process, being chlorophyll the most abundant one, found in the chloroplast of plant cells with the role of absorbing sunlight and transferring electrons during photosynthesis, and with the absence of this pigment, carbon assimilation is limited, decreasing the production of energy and consequently harming the growth and development of the plant (TAIZ *et al*., 2017). According to Silva *et al*. (2014), the photosynthetic activity stimulates agricultural productivity and this correlation occurs due to the use of available radiation. The reduction of these pigments in plants is associated with water stress, which consequently causes a gradual decrease in the photosynthetic rate (RONG-HUA *et al*., 2006).

Studies under the influence of irrigation management on the behavior of leaf pigments of cocoa seedlings of cultivars PS 1319 and ESFIP 02 have already been done (OLIVEIRA *et al*., 2019a; OLIVEIRA *et al*., 2019b). However, no studies were found to demonstrate the behavior of these characteristics under TSH 1188 genotype cocoa seedlings. In this context, this study aimed to evaluate the effect of different irrigation depths on the levels of photosynthetic pigments of TSH 1188 genotype cocoa seedlings and indicate the best irrigation depth for seedling production based on these characteristics.

2 METHODS

The study took place in the horticulture sector of the Federal Institute of Espirito Santo, Campus Itapina, located in Colatina, state of Espírito Santo, Brazil, with the following geographic coordinates: 19° 32' 22" south latitude and 40° 37' 50" west longitude, between October 20th and December 15th, 2017.

The experiment was conducted in an agricultural greenhouse, where five individual environments were installed, 2.20-m long and 1.10-m wide, covered with transparent plastic canvas on the sides. In each environment, there were six GREEN MIST anti drop nebulizers (NaanDanJain®), located 1 m above the seedlings and spaced 0.8 m apart. The frequency of irrigation was distributed over 10 hours a day, with a working pressure of 2 kgf cm^{-2}, with individual control and a 0.5 cv centrifugal pump.

The seedlings were prepared in tubes with a volume of 280 cm^3. The containers were filled with commercial substrate Tropstrato HT® Vegetables added with Osmocote Plus® 15-9-12 (3M), at a amount of 3 g $tube^{-1}$, with the following chemical composition: N=15%, (7% ammonia and 8% nitrate), P_2O_5 = 9%, K_2O = 12%, Mg = 1.3%,

S = 5.9%, Cu = 0.05%, Fe = 0.46%, Mn = 0.06% and Mo = 0.02%. The cocoa seeds used were of the TSH 1188 genotype.

The treatments consisted of applying five irrigation depths, corresponding to 4, 6, 8, 10 and 12 mm day^{-1}. The experimental design was completely randomized with 20 seedlings per treatment.

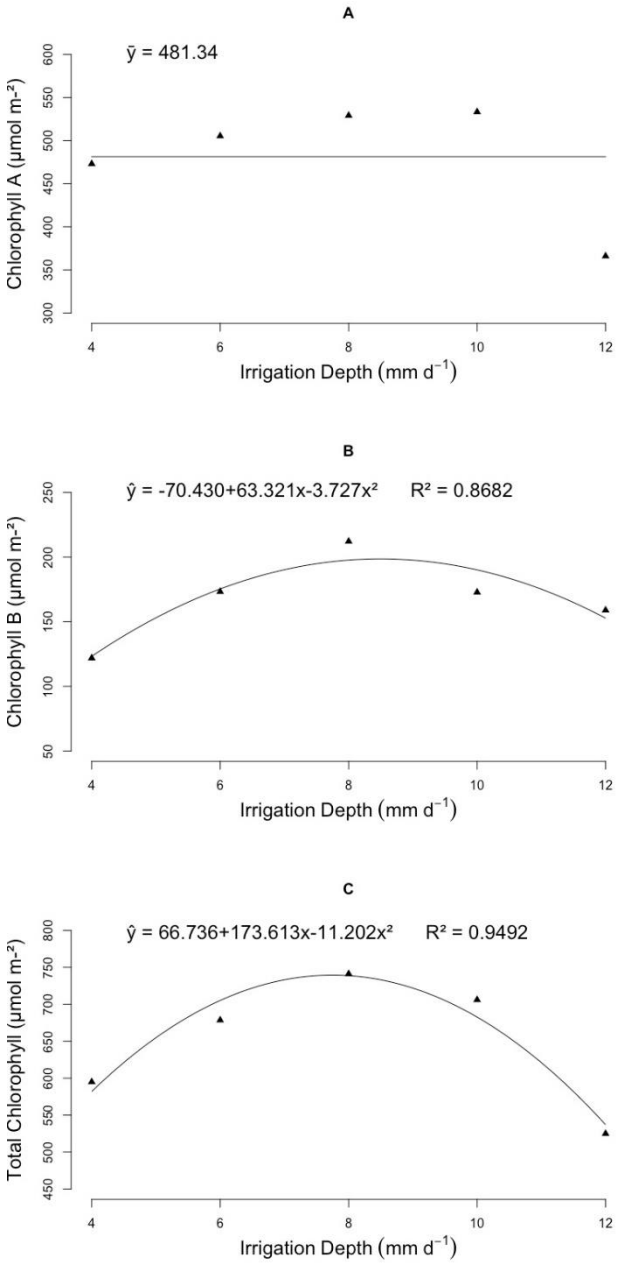
At 55 days after sowing, the extraction and quantification of photosynthetic pigment contents were carried out based on the methodology proposed by Porra *et al*. (1989), where leaf discs of known area in the middle region of leaf D are placed in a test tube containing 3 mL of Dimethylsulfoxide (DMSE) and incubated at 70°C for 20 minutes. After cooling the sample, readings were taken in the spectrophotometer at 480, 649 and 665 nm. The determination of chlorophyll A, chlorophyll B and carotenoids were based on Wellburn equations (1994). The total chlorophyll content was obtained by adding the chlorophyll A content and the chlorophyll B content.

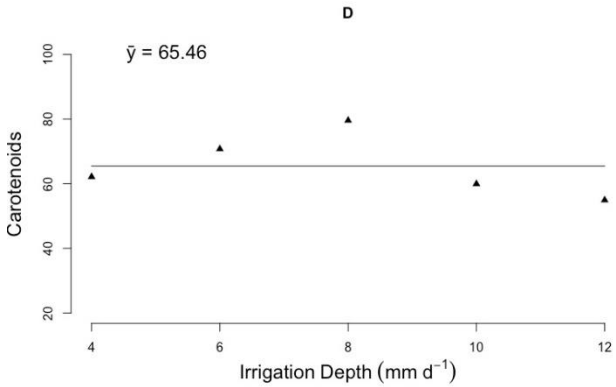
The results were submitted to analysis of variance by the F test at 5% probability. Regression models that best applied to the effects of the irrigation depth on the evaluated characteristics were adjusted. The maximum points were obtained by applying the primary derivative of the regression equations. All statistical analyzes were performed using the R software (R CORE TEAM, 2021).

3 RESULTS AND DISCUSSION

After analysis of variance by the F test ($p < 0.05$) and regression analysis by the t test ($p< 0.05$) of the characteristics evaluated in relation to the applied irrigation depths, it was observed, as shown in Figure 1, that chlorophyll A content and carotenoid content did not differ statistically between treatments with averages of 481.34 µmol m^{-2} and 65.46, respectively. Chlorophyll B content and total chlorophyll content showed quadratic adjustment with maximum estimated points of 198.52 µmol m^{-2} and 739.41 µmol m^{-2} in the irrigation depths of 8.49 mm d^{-1} and 7.74 mm d^{-1} and R^2 of 0.8682 and 0.9492, respectively.

Figure 1. Chlorophyll A content (µmol m^{-2}), chlorophyll B content (µmol m^{-2}), total chlorophyll content (µmol m^{-2}) and carotenoids of TSH 1188 cocoa seedlings under different irrigation depths.





Source: Authors.

Chlorophyll A, chlorophyll B and carotenoids are pigments involved in photosynthesis. Chlorophyll is linked to the photochemical phase of photosynthesis, while chlorophyll b and carotenoids are known as accessory pigments helping to absorb light necessary for plant metabolism (STREIT *et al*., 2005). According to Cavalcanti Filho (2017), superior results for these characteristics are favorable, since these pigments are related to the ability of plants to carry out photosynthesis.

In general, the lack or excess of water was detrimental to the analyzed parameters of TSH 1188 cocoa seedlings. The lack of water creates an environment of water stress, reducing the absorption of nutrientes,on the other hand, its excess can lead to leaching of nutrients found in the substrate (LOPES *et al*. 2005). This fact possibly explains the decrease in the total chlorophyll content caused by the decrease in the nitrogen content present in the substrate, since the nitrogen molecule is a fundamental constituent of chlorophyll. According to Fagundes *et al*. (2015), the loss of nutrients generated by the erroneous use of irrigation is very common, impairing the development of seedlings due to the low use of fertilization.

The availability of erroneous amounts of water for plants leads them to water stress and the inappropriate use of water can lead to water stress and directly interfering with the physiological characteristics of plants, therefore, the conscious use of water and interference that it has in the physiological characteristics of plants, better management of water resources for crops is essential (OLIVEIRA *et al*., 2020).

Leaf pigments have the function linked to photosynthetic processes, which leads to the production of photoassimilates having a direct relationship with the capacity of growth and development of plants, providing them with the ability to adapt to different environments (ENGEL; POGGIANI, 1991). In our studies, the total chlorophyll content showed a variable behavior in relation to the irrigation depths applied to seedlings of the TSH 1188 genotype cocoa. This leaf pigment is the most abundant in plants, being found in the chloroplast of plant cells with the role of absorb sunlight and transfer electrons during photosynthesis, and with the absence of this pigment, carbon assimilation is limited, decreasing energy production and consequently impairing plant growth and development (TAIZ *et al*., 2017).

This behavior has already been observed in other cocoa cultivars as demonstrated by Oliveira *et al.* (2019a) and Oliveira *et al.* (2019b) for the cultivars PS 1319 and ESFIP 02, suggesting that the irrigation depths of 7.97 mm d^{-1} and 7.69 mm d^{-1} respectively, were the ones that provided the highest yield for the physical characteristics of the cocoa seedlings of this

cultivar. Therefore, we indicate the irrigation depth of 7.74 mm d^{-1} as it provides a greater value for the total chlorophyll content. This irrigation depth is the most suitable for the production of seedlings of the TSH 1188 genotype cocoa.

4 CONCLUSIONS

The irrigation depth of 7.74 mm d^{-1} showed the highest total chlorophyll content, a characteristic used as an indicator of better photosynthetic activity of the plants, being the most recommended for the production of TSH 1188 cocoa seedlings.

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