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HYDROPONIC CULTURE OF CRESS UNDER DIFFERENT LIGHT INTENSITIES WITH LED'S

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Abstract: The objective of this work was to evaluate different light intensities provided by LED lamps, consisting of 20% blue LED's and 80% red LED's, in the production of hydroponic watercress. Plants were grown in Hoagland & Arnon nutrient solution for thirty-eight days under five light intensities: 0; 25; 50; 75 and 100 μmol m^{-2} s^{-1}, zero being the control treatment (natural light). The experimental design used was completely randomized with twelve replications. After 35 days of cultivation, the number of leaves, plant height, fresh mass of shoots and fresh mass of roots were evaluated. The data obtained from the luminous intensity factor were submitted to polynomial regression analysis. The light intensity factor showed a significant effect for all variables. The highest number of leaves per watercress plant (11 leaves) was obtained in plants kept under the estimated light intensity of 70,66 μmol m^{-2} s^{-1}. In the absence of artificial light, control treatment, approximately seven leaves per plant were obtained. This difference between the referred treatments represents an increase of 63.63% in the number of new leaves formed per plant. For the plant height variable, a linear behavior with a decreasing trend was observed as the light intensity was increased. The highest amount of fresh mass of shoots (57.66 g) was observed at an estimated light intensity of 78.43 μmol m^{-2} s^{-1}. Regarding the variable fresh mass of the roots, as the light intensity was increased in the cultivation environment, an increase in the amount of fresh mass was obtained.

Keywords: Light Emitting Diodes, Light Quality, Hoagland's Solution.

INTRODUCTION

The water cress (*Rorippa nasturtium-aquaticum*) It is an herbaceous plant belonging to the Brassicaceae family, the same as broccoli and cauliflower. Watercress is a leafy vegetable appreciated and consumed worldwide not only for its high nutritional value, but also for containing several bioactive compounds, such as glycosylates. There is evidence of beneficial effects of vegetables from the Brassicaceae family on human health (PAYNE et al., 2015). Therefore, some studies suggest that the regular consumption of vegetables belonging to the Brassicaceae family contributes to the prevention of cardiovascular, neurodegenerative, cancer and diabetes diseases (MANCHALI et al. 2012; PAYNE et al. 2012).

The production of vegetables in the open field is subject to the climatic seasonality of the region, so that the quantity and quality will be subject to climate conditions. On the other hand, the production of vegetables conducted in a protected environment, although it demands a higher initial investment, contributes to the plant better expressing its genetic potential and bringing forward the harvest period. In addition, cultivation in a protected environment contributes to greater control of pests and diseases.

Light is essential for plant growth and development. Therefore, light is involved in the regulation of photosynthetic rate, morphogenesis, metabolism, gene expression and other physiological processes in plants (DONG et al., 2014; RIHAN, et al., 2022). However, depending on the region of Brazil and season of the year, such as in the state of Rio Grande do Sul, the quality of light (photoperiod, light intensity and wavelength) may vary. Being the LED's a viable alternative to be used as a light source in the cultivation of plants, in a protected environment, during the period of less availability of natural light.

In recent years, the use of LED's as a light source has aroused considerable interest, including in the cultivation of micro propagated plants. In part, the use of LED's as a source of ambient lighting was possible due to the technological advances in manufacturing materials. These new materials allowed obtaining a new generation of LED's that are capable of emitting high brightness. The first-generation LED's emitted little light, so their use was limited to serving as an on and off indicator of electrical/electronic equipment. The growing interest in this new light source is related to unique characteristics, such as high energy efficiency, long useful life, among others (ZHELUDEV, 2007).

In Brazil, the use of LED's in the plant cultivation environment initially occurred in the production of in vitro strawberry seedlings (ROCHA et al., 2010). Possibly, the high cost of this type of light source limited its application in other plant cultivation environments, since for the production of plants in vitro, the space for cultivation is relatively small.

With the second generation of high-brightness LED's, lamps consisting of a combination of LED's with different wavelengths began to appear on the market. The combination of blue LED’s and red LED’s in the lamp is related to the wavelengths presented by blue light (420 to 460 nm) and red light (600 to 700 nm), which are considered as more adequate for the greater development of the plant (GAO et al., 2021; RIHAN, 2022). Lamps with LED combinations have also aroused interest in the use of hydroponic cultivation optimization studies (ROCHA, 2014), and more recently in the production of vegetable seedlings (ROCHA et al., 2023).

According to SUTULIENE et al. (2022), light intensity affects plant development and metabolism. Additionally, the leaf area, the amount of accumulated dry mass, the amount of chlorophyll and photosynthetic efficiency are strongly influenced by the light intensity available in the cultivation environment (FLORES et al., 2022).

The production of vegetables in hydroponic systems stands out for presenting a series of advantages in relation to the traditional form of production, reduction of the culture cycle, greater productivity, production close to the consumer market, reduction of climatic risks, lower consumption of water and fertilizers, better quality, among others (BEZERRA NETO & BARRETO, 2012).

Although hydroponic cultivation techniques are well established in the country, it is necessary to constantly refine the technique in order to achieve high productivity, better quality products and more competitive prices.

Given this context, the objective of this work was to evaluate the productive performance of watercress grown in the hydroponic system under different light intensities with LED lamps.

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MATERIAL AND METHODS

The experiment was conducted at the Department of Agricultural Sciences at ``Universidade Regional Integrada de Alto Uruguai e das Missões`` – URI Campus Erechim. For the study, watercress seedlings with approximately 5 cm in height were used. The seedlings grouped into five plants were cultivated in black plastic trays containing 10 liters of Hoagland & Arnon's (1950) nutrient solution, with constant aeration provided by an aquarium pump.

The trays containing the watercress plants were placed on benches kept in a protected environment with a temperature of 25 °C $\pm$ 1°C and a 16-hour photoperiod provided by LED lamps consisting of 80% red LED's and 20% blue LED's. The LED lamps were installed at a height of 60 cm from the cultivation bench. During the watercress cultivation period, the level of the hydroponic solution was adjusted according to the need for replacement.

Regarding the treatments, these consisted of different light intensities (0; 25; 50; 75 and 100 $\mu mol\ m^{-2}\ s^{-1}$) provided by LED lamps. The control treatment was considered zero, that is, the absence of artificial light; plant growth being promoted only by natural light.

The experimental design used was completely randomized with twelve replications per treatment, with a set of five plants being the experimental unit. After 35 days of cultivation, the number of leaves, plant height, fresh mass of shoots and fresh mass of roots were evaluated. The leaf number variable data were transformed into $(x + 0.5)^{½}$. Therefore, the data obtained from the luminous intensity factor were submitted to polynomial regression analysis.

RESULTS AND DISCUSSION

The light intensity factor showed a significant effect for all evaluated variables (number of leaves, plant height, fresh mass of shoots and fresh mass of roots). According to Dong et al. (2014), light intensity influences plant growth, morphogenesis and other morphological responses. In Figure 1, a quadratic behavior can be observed for the variable number of leaves as the light intensity is increased. The highest number of watercress leaves (11 leaves) was obtained in plants kept under the estimated light intensity of 70,66 µmol m^{-2} s^{-1} (Figures 1). In the absence of artificial light, control treatment, approximately seven leaves per plant were obtained. This difference between the referred treatments represents an increase of 63.63% in the number of new leaves formed per plant. The results obtained with watercress demonstrate that adjusting the light intensity with LED's in the cultivation environment with natural light contributed to the increase in the number of leaves. These results are in line with those obtained by Sutuliene et al. (2022), who evaluated the effect of different light intensities with LED's on lettuce growth (*Lactuca sativa* L.) and basil (*Ocimum basilicum* L.), observed that the increase in light intensity in the cultivation environment stimulated the formation of new leaves in plants of both cultivated species.

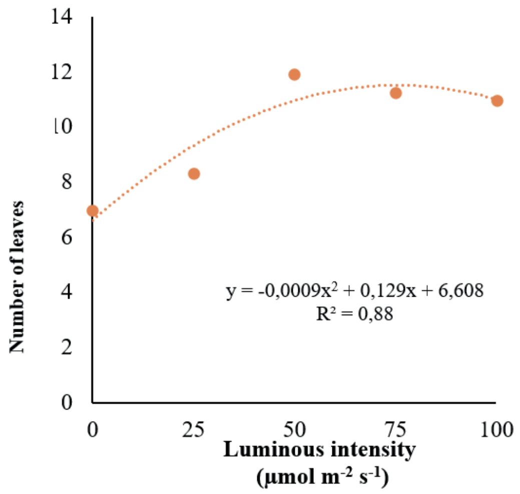

Figure 1- Number of leaves on a watercress plant, after 35 days of cultivation in Hoagland & Arnon nutrient solution and maintained under different light intensities with LED lamps (0; 25; 50; 75 e 100 µmol m^{-2} s^{-1}).

For the plant height variable, a linear adjustment with a decreasing trend was observed as the light intensity was increased in the growing environment (Figure 2). According to Liu et al. (2022) gibberellin, a plant hormone, plays a key role in regulating plant cell and stem elongation. Still according to the authors cited above, high light intensity can reduce the level of endogenous gibberellin and with that may inhibit stem elongation. Potter et al. (1999) reports that there is a positive correlation between endogenous gibberellin concentration and stem elongation of numerous plant species. Evaluating the effect of different light intensities (100;150; 200; 250 and 300 µmol m^{-2} s^{-1}), Pennisi et al. (2020) observed that increasing light intensity favored the height of basil plants. They also observed that there was inhibition of plant growth from 250 µmol m^{-2} s^{-1} (26,01 cm), because at the intensity of 300 µmol m-2 s-1 the plants reached 25.32 cm in height.

On the other hand, Yao et al. (2017) evaluating the effect of different light intensities with LED's [natural light (control); 200; 300

and 400 μmol m^{-2} s^{-1}] on the morphology of cabbage seedlings.

The *Brassica napus* L. observed that the increase in intensity contributed positively to the evaluated variables, except for the plant height variable. Nguyen et al. (2019) evaluating the effect of four light intensities (90; 140; 190 and 240 μmol m^{-2} s^{-1}) provided by LED lamps (red LED's and blue LED's) in the hydroponic cultivation of spinach (*Spinacia oleracea* L.), verified that the light intensity favored the height of the plants. However, the highest average of the plant height variable was reached in the intensity of 190 μmol m^{-2} s^{-1}.

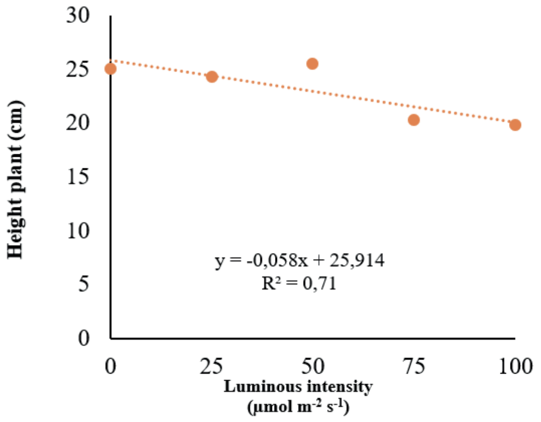

Figure 2- Height of the watercress plant, after 35 days of cultivation in Hoagland & Arnon nutrient solution and maintained under different light intensities with LED lamps (0; 25; 50; 75 e 100 μmol m^{-2} s^{-1}).

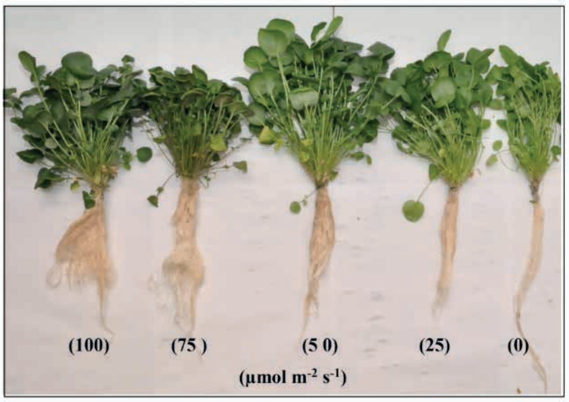

Figure 3- Watercress plants, after 35 days of cultivation in Hoagland & Arnon nutrient solution and maintained under different light intensities with LED lamps (0; 25; 50; 75 e 100 μmol m^{-2} s^{-1}).

As for the fresh mass of the aerial part, a quadratic behavior was observed as the light intensity was increased. The highest amount of fresh mass (57.66 g) was obtained in the estimated light intensity of 78,43 μmol m^{-2} s^{-1} (Figure 4). Liu et al (2022), evaluating different light intensities with LED's (30; 50; 70 e 90 μmol m^{-2} s^{-1}) on the growth of Chinese cabbage microgreens (*Brassica alboglabra* Bailey) observed that the highest amounts of fresh mass occurred at light intensities below 70 μmol m^{-2} s^{-1}. Pennisi et al. (2020) obtained an increase in the amount of fresh mass of lettuce up to the light intensity of 250 μmol m^{-2} s^{-1}. On the other hand, in the cultivation of basil, the authors mentioned above did not observe difference in the amount of fresh mass produced between the light intensities of 250 μmol m^{-2} s^{-1} (25 g) e 300 μmol m^{-2} s^{-1} (21 g). Although photosynthesis and plant biomass production are positively influenced by light intensity, according to Zhang et al. (2020), both photosynthesis and plant growth can be impaired by the high level of intensity which triggers photoinhibition.

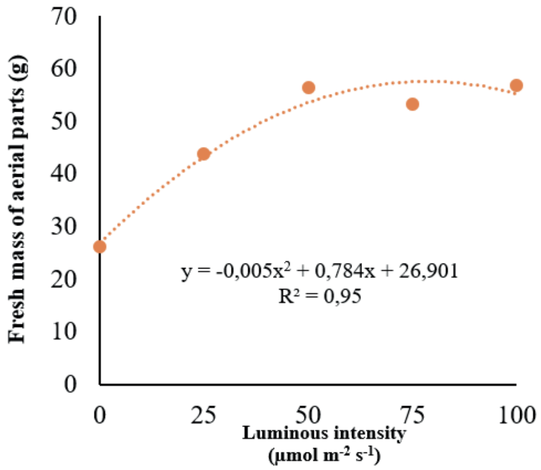

Figure 4- Fresh mass of the aerial part of watercress plants, after 35 days of cultivation in Hoagland & Arnon nutrient solution and maintained under different light intensities with LED lamps (0; 25; 50; 75 e 100 µmol m^{-2} s^{-1}).

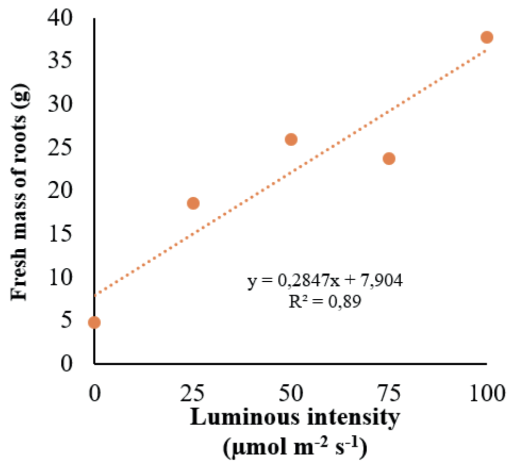

Figure 5- Fresh mass of the roots of watercress plants, after 35 days of cultivation in Hoagland's hydroponic solution and maintained under different light intensities with LED lamps (0; 25; 50; 75 e 100 µmol m^{-2} s^{-1}).

Regarding the variable fresh mass of the roots, an increasing linear adjustment can be observed in Figure 5. It is also noted in the same Figure that the increase in light intensity contributes to the increase in fresh mass. Although the product of commercial interest is the aerial part of watercress plants, it is emphasized that a well-formed root system can contribute to greater absorption of nutrients from the nutrient solution. Yao et al. (2017) evaluating the effect of different light intensities with LED's [natural light (control); 200; 300 and 400 µmol m^{-2} s^{-1}] in cabbage seedlings (*Brassica napus* L.), observed that the highest amount of fresh mass of the roots (0.18 g) occurred under the highest evaluated light intensity (400 µmol m^{-2} s^{-1}). Similar results were obtained by Modarelli et al. (2022) who evaluating different light intensities (130; 259 e 389 µmol m^{-2} s^{-1}) in the lettuce crop (*Lactuca sativa* L.), obtained after 33 days of cultivation 17.7g per plant of fresh mass in the plants grown at the highest intensity (389 µmol m^{-2} s^{-1}).

CONCLUSIONS

For the conditions in which the experiment was conducted, it can be concluded that the increase in light intensity provided by the LED's contributed to the formation of new leaves in watercress plants.

The increase in light intensity did not favor the height of watercress plants.

The recommended light intensity for watercress hydroponic cultivation is 78,43 µmol m^{-2} s^{-1}.

Root fresh mass production increased with increasing light intensity in the growing environment.

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