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Changes in light radiation and microclimatic conditions alter the pomegranate cuttings photomorphogenesis treated with aqueous extract of *Cyperus rotundus*

João Paulo da Silva[a], Patrícia da Silva Costa[b], Rener Luciano de Souza Ferraz[b], Pedro Roberto Almeida Viégas[c], Alexandre Eugênio da Silva[d], Semako Ibrahim Bonou[b], Antonio Manoel da Silva Filho[b], Aldair de Souza Medeiros[e], Ivomberg Dourado Magalhães[e], Alberto Soares de Melo[d]

[a] Universidade Estadual da Paraíba-UEPB. Campus II Lagoa Seca, Sítio Imbaúba, s/n, Zona Rural, Paraíba, Brasil. CEP: 58117-000. E-mail: jpaulotecnicoagricola@hotmail.com.

[b] Universidade Federal de Campina Grande-UFCG. Rua Aprígio Veloso, n. 882, Universitário, Campina Grande, Paraíba, Brasil. CEP: 58428-830. E-mail: patriciagroambiental@gmail.com, ferragroestat@gmail.com, bonouibrahim@gmail.com, antonio.uepb@gmail.com.

[c] Universidade Federal de Sergipe-UFS. Avenida Marechal Rondon Jardim, s/n, Rosa Elze, São Cristóvão, Sergipe, Brasil. CEP: 49100-000. E-mail: pedro.viegas@bol.com.br.

[d] Universidade Estadual da Paraíba-UEPB. Rua Baraúnas, n. 351, Universitário, Campina Grande, Paraíba, Brasil. CEP: 58429-500. E-mail: eugeniodasilvaalexandre@gmail.com; albertosoares915@gmail.com.

[e] Universidade Federal de Alagoas-UFAL. Campus A. C. Simões. Avenida Lourival Melo Mota, s/n, Tabuleiro do Martins, Maceió, Alagoas, Brasil. CEP: 57072-970. E-mail: aldairmedeiros@gmail.com, ivomberg31@hotmail.com.

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ABSTRACT

Technological advances in agriculture make it possible to manage the light spectrum radiation in a protected environment and generate improvements in plant photomorphogenesis, which can be a promising strategy for supplying seedlings of pomegranate qualities. The study aimed to evaluate whether the microclimatic environmental changes, due to the management of light spectrum radiation, modify the photomorphogenesis and water consumption by pomegranate cuttings treated with aqueous *Cyperus rotundus* (nutsedge) extract, as well as determine the most important variables to explain such effects. A completely randomized design, in a 4x4 factorial scheme, and with three replications. Four light spectrum radiation (white, blue, red, and extreme red lights) and four *C. rotundus* extract concentrations ($D_1 = 0$, $D_2 = 25$, $D_3 = 50$, and $D_4 = 100\%$) were applied in cuttings. During the experiment, the environments were monitored to determine the microclimate variables and water balance of soil and cuttings. Variables were recorded weekly and 60 days after cutting planting. Light conditions influenced all microclimatic variables. White and blue lights increased shoots by applying 0, 25, 50, and 100% nutsedge extract concentrations. Changes in light radiation and microclimatic conditions alter the pomegranate cuttings photomorphogenesis treated with aqueous extract of *C. rotundus*. All variables studied were considered important to explain the influence of environmental microclimate changes, due to light spectrum variation, on photomorphogenesis and water evapotranspiration and consumption by pomegranate cuttings.

Keywords: *Punica granatum*, light spectrum, environmental microclimate.

Introduction

Agricultural technological innovations are constantly implemented into production systems, which derive from the need to increase agricultural production to supply food reserves (Tripathi et al., 2019). An improvement in this field could be plant usage with multiple potentialities in various sectors like food (Lysenko & Schott, 2019), medicinal (Salhi et al., 2019), pharmacological (Oyenihi & Smith, 2019), and industrial (Nare et al., 2019).

The need for investments in the above-mentioned sectors is since inadequately farming causes environmental problems, mainly by the depletion of natural resources, suppression of native flora for expansion of agricultural areas, soils acidification and hydric bodies, greenhouse gases emission, ozone layer depletion, and problems that compromise the agroecosystems resilience and which cause losses in biodiversity (Wang et al., 2019a).

In this context, increasing productivity using appropriate technologies seems to be a viable alternative to the food supply associated with less depletion of natural resources. Therefore, biomass investment is a promising market because biological resources are produced and converted sustainably into value-added products (Sánchez et al., 2019) that justify the cultivation in a protected environment to obtain high yields.

Based on the above considerations, seedlings production in a protected environment, with colored coverings to obtain a better quality and quantity of light, maybe a strategy to improve the performance of seedlings in the field; this can be reflected in higher productivity, besides providing a better-harvested product quality and warranty bigger profitability to the farmer (Ahamed et al., 2019).

This scenario suggests that the production of pomegranate seedlings (*Punica granatum* L.) in a protected environment and colored coverings to promote variations in the light spectrum, besides the application of phytohormones concentrations for rooting and shooting induction, can be an effective technology to be implanted into the productive chain of this agricultural species. However, although the effects of light quality (Fukuda, 2019; Xu, 2019) and phytohormones (Jini & Joseph, 2019; Podlešáková et al., 2019; Wang et al., 2019b) are recognized in plants, little is known about the interaction of these factors and the production of pomegranate seedlings in a protected environment.

Among the plant hormones used for rooting cuttings, the auxins of the indole-3-acetic acid (IAA) and indole-3-butyric acid (IBA) group are the most important (Štefančič et al., 2007; Monder et al., 2019). Meguro (1969) confirmed the presence of IAA in nutsedge tubers (*Cyperus rotundus* L.). Later, many authors claim that tubers of this species have high concentrations of IAA and IBA (Lorenzi, 2000; Dias et al., 2012), which makes it an alternative for cutting roots (Câmara et al., 2016), mainly in agroecological cultivation.

Therefore, it is necessary to carry out research to evaluate the effects of the factors previously mentioned on pomegranate plants, because its fruits are used in bakery, beverages, and cooking industries, in addition to being widely used for several diseases treatments in different civilizations (Loizzo et al., 2019; Shakhmatov et al., 2019). Thus, the research aimed to evaluate whether the microclimatic environmental changes, due to the management of light spectrum radiation, modify the photomorphogenesis and water consumption by pomegranate cuttings treated with aqueous *C. rotundus* (nutsedge) extract, as well as determine the most important variables to explain such effects.

Materials and Methods

Local and experiment duration

The research was carried in a protected environment out from August to November of 2018 in the CCAA - Center of Agrarian and Environmental Sciences of UEPB - Paraíba State University, located in the Lagoa Seca municipality - PB, an altitude of 634 m, and at the coordinates: Latitude 7º09' S, Longitude 35º52' W, according to describe Silva et al. (2020). According to the Köppen classification, the climate is As' type (tropical humid), with an average annual rainfall of 800 mm, a temperature of 22ºC, with a minimum of 18 and a maximum of 33ºC, and relative air humidity of 80%.

Experimental design

The experimental design was a completely randomized, in a 4x4 factorial scheme, with three replications. The factors were constituted by four concentrations of aqueous extract from *C. rotundus* (AEC) obtained from tiririca's tubers (*Cyperus rotundus* L.) (AEC_0 = control 0, AEC_{25} = 25%, AEC_{50} = 50%, and AEC_{100} = 100%) and four light conditions (WHL = white light, BLL = blue light, RDL = red light, and XRL = extreme red light).

Plant material

Semi-woody cuttings (15 cm long and 4 to 5 mm diameter) with 2 or 3 shoots were harvested during the morning period (between 7 and 9 am), from two six-year-old pomegranates plants grown in a private property located in Campina Grande city, Paraíba State, Brazil (7°13'09.4" S 35°51'55.9" W). The cuttings were placed in a Styrofoam box, placed on two layers made of wet paper towel to avoid their dehydration, and taken to Phytopathology Laboratory at CCAA/UEPB, where the cuttings were washed in running water and disinfected with 2% sodium hypochlorite solution for 5 minutes (Paiva et al., 2015).

Cyperus rotundus tubers with an average size between 0.4 and 1.0 g were obtained from plants in the full flowering phenological stage, with a height of 25 to 35 cm, from 7 to 8 leaves, and from 55 to 70 days after emergence (Durigan et al., 2005). The material was obtained from

CCAA/UEPB Experimental Field (7°09'19.2" S 35°52'16.0" W), where this species grows naturally (Silva Filho et al., 2016).

The methodology procedure performed by Simões et al. (2003) was used to obtain the aqueous extract from *C. rotundus*. Concentrations of aqueous extract from *C. rotundus* were obtained by diluting the stock solution with distilled water according to Rezende et al. (2013) and Scariot et al. (2017) recommendations.

Light spectrum variation

Four mini-greenhouses with 2.0 x 1.0 x 1.0 m of length, width, and height, respectively, were built for experimental light conditions. To achieve four light conditions, initially, all mini-greenhouses were covered with a transparent plastic layer to reach white light; for BLL, the transparent mini-greenhouses were covered with two blue cellophane paper layers; for a red light, two red cellophane paper layers were used; and for extreme red light were used one red cellophane layer alternated with blue cellophane layer (Yamashita et al., 2011; Cardoso-Guimarães et al., 2018).

The mini-greenhouses had their base foundation of wood boards (1.0 m long, 10 cm wide, and 1.8 cm thick). The mini-greenhouses foundations were covered with black plastic of 200 microns thickness to prevent white light from entering these environments, except for the white light environment.

Treatments application and irrigation management

Cuttings' bases were immersed for 10 seconds into solutions related to each concentration of *C. rotundus* aqueous extract, according to the methodology described by Silva et al. (2020). The entire procedure was carried out under the green light so that it did not influence phytochromes (Pereira et al., 2011).

Water was applied in four days irrigation frequency by the weighing method, according to Silva et al. (2020).

Variables evaluated

During the experiment, ILU - illuminance, AAT - average air temperature, ARH - average relative air humidity, and AST - average soil temperature was monitored inside the mini-greenhouses. A digital luximeter model LD-400 was used for illuminance measured. A digital thermohygrometer was used to temperature and humidity measured.

Weekly observations were made for each experimental unit to quantify the number of shoots (NSH). Sixty days after planting (DAP), the number of surviving shoots (NSS) was determined, and, afterward, the cuttings were removed from the polyethylene bags, and its base was cleaned out of substrate for root number evaluation (NOR). Necessary water volumes (NWV, in L) to replenish the soil up to field capacity condition were sum, during the experiment, for cuttings evapotranspirated water consumption determining (CEW, in L). For this, was used "CEW= Σ NWV" expression.

Statistical analyzes

Data were submitted to Shapiro-Wilk's normality test (Shapiro & Wilk, 1965) and analysis of variance by F test with 95% confidence. Tukey test was applied for luminosity environment unfolding degrees of freedom. A polynomial regression analysis was carried out for concentrations of aqueous extract from *C. rotundus* (Barbosa & Maldonado Júnior, 2015) by a computational system for statistical analysis Sisvar 5.6 software (Ferreira, 2019).

Data were standardized ($\bar{X}$ = 0.0) and (σ^2 = 1.0). The Principal Components Analysis (PCA) was carried out, and the amount of relevant information was condensed into a smaller number of dimensions (Hair Jr. et al., 2009).

Results and Discussion

Based on the analysis of variance, it was verified that all evaluated variables were significantly influenced (P <0.01) by the luminosity conditions. Although the aqueous extract of *C. rotundus* did not influence significantly (P> 0.05) the assessed variables, it was calculated the adjustment of linear regression significance (P <0.05) for the cuttings water consumption. Also, for pomegranate cuttings, and water consumption, a significant interaction (P <0.01) was verified among luminosity conditions and concentrations of aqueous extract of *C. rotundus* (Table 1).

Table 1. Analysis of variance of microclimatic variables and water consumption by pomegranate cuttings under light spectrum and variations of aqueous extract of *Cyperus rotundus*. Fonte: Silva et al. (2021).

Sources of variation	DF	Average of squares				
		ILU	AAT	ARH	AST	CEW
Light spectrum (L)	3	1148826.38**	15.83**	116.13**	147.29**	241668.75**

C. rotundus extract (C)	(3)	2033.83^{ns}	1.19^{ns}	15.91^{ns}	0.99^{ns}	17885.41^{ns}
Linear regression	1	5103.08^{ns}	3.46^{ns}	7.73^{ns}	2.52^{ns}	46958.28*
Quadratic regression	1	970.19^{ns}	0.07^{ns}	10.91^{ns}	0.36^{ns}	69.35^{ns}
Regression deviation	1	28.21^{ns}	0.06^{ns}	29.10^{ns}	0.09^{ns}	6628.60^{ns}
Interaction L x C	9	1712.74^{ns}	2.13^{ns}	3.97^{ns}	1.27^{ns}	33174.15**
Residue	32	2953.91	1.49	8.68	0.80	9321.56
CV (%)		7.86	3.50	9.44	2.25	13.00

**, *, and ^{ns}: significant at 1%, 5%, and not significant by F test. SV = sources of variation; DF = degrees of freedom; CV = coefficient of variation; ILU = illuminance; AAT = average air temperature; ARH = average relative air humidity; AST = average soil temperature; CEW = cuttings evapotranspirated water.

The highest illuminance (1113.17 lx) was observed in the environment covered with clear plastic and with white light luminosity, followed by the red-light environment in which 710.58 lx illuminance was recorded. In comparison, the extreme red light ambient had an illuminance of 547 lx, and the blue light environment had a lower illuminance of about 394.58 lx (Figure 1A). Higher air temperatures were recorded with white (35.92°C) and extreme red lights (35.85°C). However, 33.65°C and 34.23°C were recorded in blue and red light environments, respectively (Figure 1B).

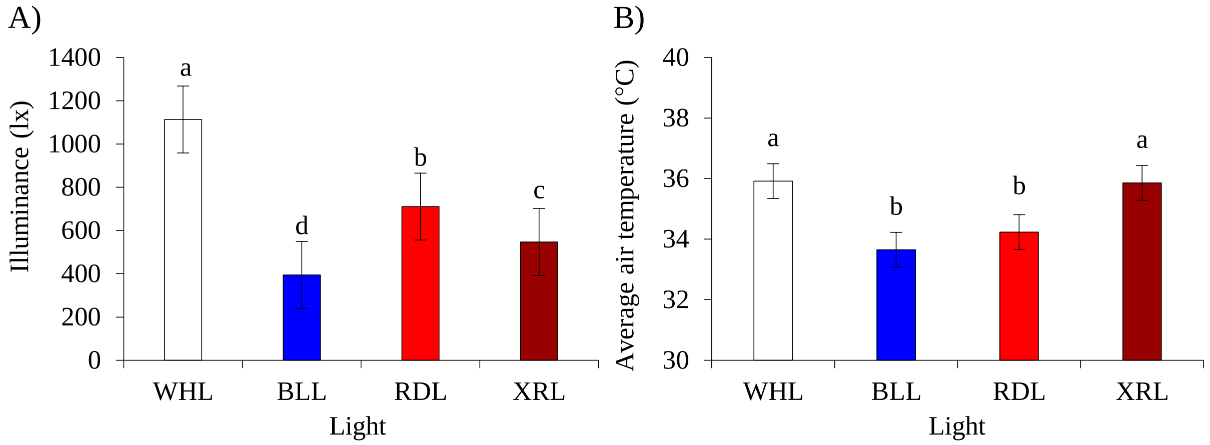

Figure 1. Illuminance (A) and average air temperature (B) in cultivation environments under different levels of light spectrum radiation. Fonte: Silva et al. (2021).

Based on these results, it may be inferred that illuminance has an important role in protected environments' internal temperature. The blue light reduces the illuminance and, consequently, the temperature, which was also observed when the environments were adapted to the red light. These information's are important to improve technological options for seedlings production and protected environment plant cultivation, especially when using colored-plastic covers (Gao et al., 2019).

Disseminating this information in rural areas is important. According to Katayama et al. (2018), in Brazil, plastic cover in agriculture has grown to reduce solar radiation flux density, allowing cultivation in periods with high energy availability. Also, it is important to characterize attenuation solar radiation because it affects the other energy balance components, such as sensible and latent heat fluxes and the photosynthetic process of growing plants in these environments (Cardoso et al., 2008).

Illuminance and temperature variations may have negatively influenced pomegranate cuttings shooting and root formation. This information is confirmed by Dueck et al. (2015) and Dueck et al. (2016) when they reported that the physiological and biochemical mechanisms that regulate cell differentiation are strongly influenced by light and temperature, mainly because these factors influence plants hormonal balance. These authors emphasize that temperature systems reduction generates high costs, and they suggest that using light spectrum variations may be a promising alternative for cultivation in protected environments.

In a protected environment, higher air humidity values were observed with red (33.33%) and extreme red lights (34.42%). The humidity in these environments did not differ significantly from each other. However, they differed significantly from the values measured in white (28.50%) and blue lights (28.58%), respectively (Figure 4A).

The average soil temperature was different in all environments due to light conditions. The highest mean temperature (43.41°C) was recorded in the soil plots conducted in the environment under extreme red light. Average soil temperatures were measured under red (42.24°C) and white lights (37.35°C); for blue light, the lowest average soil temperature was 36.6°C (Figure 4B).

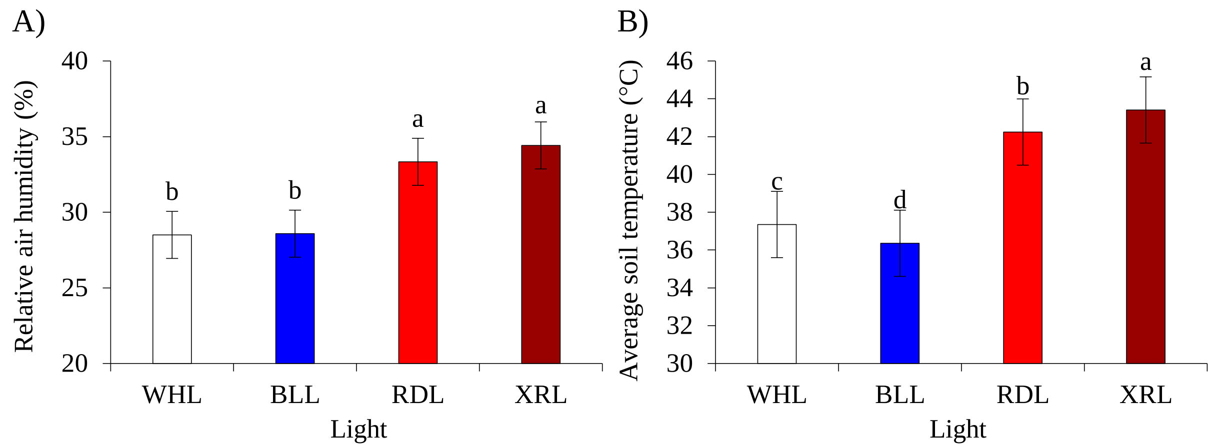

Figure 2. Relative air humidity (A) and average soil temperature (B) in cultivation environments under different levels of light spectrum radiation. Fonte: Silva et al. (2021).

In a protected environment, and under white light, the low air humidity and the average soil temperature were observed because this environment did not have its base covered with black plastic to avoid light entry. It allowed the air to flow through the internal and the external atmospheres to favor the exhaustion of the heated water vapor from the environment's internal atmosphere and the cooling of the wet soil surface. In fact, in regions where strong advection occurs, commonly observed when another dry area surrounds a wet area, wind speed and air humidity are important to the cooling process of the soil surface (Lemos Filho et al., 2010).

Under red and red extreme lights, air humidity higher values are linked to the bigger soil surface temperature and the consequent water vapor diffusion from the soil to the atmosphere. It may have occurred because the higher air temperature favored the evaporation of soil water to cool the heated atmosphere caused by the greenhouse effect (Scaranari et al., 2008). These authors also stated that very high relative humidity, above 90%, decreases the evapotranspiration rate. Hard low humidity, less than 50%, may result in high transpiration levels, causing water stress to the plants. It may explain the death of pomegranate cuttings shoots in this experiment, probably due to the occurrence of humidity below 35% during the experiment, suggesting the use of misting systems.

Sixteen days after planting (DAP), 2, 4, and 2 shoots were observed in cuttings grown in a protected environment with white light and concentrations of aqueous extract from *C. rotundus* at 0, 25, and 50%, respectively. When the cuttings were in blue light, 4, 3, 4, and 1 shoot were recorded, under concentrations of aqueous extract from *C. rotundus* of 0, 25, 50, and 100%, respectively (Figure 3). For the other two lights, no shoot was recorded independent of the concentration of aqueous extract from *C. rotundus*.

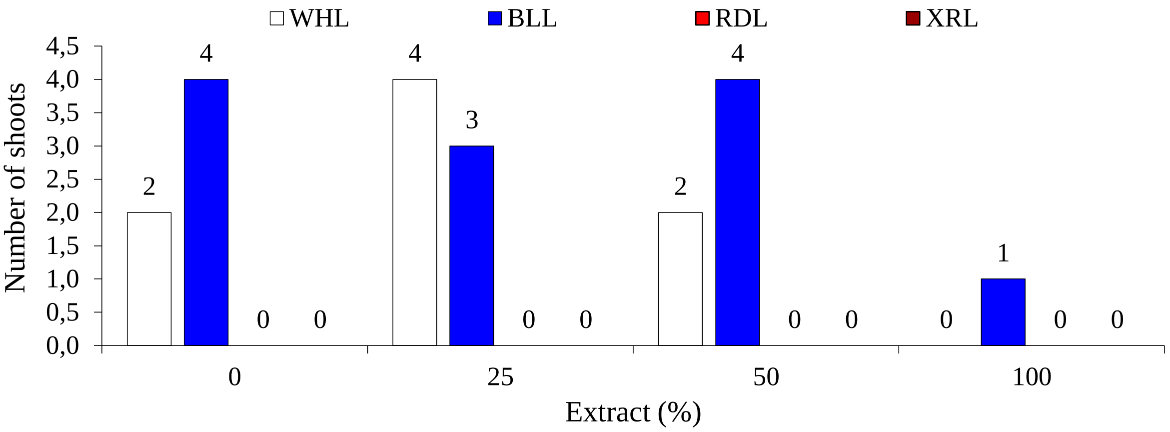

Figure 3. Number of pomegranate cuttings shoots at 16 days after planting in white (WHL), blue (BLL), red (RDL), and extreme red lights (XRL) environments and application of concentrations of aqueous extract from *C. rotundus*. Fonte: Silva et al. (2021).

The greater number of shoots observed in the cuttings grown under white and blue lights may be related to the energy reserves present in the semi-woody cuttings' barks, since this type of cuttings has secondary growth besides the high amount of carbohydrates, such as starch, may be oxidized and converted into soluble sugars required by cuttings metabolism (Campos et al., 2017). In addition, the removal of the upper end of the cuttings inhibited apical dominance. It promoted lateral shoot growth, which may also have been induced by phytohormones and their relationships with light conditions and photoreceptors (Nguyen & Emery, 2017). The changes in the mini-greenhouses luminous atmosphere may have activated the specific photoreceptors related to the growth and development of pomegranate cuttings lateral shoots in response to light. Indeed, phytochromes (phy) and cryptochromes (cry) are related to the luminous signal perception and phytohormones' biosynthetic signaling, such as gibberellic acid (GA), reflecting on growth adaptations due to the quantity and quality of light (Tsuchida-Mayama et al., 2010).

These results, in response to blue and white lights, suggest the involvement of cry in apical dominance inhibition and the induction of lateral shoot growth on pomegranate cuttings, mainly since cry is identified as modulators of photomorphogenetic responses induced by blue light, which, in turn, is also present in white light (González et al., 2019).

At the end of the experiment, after 60 DAP, it was noticed that all the shoots had died without root formation due to light and concentrations of aqueous extract from *C. rotundus* (Figure 4A-D). This occurred because the light spectrum variation has promoted changes in temperature and relative humidity in the growing environment, as, according to Duarte et al. (2011), using colored roofs causes changes in a growing environment, mainly because they reduce the rate of ventilation due to its resistance to the air stream.

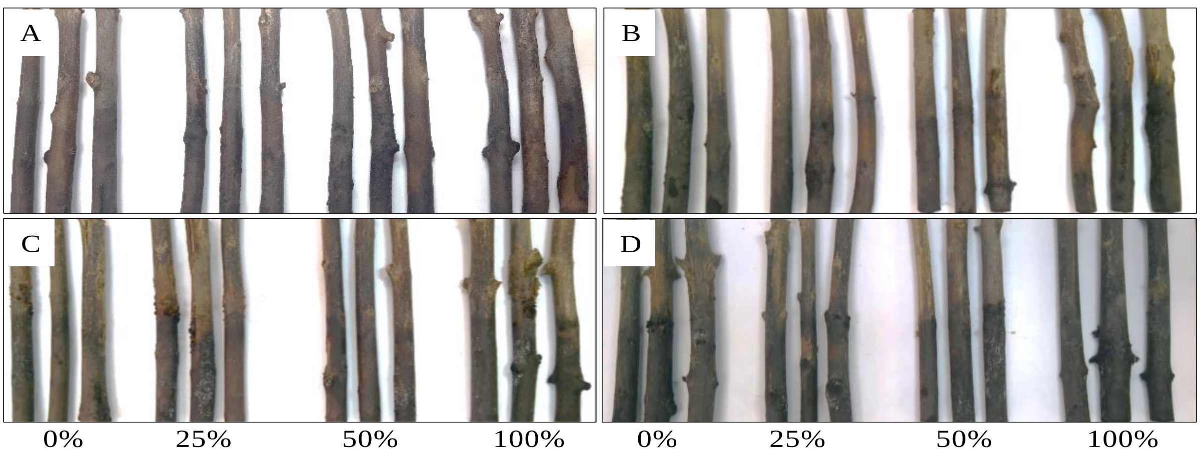

Figure 4. Pomegranate cuttings at 60 days after planting in white (A), blue (B), red (C), and extreme red lights (D) environments and application of aqueous extract from *Cyperus rotundus*. Fonte: Silva et al. (2021).

Consequently, there is a reduction in wind velocity inside the protected environments and an increase in a temperature gradient. It is worth mentioning that heat transfer reduction by the atmospheric mass displacement in the horizontal direction (advection) inside the mini-greenhouses may have attenuated the processes of energy and air mass exchange with the external environment, which induced the increase of air relative humidity (Cunha & Escobedo, 2003; Reisser Júnior et al., 2003; Teruel, 2010; Duarte et al., 2011).

It occurs if irradiance, temperature, and relative humidity rise, shoots transpiration also increases, and this fact may have led to dehydration and consequent cuttings death (Marenco et al., 2001; Marenco & Lopes, 2005; Neves et al., 2006).

Based on the unfolding interaction of luminosity conditions within the concentrations of aqueous extract from *C. rotundus*, it was observed that, under 25% of extract (AEC), the highest evapotranspirated water consumption by pomegranate cuttings was verified under blue light (957 mL). At the same time, intermediate values occurred under red (839.67 mL) and extreme red lights (675 mL), and the lowest consumption was recorded under white light (504.67 mL). With 50% of AEC concentration, the blue light-induced the highest consumption (973 mL) among the other light conditions. The addition of 100% AEC concentration induced the highest consumption under blue (838 mL), red (994.67 mL), and extreme red lights (803.33 mL) while white light promoted the consumption of 538.33 mL (Figure 5A). Under a blue light environment, the plots that received 0% AEC application had a consumption of 702.31 mL, with a significant increase to 1010.97 mL with 57% AEC application followed by a reduction to 835.31 mL, when plots received 100% AEC (Figure 5B). Under red light, the increase in AEC concentrations promoted a rise in evapotranspirated water consumption, ranging from 739 mL in plots with 0% AEC to 958.43 mL in plots receiving 100% AEC (Figure 5C). In the extreme red-light environment, plots not treated with AEC consumed 785.21 mL, with an estimated reduction to 631.95 mL with the application of 48.67% AEC, followed by the increase to 802.41 mL with an application of 100% AEC (Figure 5D).

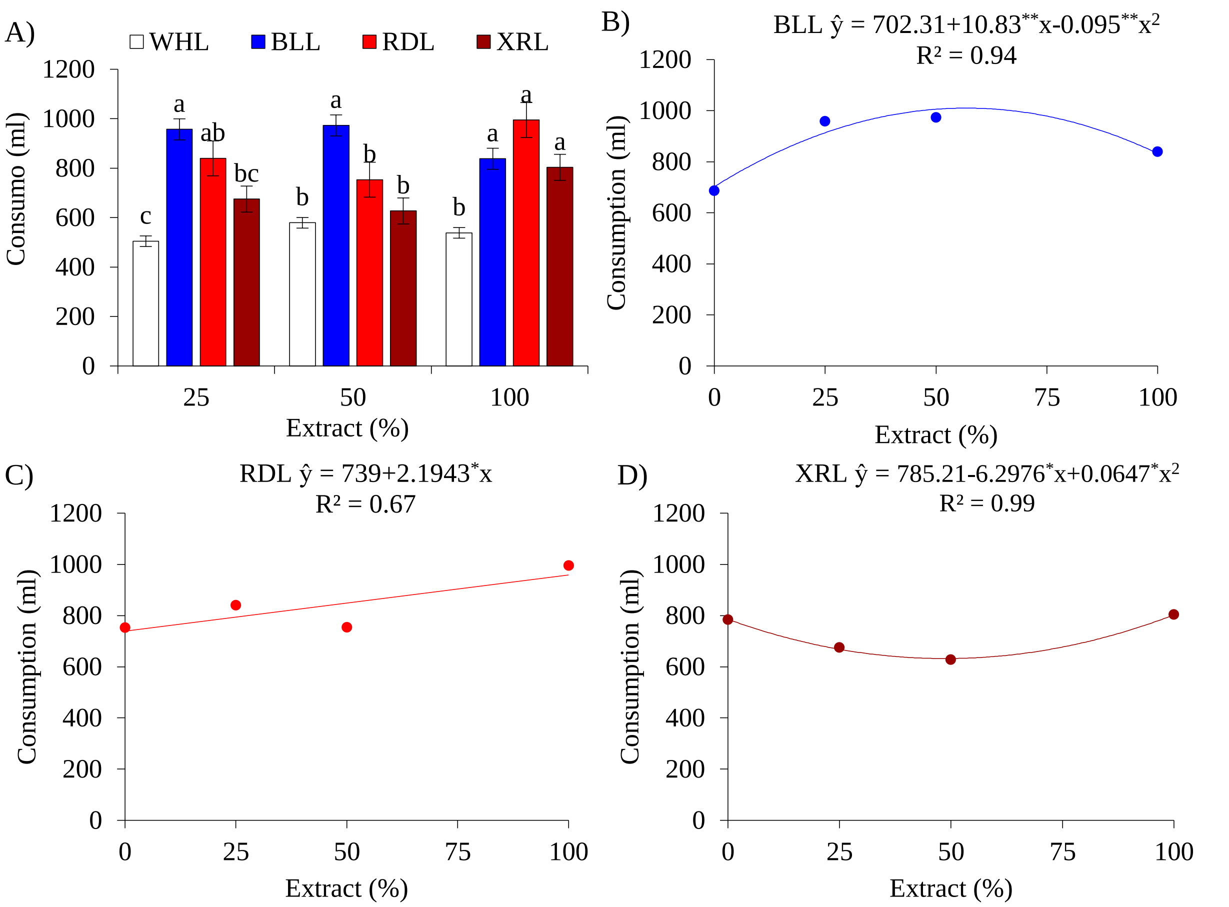

Figure 5. Evapotranspirated water consumption by cuttings according to the unfolding luminosity conditions within aqueous extract from *C. rotundus* (A) and aqueous extract from *Cyperus rotundus* within the blue (B), red (C), and extreme red lights (D). Fonte: Silva et al. (2021).

The higher consumption of evapotranspirated water by pomegranate cuttings under blue light may be related to the higher number of shoots recorded in this environment. The low air relative humidity may confirm this inference and, consequently, the higher shoots transpiration, which may be explained by the lower soil temperature in this environment, favors the transpiration flow because it allows the gas exchange between shoot and the environment, mainly due to the relationship among illuminance, light flux, temperature, and phytohormones balance (Taiz et al., 2017).

Although high illuminances have been recorded in white light and low illuminance in extreme red light, the reduced water consumption in these environments reflects the evaporated air mass retention, which can be demonstrated due to the high relative humidity in the extreme red light (absence of advection) and low relative humidity in the white light (presence of advection). It is common that, as the air temperature decreases, there is an increase in relative humidity, which causes a reduction in evapotranspiration (Medeiros, 2003).

Thus, in humid tropical regions climates, and despite the higher amount of energy available, elevated relative humidity reduces evapotranspiration, because the air is always close to saturation. Thus, the relative humidity of the environment and the air temperature determine the vapor pressure deficit, an indicator of air evaporative capacity (Lemos Filho et al., 2010). This information makes evident the possibility of increased transpiration of cuttings shoots and consequent withering and death (Taiz et al., 2017).

It is possible that the greater transpiration occurred due to the bigger stomatal conductance, which may be related to the need for CO_2 influx for photosynthetic activity and to induce a higher transpiratory rate; in addition, it may also be related to the stress caused by high temperatures, because the closure of the stomata is a mechanism that reduces water loss through transpiration, which may also explain the low root formation in the cuttings (Moreira et al., 2015).

Increases in evapotranspirated water consumption due to the application of concentrations of aqueous extract of *C. rotundus* (AEC) may be the reflection of the greater shooting under the blue light plus the greater transpiratory activity, which, can be ratified because water consumption reduction under 100% AEC application, where less shooting was observed. Consequently, the possible increasing transpiration is related to the higher shooting and consequent higher evaporative bio-tissues surfaces that may have increased the CO_2 net assimilation, since the uptake and assimilation cause water loss into the environment due to the stomatal opening (Taiz et al., 2017).

Two principal components (PCs), with eigenvalues greater than unity (λ> 1.0), were extracted, which, together, account for 82.46% of the total experimental variance. The first principal component (PC_1) held 45.50% of the variance and comprised of a linear combination of relative air humidity (ARH), average soil temperature (AST), and several shoots (NSH). The second major component (PC_2) accounts for 36.96% of the remaining variance, and it was the result of the combination of illuminance (ILU), average air temperature (AAT), and pomegranate cuttings water consumption (CWC) under light and concentrations of aqueous extract of *C. rotundus* (Table 2).

Table 2. Summary of the analysis of the photomorphogenesis and water consumption principal components by pomegranate cuttings and microclimatic changes. Fonte: Silva et al. (2021).

PCs	**λ**	**σ^2**	**Correlation coefficients (r) among variables and PCs**					
			CWC	**AAT**	**ARH**	**AST**	**ILU**	**NSH**
PC_1	2.73	45.50	-0.05	-0.36	-0.91	-0.98	0.06	0.91
PC_2	2.22	36.96	0.89	-0.76	0.21	0.08	-0.89	0.10

PCs = principal components; λ = eigenvalues; σ^2 = percentage of total variance; CWC = cuttings water consume; AAT = average air temperature; ARH = air relative humidity; AST = average air temperature; ILU = illuminance; NSH = number of shoots.

It was found that, based on the highest correlation coefficient (r), all variables were significant (r> 0.75) to explain the influence of light spectrum variations and concentrations of aqueous extract of *C. rotundus* in the photomorphogenesis of pomegranate cuttings and microclimatic environmental changes. In order of importance, the variables were ranked in the following sequence: AST>ARH>NSH>ILU> CWC>AAT (Table 2).

The original dimension reduction into two dimensions is an important strategy to understand light and phytohormones influence photomorphogenesis, water consumption, and microclimatic changes. According to Anjos et al. (2017), understanding complex studies in agriculture may be optimized by using principal component analysis. For Costa et al. (2018), the multivariate techniques, besides facilitating the understanding, can be an alternative for very extensive database management with high dispersion.

In PC_1, the highest AST and ARH occur in red and extreme red spectrum regions, while the highest NSH occurs in the blue region. In PC_2 was verified that the irradiation with white light promotes the greater ILU, with consequent increase of AAT and reduction of CWC. However, the latter is more expressive in the blue region of the light spectrum (Figure 6).

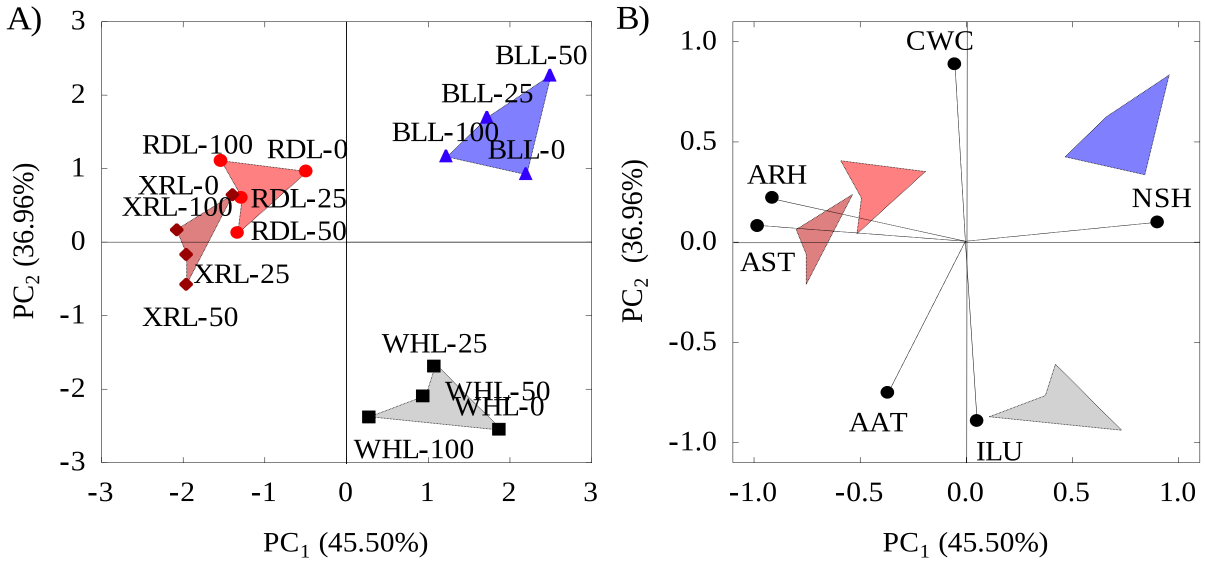

Figure 6. Two-dimensional projection of interaction among luminosity conditions and concentrations of aqueous extract from *Cyperus rotundus* (A) and the variables evaluated (B) in the first two principal components (PC_1 and PC_2). Fonte: Silva et al. (2021).

Independent two-dimensional projection allows better visualization and understanding of interaction influence between factors under study (light and aqueous extract of *C. rotundus*) on the evaluated variables, making it easier for researchers to choose the appropriate variables for the study.

This event was observed mainly in seedlings' survival rate, possibly due to the cuttings dehydration caused by leaves' transpiration. At the end of the experiment, the absence of root formation and the fact that the seedlings did not survive are linked to the effects of light spectrum variation and phytohormones in protected environments microclimate (Cardoso et al., 2008; Katayama et al., 2018) and cuttings metabolic activity, especially hormones balance and their mobilization for cell differentiation as well as lateral shoots and roots development (Dueck et al., 2016). Paiva et al. (2015) report that these results indicate the pomegranate's sensitivity to hot and dry climate conditions during the dry season of the year.

In summary, this study is important to provide an alternative for seedlings production and cultivation in a protected environment, especially because changes in light availability and quality in the protected environment promote important changes in the biochemical plant constitution, such as photosynthetic pigments accumulation and the antioxidative metabolism activity (Miao et al., 2016).

Although cultivation under a protected environment is considered a sustainable solution for food production in hot and arid climates, harsh climate and water deficit are obstacles to cultivation throughout the year, so the greenhouses must provide adequate control of its microclimates such as temperature, relative humidity, CO_2 concentration, and lighting, mainly due to crop requirement and environmental conditions (Ghani et al., 2018).

Despite the importance of using plastic coatings with specific colors, and their numerous advantages for agriculture, it is important to highlight that the extreme use of these polymers may cause residues accumulation and environmental pollution, natural resources, and living beings' contamination.

In this perspective, replacing conventional plastics with biodegradable polymers would be the most effective way to address solid plastic waste accumulation. However, the subject is still under discussion and not well accepted by all farmers and research lines (Dilkes-Hoffman et al., 2019).

Conclusion

Light spectrum variations and concentrations of aqueous extract of *C. rotundus* influence photomorphogenesis and water consumption by pomegranate cuttings and promote microclimatic changes in protected environments.

In an environment with a temperature above 30°C and relative humidity lower than 30%, shoots under blue and white lights were observed. However, exposure time to these conditions promoted the cutting's death.

Spectrum changes have shown that blue light reduces illuminance, average air and soil temperatures, and relative air humidity and promoted a significant increase in water consumption when associated with the aqueous extract of *C. rotundus* in pomegranate cuttings.

All variables studied were considered important to explain the influence of light spectrum variation and concentrations of aqueous extract of *C. rotundus* on pomegranate cuttings photomorphogenesis and environmental microclimate changes.

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