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RESEARCH ARTICLE

Water requirement of gerberas and their behavior under a water-saving strategy, in northern Bahia

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ABSTRACT

Gerbera crop evapotranspiration was defined, as well as its relationship with meteorological elements and the influence of different irrigation rates on its biometric characteristics, under a shaded mesh environment in Juazeiro-BA. The experiment was performed in randomized 4x2 blocks, with irrigation rates (60; 80; 100; and 120% of water consumption per plant) and gerbera hybrids ('Essandre' and DTCS), in five replicates. Gerbera water consumption was determined using total mass variation (vase + substrate + plant) on consecutive days. Total water volume required was 68.19 and 66.9 L $plant^{-1}$, in DTCS and 'Essandre', respectively, in a 240-day cycle after acclimatization, with no significant difference between them. Mean values of the relationship between plant water consumption and reference crop evapotranspiration outside the shaded environment were 0.042 and 0.025L $plant^{-1}$ $mm^{-1}day^{-1}$ during the vegetative phase and 0.055 and 0.029 mmL $plant^{-1}$ $mm^{-1}day^{-1}$ during the reproductive phase of 'Essandre' and DTCS, respectively. The equation ($Y = 0.1176^{*} + 0.0159^{*}x$ $ETo + 0.0008^{**}$ x DAA) estimated the water volume required by gerberas. Water stress negatively affected leaf area, number of gerbera leaves, and gerbera leaf temperature, with quadratic behavior.

Keywords: Crop Evapotranspiration; Floriculture; Semiarid

INTRODUCTION

The Submedium São Francisco River Valley is an important region for the production of fruits and vegetables in Brazil, with emphasis on irrigated fruticulture. However, cultivation diversification is required, and floriculture is a rather interesting alternative to generate income, especially gerbera. This crop has an ensured market, as it is a potted cut flower used for the elaboration of flower arrangements, especially under a protected environment and with suitable irrigation and fertilization management, which are essential for the production of quality gerbera (Silva et al., 2014).

The use of shading meshes might allow production at sites with high temperatures and radiations, such as the northeastern region of Brazil, more specifically the Submedium São Francisco River Valley, reducing the extreme effects of solar radiation on photorespiration, improving yield and quality of inflorescences (Santana Aires et al., 2020).

Studies have been conducted with irrigated pot gerbera in a protected environment. study in Cascavel-PR, with irrigation management performed according to water fractions available in the substrates (Santos et al., 2016). The crop coefficients determined for the different phenological stages of the gérbera were obtained by Piroli et al. (2020) and Carvalho et al. (2017), respectively for the South and northeast regions of Brazil.

The average values crop coefficients Gerbera jamisonii cultivated in Santa Maria-RS, varied of 0.72 to 1.33, according to phenological phases and to irrigation rates (Piroli et al.,2020), with water availability of 80% was observed the better quality and production, in the blade of maximum economic efficiency of 70.6 mm (Piroli et al., 2019).

Information on the water requirements of different gerbera cultivars, which might enable their cultivation, is scarce, especially in the Brazilian northeast.

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In the Submedium São Francisco River Valley, Carvalho et al. (2017) reported crop coefficients for Essandre gerbera (0.50, 0.75, and 1.019) varying according to the following phenological phases, respectively: initial (0-30 days after acclimatization - DAA, development (30-80 DAA), and reproductive phase (80-120 DAA).

However, information on gerbera water requirement is needed to obtain a longer cycle and variation in tolerance to water stress, in order to facilitate the adoption of an irrigation management or to increase effective water use.

The aim of this study was to quantify the tolerance to water stress and water demand in gerberas in a shaded environment and the relationships between the total volume water required by gerberas and the meteorological elements, inside and outside the screened environment, in Juazeiro-BA.

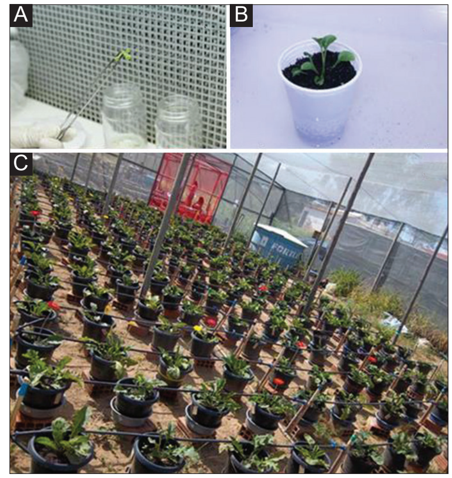

Fig 1. Micropropagation (A), seedlings in acclimatization process (B), distribution of plants in experimental design (C).

MATERIAL AND METHODS

The experiment was conducted in the experimental field of the Department of Technology and Social Sciences of the State University of Bahia, located in Campus III, Juazeiro-BA. It was carried out in a covered greenhouse with an Aluminet screen, 50% of shading, with 13 m length, 9.5 m width, and 3 meters high, in the period ranging from April do December 2016.

Climate in the region is classified as Bswh', hot, semiarid, and with rainy summer according to Köppen's classification, with high potential evapotranspiration, and temperature in the coldest month higher than 18 °C. Mean temperature is 26.3 °C, with June and July having the mildest temperatures.

The experimental design was in randomized blocks design in a 4x2 subdivided plots, with five replications. The plots were composed by four irrigation rates (60; 80; 100; and 120% of water consumption per plant) and the subplots were of two hybrids 'Essandre' and 'DTCS'.

Seedlings were produced via micropropagation (Fig. 1A) from preexisting vegetative material at the laboratory of Biotechnology/Tissue Culture of UNEB/Campus III, in Juazeiro-BA.

During the acclimatization process, gerbera plants were transferred to disposable cups filled with pine-bark based substrates and maintained in a greenhouse for 33 days (Fig. 1B), when they were transplanted to pots with volumetric capacity for 5L, filled with 2.3 Kg of substrate. Fig. 2 shows the size of the gerberas Essandre (A) e Hybrids DTCS (B), to the 46 days after the transplant. A fertirrigation was performed according to crop phenological phase, as proposed by Pais (2016).

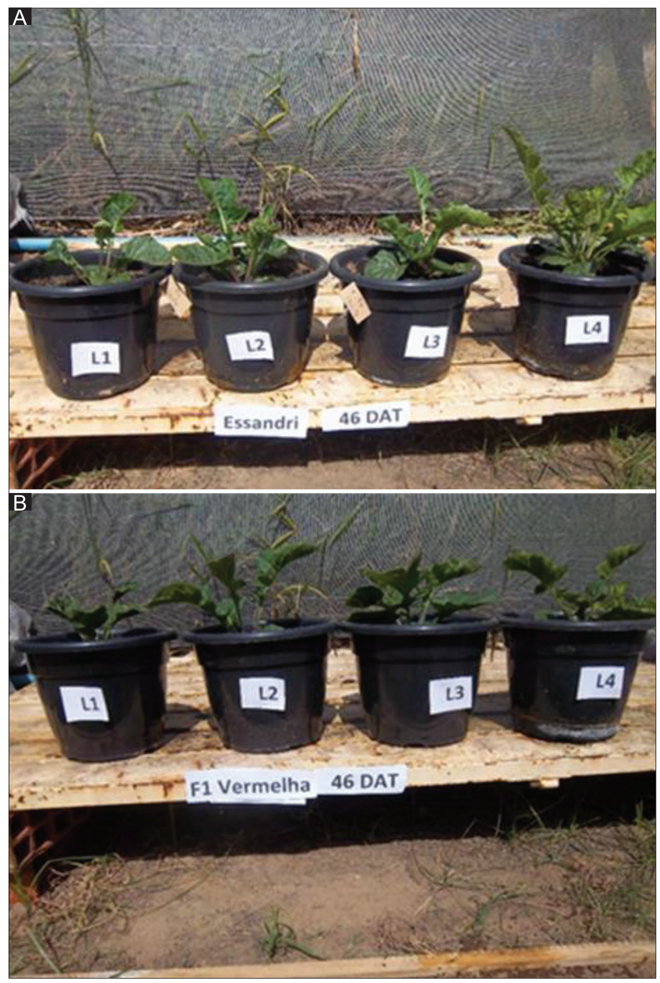

Fig 2. Size of the gerberas Essandre (A) e Hybrids DTCS (B), to the 46 days after the transplant, according to the irrigation blades applied.

Pots were distributed in the area with a 0.5 m x 0.5 m spacing, and arranged on top of bricks, forming a useful area of 81 m^2 (Fig. 1C). The irrigation system used was localized drip irrigation, with drippers spaced

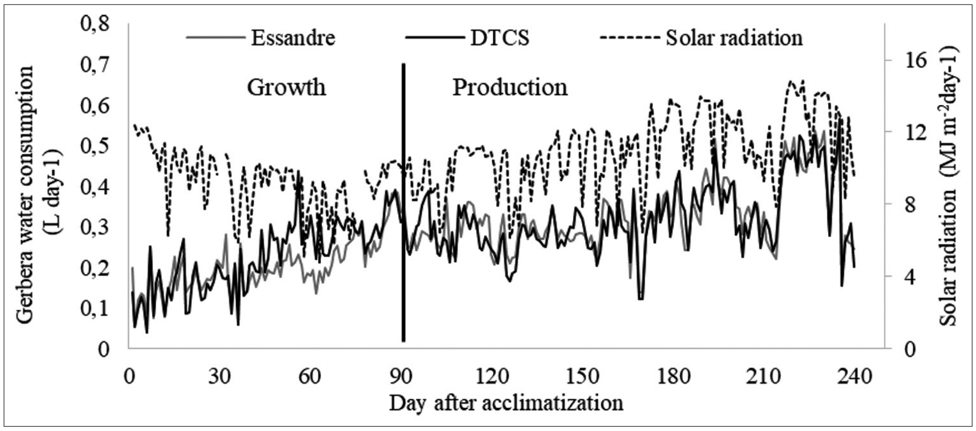

Fig 3. Solar radiation, gerbera water consumption, Hybrids DTCS and 'Essandre', under full irrigation (100% of ETc) over the days after acclimatization and separated by phenological phases, in a protected environment, Juazeiro-BA. 2016.

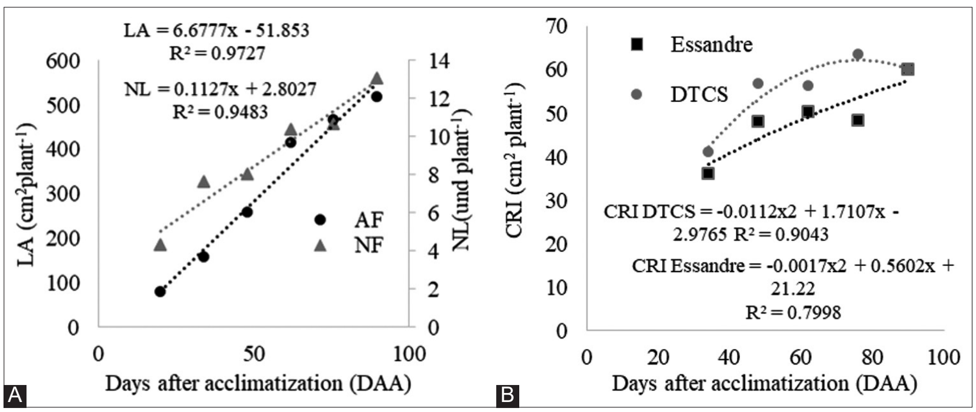

Fig 4. Mean leaf area and number of gerbera leaves (A) and relative chlorophyll index (B), as a function of days after acclimatization in a shaded environment, Juazeiro-BA. 2016.

every 0.50 m, with outflow of 2,3L h^{-1} at a pressure of 2.5 m.c.a.

The volume of water required for each gerbera hybrid was quantified by weighing lisimeter, with five repetitions, from 0 to 240 days after acclimatization, with water replacement performed so as to maintain the substrate with pot capacity moisture, according to the methodology proposed by Ludwig et al. (2015).

Initially, all plants were irrigated with 100% ETc for crop establishment, and after 20 days, they were differentiated according to the treatments proposed.

The biometric analyzes were performed from 20 days after transplantation up to 90 days. The number of $plant^{-1}$ leaves was counted and the leaf area was obtained by measuring the length and width of each leaf, using a ruler graduated in cm. Afterwards, having the product 'length x width' and using an equation that was defined for each hybrid, the linear equations (1) and (2) for DTCS and 'Essandre', respectively, the leaf area was defined in cm^2 $plant^{-1}$:

$$AF = 0.6698 * L*C \quad (1)$$

$$AF = 0.6671 * L*C \quad (2)$$

Where
L= length leaf, cm.
C= width leaf, cm.

The following were evaluated: Relative Chlorophyll Index (RCI), using a digital SPAD chlorophyll meter and collecting the data from three leaves $plant^{-1}$, and after that, obtaining a mean value per $plant^{-1}$ and temperature of leaf surface, using an infrared thermometer, at a distance of 15 cm from the leave, at 11:30 AM and 12:30 PM, on leaves exposed to the sun.

In order to monitor environmental conditions inside the shading mesh, an automatic meteorological station was installed with sensors for air temperature and relative humidity, global solar radiation, and wind velocity. Data were obtained every minute and mean values were obtained every 15 minutes. Based on the daily mean value of these meteorological elements, crop reference evapotranspiration (ETo) was

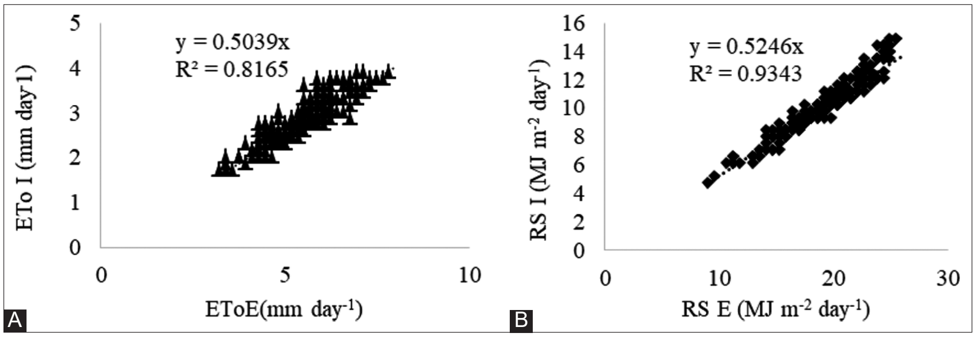

Fig 5. Relationship between reference Evapotranspiration inside and outside the shaded environment (A) and solar radiation inside and outside the shaded environment (B).

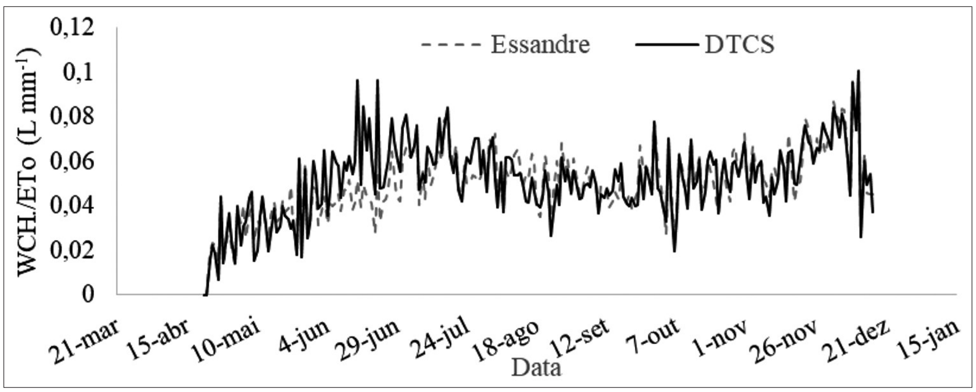

Fig 6. Mean values of the Relationship between gerbera water consumption (W.C.), hybrids 'Essandre' and DTCS, and daily reference Evapotranspiration, in the study under a protected environment in Juazeiro-BA. 2016.

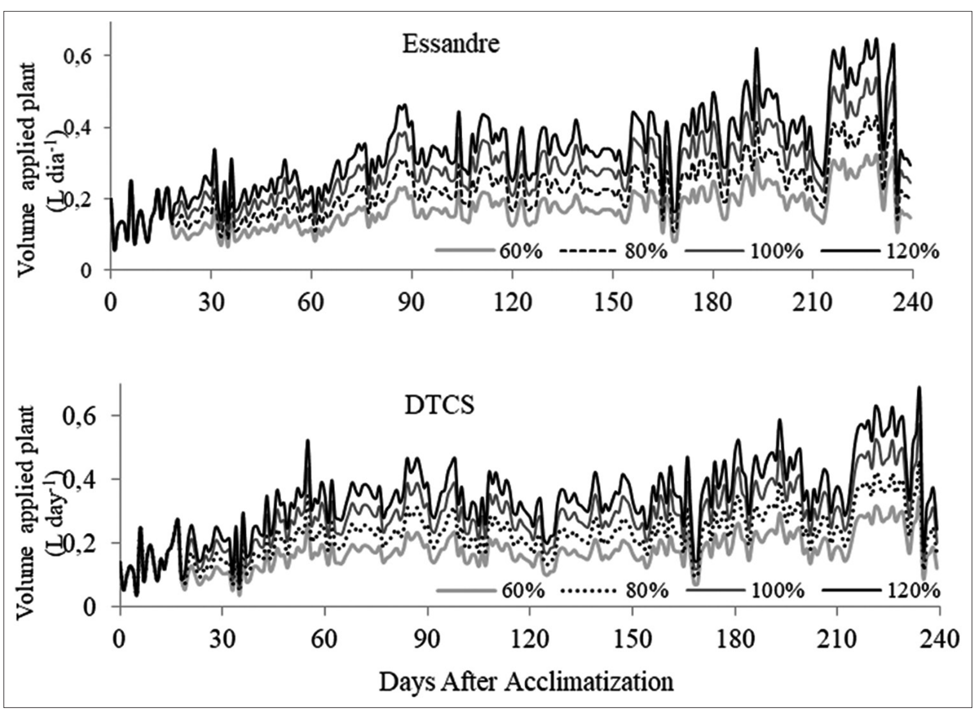

Fig 7. Mean water volume applied to gerbera crop as a function of irrigation rates (60, 80,100, and 120% of plant water consumption) and hybrids, from 0 to 240 days after acclimatization, in a shaded environment, Juazeiro-BA.

calculated inside the shaded environment, according to the equation proposed by Penman-Monteith (Allen et al., 1998).

In order to parameterize models that might help with irrigation management of pot gerberas inside a shaded

Table 1. Summary of the analysis of variance of gerbera water consumption as a function of hybrid used and days after acclimatization and total water consumption values per gerbera phenological phase, in a shaded environment in Juazeiro-BA. 2016.

V.F.	Volume of water consumed (L)	LA	NL	CRI
	F			
Hybrid	1.75ns	0.052ns	0.941ns	318.03**
D.A.A.	8.64**	179.60**	501.71**	4615.30**
HxDAA	0.15ns	0.109ns	0.597ns	43.713**

DAA	Stage	Duration	Volume of water consumed (L)	
			DTCS	Essandre
0-90	Growth	90	20.41	18.12
91-240	Yield	149	47.78	48.77
0-240	Complete cycle	240	68.19a	66.89a

Obs.: *DAA - Days After Acclimatization. Source: Personal file (2016).

Table 2. Multiple regression parameters with reference evapotranspiration (ETo) outside the shaded environment and days after acclimatization (DAA), to estimate the volume of water consumed by gerbera crop (Y).

Mean evapotranspiration of gerbera crop	
Multiple Regression (Y= ß0+ß1xETo+ß2 x DAA)	PR> Fc
Y=0.1176 *+ 0.0159*x ETo+ 0.0008** x DAA	0.0001
R^2 =0.5363	

Obs.: * and ** Significant at 5% and 1% using the t-test, respectively. Source: Personal file (2016).

environment, data in this environment were correlated with the data from the meteorological station of DTCS/UNEB, located approximately 500 meter from the shaded environment.

Meteorological data outside the shaded environment were obtained from the Agrometeorological Station of DTCS/UNEB, which has an automatic data acquisition system (Datalogger CR1000), scheduled to perform readings every second and mean values every 60 minutes.

The relationship between gerbera water consumption (Fig. 6) and ETo was quantified throughout the experiment using a multiple regression analysis to define a model that might aid in gerbera irrigation management under similar conditions as those of the experiment.

Data on water volume required, biometry and water stress indicators by gerberas were submitted to an analysis of variance, a joint variance analysis was performed to verify the isolated or combined effects of the evaluated days after acclimatization (3 to 240 DAA), hybrids (DTCS and Essandre), and irrigation rates, using an F-test.

When values were significant, a regression analysis was performed, with interaction between factors or quantitative factors, and mean values of each hybrid were compared using Tukey's test at 5% of probability, using Sisvar software (Ferreira, 2011).

RESULTS AND DISCUSSION

The water consumption of the gerbera and the global radiation throughout the phenological cycle are shown in the Fig. 3.

The lowest values (0.05 L and 0.048L day^{-1}), the highest values (0.537 and 0.565 L day^{-1}), and the mean values of plant water requirement (0.284 L and 0.278 L day^{-1}) were recorded for DTCS and 'Essandre', respectively, throughout the cycle of 240 DAA.

During the growth phase (0 to 90 days DAA), mean water consumption of hybrids DTCS and 'Essandre' was 0.22L and 0.20L plant^{-1} day^{-1}, respectively, and during the productive phase (91 to 240 DAA), it varied from 0.31L (DTCS) to 0.32L plant^{-1}day^{-1} ('Essandre').

These results are in accordance with the water demand of 'Rambo' gerbera (0.297 L plant^{-1} day^{-1}), cultivated in a sandy loam soil, in pots with volumetric capacity of 5L, during a cycle of 150 days in a greenhouse in Campina Grande-RS (Medeiros et al., 2010), despite the difference in cultivation site and types of substrates used.

A similar behavior of hybrids is observed concerning water consumption and solar radiation tendency, except for days 40 to 77. It is worth noting that despite the apparent higher vigor of DTCS, there was no significant difference in absolute values of DTCS during this period regarding leaf area (LA), number of leaves (NL), and water consumption (Table 1) although it has caused a water saving of 2% in the complete crop cycle. However, there was increased water consumption by gerbera according to plant development during the cycle, with linear increase in leaf area and in number of gerbera leaves over the days after acclimatization, under full irrigation (100% ETc) (Fig. 4A).

DTCS had higher relative chlorophyll index values than 'Essandre' (Fig. 4B), as it exhibits a stronger green leaf coloration, possibly resulting in a higher photosynthetic capacity. A plant with high chlorophyll concentration has the capacity of reaching higher photosynthetic rates (Rêgo et al., 2004).

Crop water consumption is known to occur due to cell expansion and division in the plant: the water maintains cell turgidity allowing its multiplication and ensuring cell physiological processes.

Table 3. Regression equations for Leaf Area (LA), Number of leaves (NL), Relative chlorophyll index (RCI), leaf temperature (Tl) of gerbera, according to irrigation rates (60, 80, 100, and 120 % of crop Evapotranspiration), in a shaded environment, at different dates, expressed in Days After Acclimatization (DAA0, Juazeiro‑BA. 2016.

V.F.	Equations	R^2	Overall mean	Standard deviation
		34 DAA		
Rate	$RCI= 0.000000X^2+ 5.5900X + 30.7475$ **	1	39.13	4.55
	$Tl= 0.002134X^2 - 0.409813X + 44.921250$ **	0.766	26.39	1.88
		48 DAA		
	$Tl= -0.000750x^2 + 0.073950x + 32.3470$**	1	32.55	1.86
		62 DAA		
	$Tl = 0.001572X^2-0.32812+43.668750$ **	0.998	28.04	1.5
		76 DAA		
	$LA= -0.075046X^2+16.146575X-422.4710$ **	0.924	385.32	117.2
	$Tl= 0.002591X^2- 0.540988X+54.025750$**	0.999	27.61	1.234
		90 DAA		
	$LA = -0.112302X^2+24.479610X-811.940400$ **	0.999	425.42	140.24
	$NL = -0.001469X^2+0.310125X-3.792500$ **	0.903	11.48	1.73
	$Tl = 0.002296X^2-0.483015X+56.767100$ **	0.997	33.04	0.99
		145 DAA		
	$Tl = 0.002822X^2-0.552962X+57.237250$**	0.983	31.73	2.05
		176 DAA		
	$Tl = 0.003156X^2-0.616925X+60.217000$**	0.972	31.83	2.33
		202 DAA		
	$Tl = 0.002540X^2-0.505479X+55.945275$**	0.999	32.29	2.24
		230 DAA		
	$Tl= 0.002844X^2-0.543325X+55.9588$**	0.996	31.51	1.89

Obs.: * and ** Significant at 5% and 1% using the t‑test, respectively. **Source:** Personal file (2016).

Increase in water demand with increased plant development is expected, according to Girardi et al. (2016), studying alstroenemeria cut flower cultivated in a greenhouse in Santa Maria- RS.

The volume of water required by gerberas was higher than those reported for 'Festival Eyes Red' gerberas (58.55 L plant^{-1}) cultivated in soil, in a shaded environment with red screen and irrigation performed based on soil water tension and with water replacement at a soil matric potential of -15 kPa, in a cycle of 87 days, in Lavras-MG (Pereira, 2013); and for 'Essandre' gerbera (51.33 L plant^{-1}), in a cycle of 120 DAA, using a drainage lysimeter as reference and Piché evaporimeter for irrigation management, in Juazeiro-BA (Carvalho et al., 2018).

In gerberas of 'Nevada' (yellow flowers with black core) and 'Testarosa' varieties (red flowers with yellow core) under hydroponic condition, different values of total water volume required were observed according to variety, with emphasis on 'Nevada', which had the highest water requirement, especially in months with higher water demand (November and December) in Buenos Aires, Argentina (Mascarini et al., 2003).

This difference in total water consumption by gerberas between different studies results, among other factors, from differences in meteorological conditions at cultivation sites, from the genetic material of the gerberas used, from the variation in phenological cycle duration, from soil and/or substrate conditions, and from the difference in evaporating surfaces adopted in the crops.

ETo was mitigated by 49.61% by using shading screen, especially due to reduction in solar radiation by 47.54% inside the shaded environment (Fig. 5), with linear models substantiated by high coefficients of determination, indicating the reduction in water consumption under shaded conditions, resulting in water economy, and data outside this environment and corrected by the equations shown might be used for conditions that are similar to those of the present study.

Crop evapotranspiration might vary according to soil, climate, and species and/or hybrids, due to intrinsic genetic factors of each plant, such as a higher evaporating and photosynthesizing surface, stomatal density per area unit, and their ability to control their opening and closing; the latter can affect the higher or lower accumulation of photosynthates, which might be converted into leaf area and number of leaves, biomass, and/or yield. Crop evapotranspiration might also be affected by either environmental or physiological conditions (Gomide & Maeno, 2008).

Coefficients of multiple regression used to estimate mean gerbera Evapotranspiration according to ETo outside the shaded environment, and according to days after acclimatization are shown in Table 2. Coefficients that relate ETo and DAA to mean water consumption value of gerbera crop were significant ($p<0.01$), with R^2 higher than 50%.

Although the coefficient of determination was not high, it was possible to adopt a multiple equation to estimate the water volume required by gerbera, under similar cultivation conditions, especially due to the easy availability of data on reference evapotranspiration outside shaded environments and the definition of days after acclimatization of the crop.

Literature has recommended the use of the existing relationship between reference evapotranspiration and/or solar radiation and temperature to estimate crop water requirement, especially in a protected environment.

In a study conducted with Gerbera (*Gerbera jamesonii,* Vr. *Rambo*), in Teresina-PI, quadratic adjustments were reported and approximately 60% of ETo variation was affected by mean air temperature (Andrade junior et al., 2011). Additionally, according to these authors, although air temperature results in a lower accuracy compared to other independent variables and to multivariate analysis, this variable is easily provided by farmers, and can be adopted in ETo estimates.

Regarding the relationship between water consumption by plants (W.C.) and $ETo_{external}$ throughout the study, Fig. 4 shows mean values of 0.042 and 0.025 L plant^{-1} mm^{-1}day^{-1} in the vegetative phase and 0.055 and 0.029 mm^{-1} mm^{-1}day^{-1} in the reproductive phase for 'Essandre' and DTCS, respectively. There was a linear increase with increased W.C./ETo per increased LA, especially until 90 DAA, when loss of leaves increased in both hybrids, subsequently varying according to prevailing meteorological conditions.

Mean daily water volumes (Fig. 7) applied to gerbera crops according to hybrids, different irrigation rates, and days after acclimatization, resulted in water economy of 27.89 and 13.95 L plant^{-1} in 'Essandre' and of 29.25 and 15.08 L plant^{-1} in DTCS, with water restriction of 40 and 20%, respectively, compared to full irrigation.

Noya et al. (2014) reported water economy of 37.8 and 43.2 L plant^{-1} adopting an irrigation frequency of two and three days, respectively, compared to daily irrigation during spring, with *Stenachaenium megapotamicum*, an ornamental plant cultivated in a greenhouse in the municipality of Curitiba-PR.

Considering growth and stress responses of gerbera to different irrigation rates applied (Fig. 4 e Table 3).

Gerbera leaf area and number of leaves changed according to irrigation rates, at 76 and 90 DAA, reducing quadratically with decreased water applied, substantiated by coefficients of determination. At 76 DAA, the maximum LA of 446 cm^2 was obtained with the replacement rate of 107.58% of crop water consumption, and at 90 DAA, the maximum FA and NL were 522.07 cm^2 and 12.57 leaves, respectively, when using the rates of 108.9% and 105.5% of gerbera water consumption. It is worth emphasizing that from 90 DAA onwards, leaf loss started to increase in both hybrids, which is typical of this crop, and thus, LA was no longer quantified.

These results corroborate the reduction of LA and NL in gerberas with decreased irrigation rate applied in pot cultivation, found in studies conducted by Ludwig, (2013), in Botucatu-SP. Irrigation deficit might cause an increase in electric conductivity in the substrate solution that is higher than the value (2 dS m^{-1}) tolerated by gerbera crops (Mota et al., 2014) and reduction in stem height in gerbera inflorescences, as observed by Santos et al. (2018) with EC values ranging from 2.03 to 3.89 dS m^{-1}.

Under water excess in the substrate, with obstruction of free drainage, there was substrate soaking for a few hours or days, and according to Duarte et al. (2015), the blocking of oxygen uptake near the root zone negatively affects plant development, due to aeration deficit, among other causes.

Transpiration of a plant is directly related to leaf area. Thus, increase in leaf area shall provide higher transpiration values (Angelocci, 2002).

According to Taiz & Zeiger (2013), reducing leaf area is an adjustment performed by plants submitted to water stress, which, according to these authors, start the senescence stage and fall after leaves expand; this is an important strategy for plant to adjust to an environment with water restriction.

If the plant is submitted to water restriction during its growth phase, there will be a decrease in number of cells, and consequently, reduced leaf area and compromised yield (Lacerda, 2007).

RCI did not change with different irrigation managements, although gerbera leaf surface temperature did change (Tl), with a quadratic behavior, over the dates evaluated, substantiated by high coefficients of determination.

Tl of gerbera leaves varied according to different irrigation rates, with minimum points of 25.24, 26.54, 25.78, 31.36, 30.14, 30.06, 30.79, and 30 for gerbera irrigation based on 96, 104.36, 104.9, 105.18, 97.97, 97.73, 99.50, 95.52% of water consumption, respectively at 34, 62, 76, 90, 145, 176, 202, and 230 DAA, and maximum foliar temperature point of 34.16º C, for irrigation with replacement of 49.3% of water consumption by plants, at 48 DAA. Plants irrigated with both irrigation deficit and excess exhibited difference in mean Tl of 0.9, 3.5, and 1.5 °C, respectively, compared to those submitted to full irrigation.

Under stressful conditions caused by water deficit, stomata close, thus favoring a progressive increase in leaf temperature, due to reduced sap flow, which might lead to a halt of physiological processes, causing tissue destruction and death (Tribuzy, 2005) and Tl might thus be viable as an indicator of water stress in plants submitted to different water regimes under the same atmospheric conditions (Angelocci, 2002).

The difference between gerbera leaf temperature and air temperature in the shaded environment was 3.29 °C under deficit (60% of ETc), at 90 DAA, which occurred in the production phase and in the hottest period of the year in this region, from August to November, with mean air temperatures higher than 30 °C.

Plants under water deficit might have their leaf temperature increase rapidly from 4 to 5 °C above room temperature, at the hottest times of the day due to stomata closure, causing a thermal stress and delaying the integral growth of the plant.

Water stress provides increase in leaf temperature, which indirectly affects stomata movement, and rise in temperature after an optimal point leads to decreased cell activity, causing an increase in transpiration that becomes higher than photosynthesis, thus leading to a higher energy expenditure (Kerbauy, 2013).

CONCLUSIONS

The water requirement of gerbera hybrids 'Essandre' and DTCS in a shaded environment in Juazeiro-BA is similar. Water stress reduces leaf area and number of leaves in gerberas, starting at 76 DAA, regardless of the hybrid Gerbera leaf temperature indicated water stress, determined by different rates, with different CRI responses according to the hybrid used, particularly DTCS; which might indicate different impacts on gerbera yield. Gerbera irrigation management might be performed based on volume of water consumed by plants on a daily basis, throughout days after acclimatization. This is due to the relationship between water consumption and ETo outside the shaded environment per phenological phase and according to the multiple regression equation ($ETc=0.1176^{*}+ 0.0159^{*}x\ ETo+ 0.0008^{**}x\ DAA$), which estimates ETc according to ETo data obtained outside the shaded environment and days after acclimatization.

Authors' contributions

Damiana de Oliveira Silva: Conceptualization; Experiment design; Experiment performer; Drafted the manuscript; Data analysis; Writing - review and editing. Lígia Borges Marinho: Funding acquisition; Conceptualization; Experiment design; Study orientation; Supervision, Validation, Visualization, Writing - review and editing. Joselita Cardoso de Souza: Conceptualization; Experiment design; Study orientation; Supervision, writing - review and editing. Thomaz da Silva Felisberto: Experiment performer; Validation, Visualization. Lucas Melo Vellame: Supervision, validation, visualization, writing - review and editing. Gertrudes Macário de Oliveira: Supervision, validation, visualization, writing - review and editing. Larissa de Sá Gomes Leal: Data curation, formal analysis, writing - original draft. All authors revised the document critically and approved the final manuscript for submission to the Journal.

REFERENCES

Allen, R. G., L. S. Pereira, D. Raes and M. Smith. 1998. Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage Paper, 56, Food and Agriculture Organization, Rome.

Andrade, A. S. Jr., L. M. O. Damasceno, N. S. da Dias, H. R. Gheyi and C. Guiselini. 2011. Climate variations in greenhouse cultivated with gerbera and relationship with external conditions. Engenharia Agrícola. 31: 857-867.

Angelocci, L. R. 2002. Água na Planta e Trocas Gasosas/Energéticas Com a Atmosfera: Introdução ao Tratamento Biofísico. NLM. Angelocci LR, Piracicaba.

Carvalho, P. H. M., W. R. S. Costa, J. Silva and S. O. P. Queiroz. 2017. Evapotranspiração e Coeficiente de Cultivo da Gérbera Essandre em ambiente Protegido. Inovagri International Meeting, IV, Anais, Fortaleza, pp. 1-7.

Carvalho, P. H. M., W. R. S. Costa, J. S. E. Silva, S. O. P. Queiroz and J. C. Souza. 2018. Desempenho agronômico de gérbera sob reuso de água. Rev. Bras. Agric. 12: 3040-3047.

Duarte, S. N., Ê. F. F. Silva, J. H. Miranda, J. H. Medeiros, R. N. T. Costa and H. R. Gheyi. 2015. Fundamentos de Drenagem Agrícola. Instituto Nacional de Ciência e Tecnologia em Salinidade, Fortaleza.

Ferreira, D. F. 2011. Sisvar: A computer statistical analysis system. Ciênc. Agrotecnol. 35: 1039-1042.

Girardi, L. B., M. X. Peiter, R. A. Bellé, A. D. Robaina, R. R. Torres, J. H. Kirchner and L. H. B. Luis Ben. 2016. Evapotranspiração e coeficiente de cultura da Alstroemeria (*Alstroemeria x hybrida*) cultivada em estufa. Irriga Botucatu. 21: 817-829.

Gomide, R. L. and P. Maeno. 2008. Requerimento de água pelas culturas. In: P. E. P. Albuquerque and F. O. M. Durães (Eds.), Uso e Manejo de Irrigação. Embrapa Informação Tecnológica, Brasília.

Kerbauy, G. B. 2013. Fisiologia Vegetal. 2nd ed. Guanabara Koogan, Rio de Janeiro.

Lacerda, C. F. 2007. Relações Solo-água-planta em Ambientes Naturais e Agrícolas do Nordeste Brasileiro, Recife-PE.

Ludwig, F., A. C. Guerrero, S. O. Gonçalves, D. M. Fernandes and R. L. Villas Bôas. 2013. Lâminas de fertirrigação e substratos na produção e qualidade de gérbera de vaso. Irriga. 18: 635-646.

Ludwig, F., D. M. Fernandes, A. C. Guerrero, R. L. Villas Boas and D. Laschi. 2015. Substratos no desenvolvimento de cultivares de gérbera envasada. Rev. Bras. Hortic. Ornament. 21: 177-184.

Mascarini, L., O. Delfino, A. Mascarini, F. Vilella and V. Petasne. 2003. Estimación de la evapotranspiración de dos cultivares de Gerbera jamesonni en condiciones de hidroponía. Rev. Bras. Hortic. Ornament. 9: 42-52.

Medeiros, S. S., H. R. Gheyi and F. A. L. Soares. 2010. Cultivo de flores com o uso de água residuária e suplementação mineral. Engenharia Agrícola. 30: 1071-1080.

Mota, P. R. D., R. L. Villas Boas, F. L. Ludwig, D. M. Fernandes, M. V. Folegatti. 2014. Portable meters for nutritional assessment in plants of gerbera fertigated with electrical conductivity levels. Rev. Bras. Engenharia Agrícola Ambiental. 18: 258-262.

Noya, M. G., F. L. Cuquel, R. A. Armindo and J. L. M. Souza. 2014. Cultivo de Stenachaenium megapotamicum em diferentes regimes de irrigação. Ciência Rural. 44: 79-84.

Pereira, L. G. 2013. Produção de hastes florais em gérberas submetidas a diferentes tensões de água no Solo. (Dissertação de Mestrado), Universidade Federal de Lavras, Lavras.

Pais, A. K. L. 2016. Micropropagação de Gérberas Por Meio de Esterilização Química e Avaliação das Bactérias Promotoras de Crescimento no Desenvolvimento das Mudas. (Tese de Mestrado), Universidade do Estado da Bahia, Juazeiro, BA.

Piroli, J. D., M. X. Peiter, A. D. Robaina, M. A. Rodrigues, R. Boscaini and P. E. C. Rodrigues. 2019. Eficiência técnica e econômica da irrigação na produção de gérbera de corte em ambiente protegido. Irriga. 24: 569-581.

Piroli, J. D., M. X. Peiter, A. D. Robaina, M. A. Rodrigues, L. D. Ferreira, F. A. Bortolás, S. A. Rodrigues and J. Bruning. 2020. Crop coefficient of cut gerbera with water supplementation in a protected environment. Rev. Bras. Cienc. Agrárias. 15: e7652.

Rêgo, J. L. 2004. Efeitos de níveis de irrigação sobre a cultura do crisântemo. Rev. Ciênc. Agron. 35: 302-308.

Santana Aires, E., Alberto Aragão, C., Borges Marinho, L., Silva Gomes, Í. L., Nunes Oliveira, A. B. and J. E. Yuri. 2020. Performance of crisphead lettuce cultivars under protected environment in different times of production. Rev. Ceres. 67: 40003.

Santos, F. T., F. Ludwig, L .A. M. Costa, M. S. S. Costa, M. Remor and P. E. R. Silva. 2016. Growth analysis of potted gerbera conducted with mineral fertilization and organic fertigation. Rev. Cienc. Investig. Agraria. 43: 111-120.

Silva, B. A., A. R. Silva and L. G. Pagiuca. 2014. Cultivo Protegido. Em busca de Mais Eficiência Produtiva. Hortifruti Brasil. Available from: https://www.hfbrasil.org.br/br/revista/cultivo-protegido-versus-campo-aberto.aspx. [Last accessed on 2016 Oct 08].

Taiz, L. and E. Zeiger. 2013. Fisiologia Vegetal. 5th ed. Artemed, Porto Alegre.

Tribuzy, E. S. 2005. Variações da Temperatura Foliar do Dossel e o Seu Efeito na Taxa Assimilatória de CO_2 na Amazônia Central, (Tese de Doutorado), Escola Superior de Agricultura Luiz de Queiroz, Piracicaba.