INVESTIGATION OF THE BIOLOGICAL RESPONSE DUE TO THE CULTIVATION IN PROTECTED AREAS OF TOMATO PLANTS ILLUMINATED WITH LED LIGHT, BY PHYSIOLOGICAL DETERMINATIONS AT LEAF LEVEL

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Abstract. The treatment method tested in the present experiments aimed at increasing the performance of physiological processes during the development of tomato plants from 3 Romanian varieties (Hera, Coralina and Sonia de Buzau), under the effect of high-power monochrome light emitted diodes (LEDs) (red, blue and white light). The observations focused on investigating the biological response due to the cultivation in protected areas of tomato plants additionally exposed for 30 minutes to LEDs, by physiological determinations for the leaves situated near the top of the main stem. The photosynthesis intensity, transpiration intensity, stomatal conductance, internal CO_2 concentration, as well as the amount of chlorophyll were determined in tomato seedlings, during the vegetative growth phase until the formation of the second inflorescence. The obtained results showed that the physiological determined indicators values varied according to the cultivar, the age of plants and the monochromatic light treatment. A stimulating effect has been noticed especially in the case of blue light, regarding both the photosynthesis rate and the transpiration rate. Blue and white light increased the stomatal conductance compared to the control, while exposure to red light caused a statistically significant decrease of the values of this indicator. Prior to the treatments, the internal concentration of carbon dioxide did not vary according to the cultivar, but subsequently, values were significantly lower than the control (e.g. Hera cv.) in the case of LED light, while, usually, no significant differences were recorded between the varieties and the applied treatments. Total chlorophyll content increased for control variants with the advancing age of the seedlings, but the trend was not the same for monochromatic light treatments.

Keywords: physiological determinations, tomatoes, LED lights.

Rezumat. Investigarea răspunsului biologic datorat cultivării în spații protejate al plantelor de tomate iluminate cu lumină LED, prin determinări fiziologice la nivel foliar. Metoda de tratament testată în prezentele experimente a avut drept scop creșterea performanței proceselor fiziologice în timpul dezvoltării plantelor de tomate din 3 soiuri românești (Hera, Coralina și Sonia de Buzău), sub efectul diodelor care emit lumină monocromatică de înaltă putere (LED-uri) (lumină roșie, albastră și albă). Observațiile s-au concentrat pe investigarea răspunsului biologic datorat cultivării în spații protejate al plantelor de tomate expuse suplimentar timp de 30 de minute la LED-uri, prin determinări fiziologice pentru frunzele situate în apropierea vârfului tulpinii principale. Intensitatea fotosintezei, intensitatea transpirației, conductanța stomatică , concentrația internă de CO_2, precum și cantitatea de clorofilă au fost determinate în răsadurile de tomate, în faza de creștere vegetativă până la formarea celei de-a doua inflorescențe. Rezultatele obținute au reliefat că valorile indicatorilor fiziologici determinați au variat în funcție de cultivar, vârsta plantelor și tratamentul cu lumină monocromatică. Un efect stimulator a fost observat special în cazul luminii albastre, atât în ceea ce privește rata fotosintezei, cât și în ceea ce privește rata transpirației. Lumina albastră și albă au crescut conductanța stomatică în comparație cu controlul, în timp ce expunerea la lumina roșie a provocat o scădere semnificativă din punct de vedere statistic a valorilor acestui indicator. Înainte de tratamente, concentrația internă a dioxidului de carbon nu a variat în funcție de cultivar, dar, ulterior, valorile au fost semnificativ mai mici decât controlul (de ex. Hera cv.) în cazul luminii cu LED-uri, în timp ce de obicei nu au existat diferențe semnificative între soiurile și tratamentele aplicate. Conținutul total de clorofilă a crescut pentru variantele de control odată cu înaintarea în vârstă a răsadurilor, dar tendința nu a fost aceeași pentru tratamentele cu lumină monocromatică.

Cuvinte cheie: determinări fiziologice, tomate, lumini LED.

INTRODUCTION

Scientific literature in the field of crop plant physiology mentions that physiological processes are influenced by many external factors, such as: light, temperature, soil and air humidity, soil solution concentration, atmospheric pressure and air flow (BURZO et al., 2004; DELIAN, 2008).

Among them, light directly influences the intensity of the transpiration process through its caloric effect, as well as by activating the mechanism of opening and photoactive closure of the stomata. At the same time, light is essential for the development of the photosynthesis process, the solar light energy being transformed through this process into biochemical energy. Blue radiation, which has the highest amount of energy determines the achievement of a maximum photosynthetic rate, followed by the red radiation in which a lower maximum is also recorded (INADA, 1976).

Regarding the intensity of photosynthesis, it is considered that the species is a factor with a considerable impact (SESTAK & ČATSKÝ, 1985; LARCHER, 1995), the net values of this parameter can vary between 3-63 mg CO_2 / dm^2 / h, and in the case of tomatoes (*Lycopersicon esculentum*) between 14-21 CO_2 / dm^2 / h. Light influences the process of plant growth through intensity, duration and spectral composition (BURZO et al., 2004; MANDA et al., 2018). As regard as the light intensity effect, the initiation of the photosynthesis process takes place at light intensities of 0.5W / m^2 for photophilic plants and an increase of the rate is achieved at values up to 520 W / m^2. In shade plants, the growth process is controlled by cryptochrome, which is a receptor of blue radiation and is a mixture of flavones and cryptochromes. The morphogenic action of light has also been studied in the case of many plant species, through which processes such as: growth, development or differentiation can be directed, with particularly useful applications in technological practice (BROWN et al., 1995; MENARD et al., 2006; RUNKLE, 2017).

Environmental factors, including temperature, light intensity and nutrition are of major importance for the growth rate of *Solanaceae* plants, as well as in stimulating the shorter initiation of fruiting processes. In tomato plants, growth is also stimulated by oscillations of at least 10°C between day and night (THOMAS, 1999).

MATERIAL AND METHODS

Biological material. Tomato seedlings of 3 varieties (Hera, Coralina and Sonia de Buzău) were used, with the first 4-6 pairs of well-formed true leaves. From the point of view of the characteristics of the fruit in the selected tomato assortment: the Hera variety is distinguished, in particular, by the elongated shape of the fruit, which closely resembles the kapia pepper; for Coralina the fruits have a round appearance, of cherry type and an average weight of 25 grams and those of the Sonia de Buzău variety have a cordiform shape and cherry fruiting type.

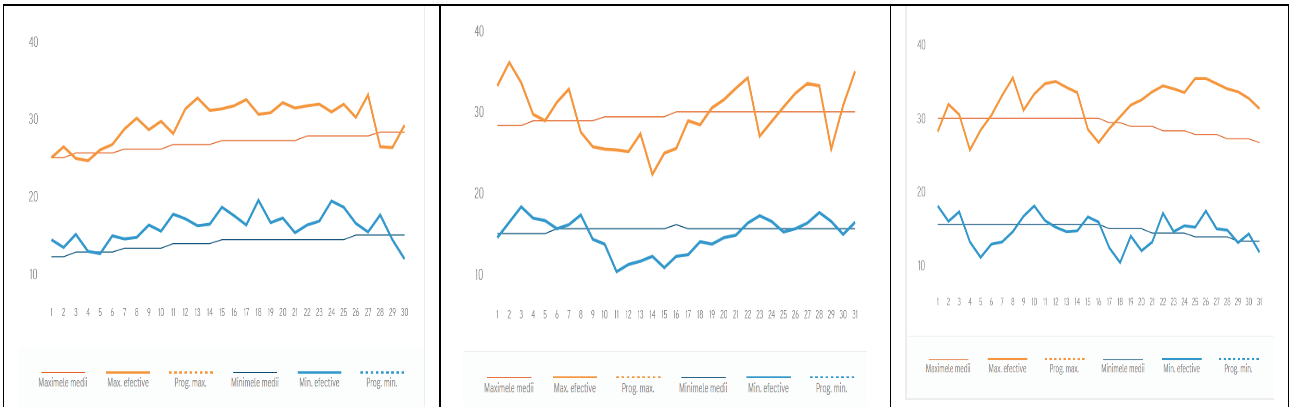
Experimental methods applied. The experiments took place in the Vegetation House of University of Agronomical Sciences and Veterinary Medicine from Bucharest (UASVM Bucharest) between June and August 2019. At the beginning of the experiment (the third decade of June) seedlings required the transfer from the alveolar pallets used in pots with the size: 11 cm high, 10 cm wide. The volume of soil used in these pots was 500ml. For transfer, KEKILLA Professional type peat was used, with 90% organic matter, addition of nitrogen (N), potassium (K), phosphorus (P) nutrients in a ratio of 15-24-5, calcium carbonate ($CaCO_3$), pH 5.9 and humidity between 50-65%.

During the quantification of the effects due to the additional lighting with monochrome LEDs, the following care works were periodically applied to the tomato plants: removal of the yellowed leaves from the base of the stems, tying the plants to the stakes and applying periodic watering correlated with the temperature values, atmospheric humidity and air flow, recorded between June and August 2019, in the compartment used in the "Vegetation House" of UASVM Bucharest. In order to ensure optimal culture conditions, daily temperature monitoring was performed, with the help of the thermometer from the culture space, during the 50 days of experiments, and when applying the daily aerations and watering, the recorded thermal values were taken into account from the third decade of June to the second decade of August 2019. Thus, Table 1 presents the average values of climatic conditions (temperature, atmospheric humidity, atmospheric precipitation and wind speed), and Fig. 1 shows the daily thermal values recorded in dynamics, for the Bucharest area.

Table 1. Climatic conditions registered in July-August 2019, for the area of experiments (Climate data registered in Bucharest-Otopeni); average values and monthly totals. (Source: https://en.tutiempo.net/climate/08-2019/ws-154210.html).

Month value	T	TM	Tm	H	PP	VV	V	VM
June 2019	23.3	29.8	17.3	71.5	64.26	9.7	11.1	25.6
July 2019	22.8	29.6	16.1	67	22.86	9.8	8.9	22.2
August 2019	24.5	32	16.8	54.2	2.79	10	9.3	19.7

T- Average Temperature (°C), TM- Maximum temperature (°C), Tm- Minimum temperature (°C), H-Average relative humidity (%), PP-Total rainfall (mm), VV- Average visibility (Km), V- Average wind speed (Km/h) and VM- Maximum sustained wind speed (Km/h).



June 2019	July 2019	August 2019

Figure 1. Temperature values recorded in June-August 2019, for the area of experiments (Climate data registred in Bucharest); (Source: https://www.accuweather.com/ro/ro/bucharest/287430/august-weather/287430?year=2019).

Experimental device. The technology of using additional light with LEDs in culture spaces has many benefits, such as enhancing crop timing, yield, and specific responses such as antioxidant content, organoleptic and ornamental quality, and post-harvest shelf life. LED technology will also be applied in horticultural facilities used for propagation, graft healing, sorting, and grading of horticultural harvested products, as highlighted since the first studies by BULA et al., (1991), and later in numerous publications (SCHUBERT & KIM, 2005; MASSA et.al. 2008; OKAMOTO et.al. 2008; BRUMFIELD et.al. 2009; MITCHELL et.al 2012).

In the experiments developed in this work, the treatments with additional light were applied for a period of 30 minutes, by means of LED panels, with the emission of light in the band specific to the red, blue and white colours, and then the seedlings of tomatoes from the experimental variants were kept in natural light.

The 3 LED panel models-VegetaLED were made by the company S.C. Electromagnetica SA. -Bucharest, Romania (www.electromagnetica-led.ro), at the dimensions of: 385mm x 264 mm x 169mm and provided an additional illumination of 10,000 lx. These devices have been specially designed for the lighting of agro-industrial complexes such as greenhouses, climate chambers and solariums, being able to bring energy savings of at least 60% and reduce costs associated with growing plants with artificial lighting compared to traditional lighting systems. The construction scheme, spectral distribution and light intensity distribution of the used device, i.e. VegetaLED model, are shown in Fig.2.

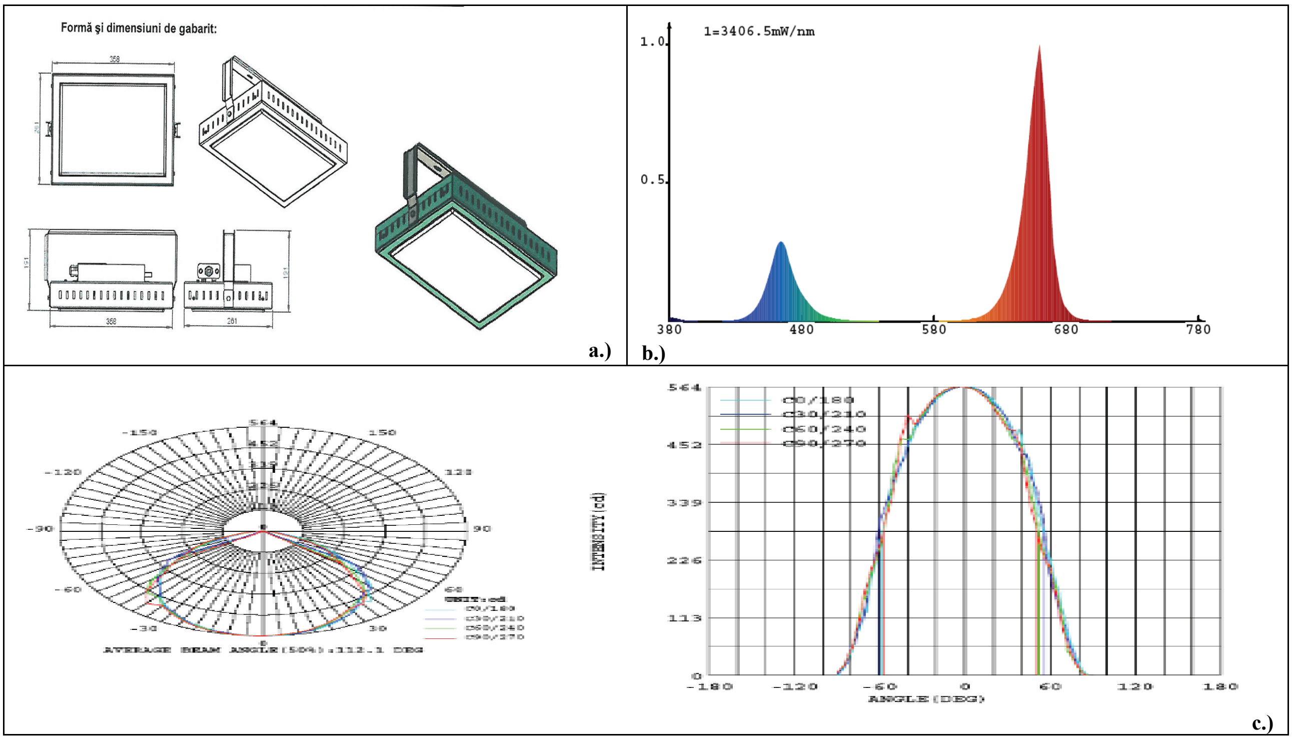


Figure 2. VegetaLED lighting device consisting of a panel with monochrome LEDs in the white, red and blue range: a.) the constructive aspect; b.) spectral distribution and c.) light intensity distribution. (Source -Electromagnetica S.A. Bucharest; *www.electromagnetica-led.ro*)

The device was adapted to the suspended support system, at an adjustable height above the plants, in order to cover a larger exposure area with additional light (Fig. 3).

Figure 3. Appearance from the moment of performing the treatment with white, red and blue LEDs on the tomato plants from the Sample variants (USAMV Bucharest - Vegetation House) (original photos).

Determination of physiological parameters. In order to evaluate physiological indicators such as: photosynthesis intensity (µmoles CO_2 $m^{-2}s^{-1}$), transpiration intensity (mmol H_2O $m^{-2}s^{-1}$), stomatal conductance (mmol H_2O $m^{-2}s^{-1}$) and internal CO_2 concentration (µmol CO_2 mol^{-1}), the portable analyser - LCPro-SD was used. To determine the amount of total chlorophyll (mg m^{-2}) in tomato leaves, the CCM-300 Opti Sciences chlorophyll meter was used, as a non-destructive method.

Three determinations of the physiological parameters were performed on the leaves of tomato plants from the varieties: Hera, Coralina and Sonia de Buzău. The first determination was performed on 3^{rd} July 2019, 1 week after transplanting the seedlings from the alveolar trays into the black pots and respectively one week before the first monochrome LED lighting that took place on 9 July 2019. The following 2 determinations were made on 08.08.2019 and 19.08.2019, at intervals of 30 and 40 days respectively. To determine the amount of total chlorophyll **(**mg m^{-2}) there were done 3 determinations on the same calendar dates (July 3, 2019; August 8, 2019 and August 19, 2019), at the level of the 3rd leaf at the apex of the main stem of tomato plants.

Statistical analysis. The experiment has been carried out in a completely randomized block design. The data were analysed through one-way analysis of variance (ANOVA) and T-Test ($P < 0.05$) in order to define the differences signification between treatments. The experimental scheme was composed as follows: Factor **A** was represented by the 3 Romanian tomato varieties: Hera, Coralina and Sonia de Buzău; Factor **B** was represented by the light emitted by the LEDs arranged on panels in 3 colour gradations (red, blue, white) compared to the natural light indicator (12-14 hours / day) and Factor **C** was represented by the lighting time of 30 minutes. For each of these, samples were provided in 3 repetitions.

RESULTS AND DISCUSSIONS

The physiological indicators showed different trends according to the light spectral region of the treatments (Tables 2; 3; 4; 5), taking into consideration that, in terms of light intensity, they was controlled to be around 200 µmoles $m^{-2}s^{-1}$.

The photosynthesis rate. Regarding the intensity of the photosynthesis process, as it can be seen from the data presented in Table 2, the values varied during the determinations, from negative values (Coralina variety) to very high values for tomato leaves, respectively 46.64 µmoles of CO_2 $m^{-2}s^{-1}$ (Sonia de Buzău cv.), in the first decade of August. If we analyse the values recorded in young plants, before treatment, we notice statistically significant differences ($P <0.05$) between the three varieties, with maximum values in Coralina cv. (17.85 µmoles CO_2 $m^{-2}s^{-1}$), followed by the variety Sonia (10.52 µmoles CO_2 $m^{-2}s^{-1}$) and respectively the variety Hera (6.61µmoles CO_2 $m^{-2}s^{-1}$).

LED treatments have had variable effects in close connection with the variety, but also with the plant development phase. In Table 1, the average values and respectively the significance of the differences compared to the control are represented. As expected, the values were generally higher in the first decade of August, compared to those obtained on August 19. At the same time, it is noteworthy that the blue light determined a very strong statistically significant increase ($P <0.001$) of the photosynthesis rate in the Hera and Sonia de Buzău varieties on August 8 (30 days, application of the treatments), following that, at the last determination, the values should be significantly higher ($P <0.01$) in Coralina cv., compared to the Control and respectively significantly higher ($P <0.05$) in Hera and Sonia de Buzău. The stimulating effect of white light was lower, and in the case of red light there were significantly lower values ($P <0.05$) compared to the Control or the differences were insignificant ($P> 0.05$).

Table 2. Net photosynthesis rate (µmoles CO_2 $m^{-2}s^{-1}$) of tomato leaves for some cultivars exposed to different light quality of LED lighting (mean ± SE).

Tomatoes Variety	**HERA**		**CORALINA**		**SONIA at BUZĂU**	
1^{st} determination	July 3, 2019 – before treatment					
	6.61±0.33C		17.85±0.50A		10.52±0.24B	
$2^{nd}/3^{rd}$ determination	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019
Control	21.57±2.20	2.46±0.86	12.80±2.61	8.58±0.41	27.66±4.18	15.82±2.26
Blue LED	37.14±2.14^{xxx}	19.16±4.47^{x}	22.74±0.68^{xx}	12.12±3.09^{ns}	46.64±2.86^{xxx}	18.67±2.74^{x}
Red LED	14.66±2.49^{0}	4.33±0.86^{ns}	-2.43±0.70^{000}	0.00	28.44±3.00^{ns}	0.00
White LED	33.29±0.69^{xxx}	12.19±3.29^{x}	18.69±1.09^{x}	10.31±3.04^{ns}	26.71±2.30^{ns}	13.88±1.99^{0}

Note: For the first determination made on July 3, 2019 - different capital letters in a row mean statistically significant differences ($P<0.05$). For small, different letters on the column, the difference from the control is revealed (by varieties and respective determination data) (**^{xxx}**, 000 – $P<0.001$; **^{xx}**, 00 – $P<0.01$; **^{x}**, 0- $P<0.05$; **ns** – nonsignificant).

Unlike various previous studies which show that monochromatic light can have photosynthetic inhibitory effects, and that a certain ratio between different types of light radiation, such as blue + red, can be beneficial, an opposite effect can be seen in this study. Especially the blue light, but also the white light favoured the photosynthesis process. Moreover, the addition of blue LEDs to TLD lamps improved the biomass of both indoor ornamental plants, resulting in more saleable plants to growers and gardeners (GARCÍA-CAPARRÓS et al., 2020).

The transpiration rate. The data regarding the intensity of the transpiration process are presented in Table 3. At an overview, there are generally high values, up to 8.78 mmol H_2O $m^{-2}s^{-1}$ (Sonia de Buzău cv. - August 8, 2019), more frequent in the case of the treatment with blue LED, where significantly higher values are observed compared to the control ($P < 0.001$), except for the Coralina cv., in whose case the lowest value was recorded (1.09 mmol H_2O $m^{-2}s^{-1}$) on August 19, 2019. Also, white light generally led to an intensification of the transpiration process, with smaller differences for the Sonia cv. For the Coralina cv., the values are generally lower than the other two varieties, but the blue and white light favoured the process at the beginning of August.

Table 3. Transpiration rate (mmoles H_2O m^{-2} s^{-1}) of tomato leaves for some cultivars exposed to different light quality of LED lighting (mean ± SE).

Tomato variety	HERA		CORALINA		SONIA at BUZĂU	
1st determination	July 3, 2019 – before treatment					
	3.50±0.20C		7.25±0.24A		3.97±0.03B	
2nd/3rd determination	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019
Control	3.32±0.09	1.38±0.08	1.57±0.12	1.09±0.26	3.17±0.29	3.50±0.67
Blue LED	8.20±0.06^{xxx}	8.07±0.95^{xxx}	5.77±0.20^{xxx}	2.88±0.55^{x}	8.78 ±0.18^{xxx}	6.17±0.74^{xx}
Red LED	3.62±0.07^{xx}	1.99±0.32^{ns}	1.77±0.02^{ns}	0.00	5.50±0.10^{xxx}	0.00
White LED	5.82±0.13^{xxx}	3.32±0.73^{x}	3.78±0.07^{xxx}	2.68±0.45^{x}	3.67±0.1^{ns}	5.00±0.41^{x}

Note: For the first determination made on July 3, 2019 - different capital letters in a row mean statistically significant differences ($P<0.05$). For small, different letters on the column, the difference from the control is revealed (by varieties and respective determination data) (^{xxx}, 000 – $P<0.001$; ^{xx}, 00 – $P<0.01$; ^{x}, 0- $P<0.05$; **ns** – nonsignificant).

The stomatal conductance. The values regarding the stomatal conductance presented in Table 4 also highlight a wide variety, from 0.04 moles of H_2O m^{-2} s^{-1} (Hera - at the final determination), to 0.37 moles of H_2O $m^{-2}s^{-1}$ (Coralina - beginning of August). It is observed that the blue light increases the stomatal conductance compared to the control (possibly in close connection with favouring the process of opening the stomata) and the differences are generally very statistically significant. An almost similar situation occurred in the case of white light. In contrast, exposure to red light caused a statistically significant decrease in the values of this indicator.

Table 4. Stomatal conductance (mols H_2O m^{-2} s^{-1}) of tomato leaves for some cultivars exposed to different light quality of LED lighting (mean ± SE).

Tomato variety	HERA		CORALINA		SONIA at BUZĂU	
1st determination	July 3, 2019 – before treatment					
	0.08±0.01C		0.30±0.04A		0.11±0.00B	
2nd/3rd determination	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019
Control	0.30±0.01	0.04±0.00	0.11±0.01	0.06±0.01	0.39±0.05	0.14±0.03
Blue LED	1.10±0.05^{xxx}	0.32±0.05^{xx}	0.37±0.03^{xxx}	0.09±0.02^{x}	1.90±0.23^{xxx}	0.21±0.03^{xx}
Red LED	0.16±0.00^{000}	0.05±0.00^{x}	0.06±0.00^{000}	0.00	0.32±0.00^{ns}	0.00
White LED	0.66±0.04^{xxx}	0.12±0.03^{x}	0.33±0.01^{xxx}	0.09±0.01^{x}	0.24±0.00^{00}	0.21±0.03^{x}

Note: For the first determination made on July 3, 2019 - different capital letters in a row mean statistically significant differences ($P<0.05$). For small, different letters on the column, the difference from the control is revealed (by varieties and respective determination data) (^{xxx}, 000 – $P<0.001$; ^{xx}, 00 – $P<0.01$; ^{x}, 0- $P<0.05$; ns – nonsignificant).

The internal CO_2 concentration. Data on the internal concentration of carbon dioxide are presented in Table 5. As it can be seen, there were no statistically significant differences between varieties before the treatment with monochromatic LEDs. Subsequently, at the first determination after treatment, for the Hera variety in particular, the values were significantly lower than the control, while there were usually no significant differences between the varieties and the applied treatments. An exception in this respect is noticed in the Coralina variety, where at the first determination after treatment with red light the values were significantly higher than the control (514 µmol CO_2 mol^{-1}).

Total chlorophyll content. Table 6 presents the results regarding the estimation of the total amount of chlorophyll. These ranged from a minimum value of 634.20 mg m^{-2} (Hera- August 8, 2019 - control), to a maximum of 739.60 mg m^{-2} (Coralina - August 19, 2019 - control). After LEDs light treatment, statistically significantly higher values were recorded, compared to the control, especially in Sonia de Buzău (for all types of LEDs), followed by Hera (blue and red LED) and Coralina, respectively red LED.

With the advancing age of the plants (at 40 days, on August 19), even if the total chlorophyll content increased for the controls, in the case of variants subjected to monochromatic LEDs, the recorded values are generally lower or the differences are not statistically significant compared to the control.

The increase in the amount of chlorophyll was also recorded in the case of blue light illumination and this can be explained by favouring its biosynthesis process, thanks to the activation of the production of chlorophyll precursor represented by 5-aminolevulinic acid, which consequently induces tetrapyrrolic nucleus biosynthesis (KAMIRA et al., 1983, CARVALHO et al., 2011).

Table 5. Internal CO_2 concentration (µmol CO_2 mol^{-1}) of tomato leaves for some cultivars exposed to different light quality of LED lighting (mean ± SE).

Tomato variety	**HERA**		**CORALINA**		**SONIA de BUZĂU**	
1st. determination	July 3, 2019 – before treatment					
	226.2±9.33A		214.9±6.36A		208.9±5.06A	
2nd/3rd determination	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019
Control	310.1±15.16	312.13±29.83	276.1±28.43	125.19±47.46	260.2±27.73	188.66±10.95
Blue LED	$245.4±9.83^{000}$	$229.30±23.54^{0}$	247.9±2.67	129.47±20.30	211.4±9.21	191.36±11.82
Red LED	$255.1±26.69^{0}$	267.77±10.44	$514.1±16.59^{xxx}$	0.00	$204.1±15.29^{0}$	0.00
White LED	$258.1±3.10^{00}$	$221.55±23.21^{0}$	$334±12.79^{x}$	213.47±41.86	$191.3±17.5^{x}$	$248.80±8.60^{x}$

Note: For the first determination made on July 3, 2019 - different capital letters in a row mean statistically significant differences (P<0.05). For small, different letters on the column, the difference from the control is revealed (by varieties and respective determination data) (^{xxx}, 000 – P<0.001; ^{xx}, 00 – P<0.01; ^{x}, 0- P<0.05; ns – nonsignificant).

Table 6. Total chlorophyll content (mg m^{-2}) of tomato leaves for some cultivars exposed to different light quality of LED lighting (mean ± SE).

Tomato variety	**HERA**		**CORALINA**		**SONIA de BUZĂU**	
1st determination	July 3, 2019 – before treatment					
	635.4±7,96B		677.2±2,24A		674.8±1,20A	
2nd/3rd determination	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019	August 8, 2019	August 19, 2019
Control	634.2±2.58	716.4±2.4	661.8±1.2	739.6±4.46	645.6±2.46	725.4±3.72
Blue LED	$664.6±2.46^{xxx}$	$693.8±7.32^{000}$	$646.8±1.71^{000}$	$721.6±2.46^{0}$	$684.8±3.28^{xxx}$	$737.0±4.28^{x}$
Red LED	$648.2±1.72^{xx}$	$706.4±10.44^{ns}$	$667.2±1.71^{xx}$	0.00	$673.6±1.47^{xxx}$	0.00
White LED	$639.6±3.10^{ns}$	$694.8±2.8^{000}$	$672.4±2,4^{xx}$	$716.4±2.4^{00}$	$673.6±2.4^{xxx}$	$728.0±2.41^{ns}$

Note: For the first determination made on July 3, 2019 - different capital letters in a row mean statistically significant differences (P<0.05). For small, different letters on the column, the difference from the control is revealed (by varieties and respective determination data) (^{xxx}, 000 – P<0.001; ^{xx}, 00 – P<0.01; ^{x}, 0- P<0.05; ns – nonsignificant).

Regarding the decrease of chlorophyll content in the case of treatments, especially over a longer period of time, this is in agreement with previous studies that have shown a possible biodegradation of the pigment caused by the effect of monochrome light (TAIZ & ZEIGER, 2006; DĂNĂILĂ-GUIDEA et al., 2019).

CONCLUSIONS

The obtained results showed that the physiological determined indicators values varied according to the tomato cultivar, plant age and monochromatic light treatment. A stimulator effect has been seen especially in the case of blue monochrome light, as regard as photosynthesis rate, as well as concerning the transpiration rate. Blue and white light increased the stomatal conductance compared to the control, while exposure to red light caused a statistically significant decrease of the values of this indicator.

Before the treatments, the internal concentration of carbon dioxide did not vary according to the cultivar, but, subsequently, values were significantly lower than the control (e.g. Hera cv.) in the case of LEDs light, while there were usually no significant differences between the varieties and the applied treatments. Total chlorophyll content increased for control variants with the advancing age of the seedlings, but the trend was not the same for monochromatic light treatments.

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