Scientific Papers. Series A. Agronomy, Vol. LXIV, No. 1, 2021
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

BIOCHEMICAL CHANGES, INDUCED BY LED LIGHT, IN TOMATO PLANTS, GROWN IN THE INTEGRATED MANAGEMENT SYSTEM (SMI) OF AGROECOSYSTEM RESISTANCE

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Abstract

In this research, biochemical analyses were monitored by determination at the level of tomato plants and fruits, within a protected growing environment (vegetation house), before and after the application of light provided by LEDs in red, blue and monochrome white, in addition to natural light, during the summer (June, 3rd decade -August 3rd decade, 2019). In parallel with the analysis of tomato plants, the substrates from the pots corresponding to the plants were analyzed. Values obtained for tomato plants of the analyzed varieties (Solanum lycopersicum L. cv. 'Sonia de Buzau', cv. 'Coralina' and cv. 'Hera') after 2 months of cultivation, regarding the content in mineral elements of non-metabolized forms (nitrates N-NO_3, ppm (phosphates P-PO_4, ppm, and K + ppm), showed a good supply of them, fact that determined their normal development in the protected cultivation area. The obtained biochemical results were situated within the limits accepted by the scientific literature, but were differentiated in correlation with the tomato genotype, LED light and daily exposure time, compared to control plants (unexposed to additional LED light). The fruits formed at the level of the first fruiting stage, toward the end of the experimental period, were analyzed together with the mineral elements and their contents in acidity %, soluble carbohydrates (%) and vitamin C (mg/100 g fresh product). The response to the applied treatment ensured uniform fruiting yield, after exposure to the treatment for 45 minutes/day with monochrome LEDs for all three colors, in the case of 'Coralina' tomato assortment, compared to the other 2 study varieties.

Key words: *monochrome LEDs, biochemical changes, tomatoes protected culture.*

INTRODUCTION

The main aim of an integrated management system in agriculture is to develop nonpolluting agricultural management practices, that are reduced the danger of infestation with various pathogens of agricultural crops. This can be achieved with methods that raise soil fertility, increase and conserve biodiversity, reducing the vulnerability of plants to abiotic and biotic stress factors andreducing the danger of polluting the environment with pesticides, by decreasing the number of chemical phytosanitary treatments and using ecological methods instead (STANDARD ICS: 65.020.20, AGRO 2–1).
Supplementation of natural light in protected environments is essential, especially in the areas located in the northern hemisphere, where light intensity and day length are reduced, particularly during autumn, winter and spring (Palmitessa el al., 2020).
A major limitation for tomato-seedling growth is represented by their high light demands, especially in temperate areas, where the days are short and cloudy during the time the seedling production starts. Supplementation of natural light with red and blue LED light can promote better growth.
Results obtained by Gomez and Michel (2015), demonstrated that supplementing the natural light with a combination of red and blue light induced better growth in tomato seedlings, by increasing the hypocotyl diameter, epicotyl length, dry mass, and the number and size of leaves.
To prevent light deficit in protected growing environments, different illumination technologies can be used to increase plant productivity: fluorescent lamps, high-pressure sodium lamps (HPS), metal halide lamps (MH) or light emitting diodes (LED) (Paucek et al., 2020). Although in the past, HPS lamps were the most used source of artificial lightning in

greenhouses, they present numerous inconveniences: low energy efficiency, variable spectral distribution and release of a large amount of radiant heat (Bantis et al., 2018). Recent studies have focused on using light emitting diodes (LED) to increase the light level in protected culture environments. They present multiple advantages, such as low energy usage, better operating life and they do not release radiant heat (Lu et al., 2012). Even though high-pressure sodium lamps (HPS) are an excellent light source, they are not the most efficient in obtaining high yield. LED lamps can be adjusted to emit only certain wavelengths, to maximize plant yield (Deram et al., 2014).

Paucek et al. (2020), demonstrated that supplementing natural light with LED in 'Siranzo' tomatoes grown in hydroponic system in the Mediterranean climate, accelerated fruit maturation with one week during the spring and two weeks during summer. Also, supplementing natural light with LED light increased cumulated productivity with 16%, compared to control plants. Palmitessa et al. (2020), obtained an increase of 21.7% in production by using LED during winter, on 3 cultivars of tomatoes (Juanita, Sorentyno and Salarino) cultivated in greenhouses in southern Italy.

The idea of a planned vegetable production that uses a factory has been suggested for years as a technology to extend horticulture under greenhouse conditions. The enclosed environment of the greenhouse has its own unique requirements, compared to cultivating crops in the field. Pests, diseases and the extreme values of heat and humidity must be controlled, and irrigation is necessary to supply water permanently (Sugimura et al., 2015).

Worldwide and in Romania, commercial seedling producers are facing inconsistencies in seedling morphology, possibly because of the change in light quality in the afternoon (Delian, 2008). In this situation, using supplementary sources of light and heat is necessary, especially during winter for vegetable production (Massa et al., 2008; Olle & Virsile, 2013; Sugimura el al., 2015). Because greenhouse temperature and humidity must be constantly monitored to ensure optimal growing conditions, a wireless network of sensors may be used for remote data collection. Information is transmitted to a control location and it is used to control the heating system, cooling and irrigation and to inervine in real time and at optimal values (Delian, 2008; Smith, 1982).

Light emitting diodes present a narrow light spectrum, which allows them to focalize a specific wavelength necessary for plant growth. Even more, it is possible to completely reduce infrared radiation. This means that the light source can be positioned at a short distance from the plants. Moreover, the absence of infrared radiation represents an advantage regarding the cost of temperature management in an enclosed growing system (Massa el al., 2008; Olle & Virsile, 2013; Sugimura el al., 2015).

Light influences the metabolic processes by its duration and intensity, but also by its spectral composition (Smith H., 1982; Delian, 2008; Dănăilă-Guidea & Delian, 2020a). Dănăila-Guidea & Delian, (2020a), in a review article, mentioned the scientific results of numerous researchers, results that showed the general effects that blue light has on the functioning of plants during the vegetation period, but also the influences on harvested fruits and their storage capacity. The use of blue light emitted by LED diodes was proved to be a good technology to modify the light spectrum, to regulate the growth process of obtaining high horticultural crops with high nutritional and nutraceutical content (Ballester et al., 2018; Jensen et al., 2018; Manivannan et al., 2017; Burescu et al., 2015; Kopsell et al., 2013; Brazaitytė et al., 2010; Morrow, 2008).

Red light is the most efficient from the light spectrum to stimulate de process of photosynthesis. According to Goto E. (Gotto, 2003), the growing and development plant processes are obstructed in monochromatic red light conditions. Growing plants in monochromatic red light reduces chloroplast number, thin cell walls, mesophyll tissues with abnormal structures, aspects that can be prevented by supplementing the light spectrum with blue light (Miao et al., 2019).

In this paper, the results obtained on tomato plants regarding the applied treatment with monochrome light emitted by LEDs were analysed, from the experimental scheme developed.

By using light emitting diodes (LEDs) characterized by a narrow spectrum of light, which allows them to focus light with the wavelength necessary for plant growth, the aim was to develop nonpolluting management technology for agro-systems, in a protected area, for growing vegetables.

MATERIALS AND METHODS

Biological material and experimental scheme
Experiments occurred at the Vegetation House within UASVM Bucharest during June – August 2019. The experimental scheme was composed of three factors arranged using the block design, in 3 repetitions: Factor **A** was represented by the tomato cultivar (Sonia de Buzau, Hera, Carolina); Factor **B** was represented by the monochromatic light emitted by LEDs (red, blue and white) and Factor **C** was represented by the illumination period in three times (15 minutes/day, 30 min/day, and 45 minutes/day) supplemented daily to natural light, compared to the control group which was not exposed with supplementary LED-produced light;
Figure 1 illustrates the devices represented by LED diodes panels (Factor C), during the daily application of monochromatic light treatment on the selected tomato seedlings (Factor A), cultivated in the Vegetation House of UASVM Bucharest.
The biological material used for this study was represented by seedlings of the three tomato cultivars registered at S.C.D.L. Buzau, two of them with cherry type fruit (Sonia de Buzau and Carolina) [General Catalog Vegetable Varieties And Hybrids SCDL BUZĂU (1957 – 2015)], and the third one, Hera, with kapia pepper type fruit (https://agrointel.ro/80100/hera-soiul-de-rosii-cu-forma-de-ardei-capia-creat-la-statiunea-de-la-buzau). Details about the morphological characteristics and productivity of the biological material (Sonia de Buzau, Coralina and Hera) and the characteristics of the experimental devices were described and detailed by this research team, in two previous publications published in 2020. (Dănăilă-Guidea et al., 2020b; Dănăilă-Guidea et al., 2020c).
During the growing period of tomato plants, two fertilizers were used: Florovit (NPK 7-5-6) and organic fertilizer Lumbreco based on biohummus, that were administered by alternative leaf treatments, to supply the plants with the necessary nutrients and to stimulate the growth of the seedlings. Also, to increase the resistance of the plants to specific pests (whitefly, the common red mite and thrips) and to counter the attack of *Operophtera brumata,* that was identified in the growing environment, two nontoxic and ecological products were used: Rock Effect (Natura products, AGRO CS) and PIPER-CIP (AMIA International) insecticide.
The results obtained from the biochemical determination performed at the level of young plants from the Romanian tomato varieties, before and after the additional treatment of short-term exposure to monochrome LED light, administered daily, were analyzed using statistical correlations.

Figure 1. Location of the experiments regarding the supplementary illumination with monochromatic LED devices on Sonia de Buzau, Coralina and Hera tomatoes in the Vegetation House of UASVM Bucharest (original photo – June 2019)

Biochemical analysis was performed at the plant level (nitrates N-NO3, ppm; phosphates P-PO4, ppm, and K+, ppm), at fruit level (nitrates N-NO3, ppm; phosphates P-PO4, ppm; K+ ppm; soluble carbohydrates % and vitamic C content mg/100 g fresh fruit) and at substrate level (soluble salts content - N, P, K, expressed in % and ppm).

Methods used for biochemical parameters determination

Before and after the application of supplementary monochromatic red, blue and white LED light during the summer (June, 3rd decade and August, 3rd decade, 2019), plants were harvested and analyzed regarding the supply of nutritive elements necessary for their growth and development.

Analyses on tomatoes in their juvenile stage (seedlings) and mature stage (during flowering and fruiting), were done accordingly to the INCDAP Bucharest methodology (ICPA Bucharest, 1980) and included the following: N-NO3- determination, in CH3COOH 2% extraction and colorimetric analysis with AFDS (Griess Analysis – STAS 3048–77), P-PO4 determination, in CH3COOH 2% extraction and colorimetric analysis with Duval reagent, as well as K+ determination in CH3COOH 2% extraction 1:2 and flame fotometric analysis.

Three plants of each variety and experimental variant were used, and the results were compared with control plants grown only in natural light in the same protected area represented by the vegetation house of UASVM Bucharest.

Fruit analysis included acidity (%) determination, extracted în distilled water, 1:2,5 and titrimetric determination with NaOH 0,1 N, soluble carbohydrates (%) determination using the Abbe refractometric method; volumetric determination of vitamin C (mg/100 g fresh fruit), using 2,6-diclorohenoldiphenol titration.

Simultaneously, plant nutrients and agrochemical indices of the growing substrate were analyzed for each experimental variant. Analyses covered pH în aqueous extract 1:2,5 and potentiometric analysis (SR ISO 10523–2012); soluble salt content în water extraction 1:5 and conductometric analysis with AFDS for nitrates, Nessler reagent colorimetric analysis for N-NH4+, Duval reagent colorimetric analysis for P-PO4 3 – and flame fotometric analysis for K + (STAS 7184/19-82).

The analysis methodology and interpretation of the results was done accordingly to norms and standards existent în Romania (ICPA Bucharest, 1987). Polynomial function was selected to interpret the results. Linear regression (R) was calculated using Microsoft Excel software.

RESULTS AND DISCUSSIONS

This study presents the variability of the response to the factors represented by 3 monochromatic colors, emitted by the LED panels (Factor B: red, blue, white) and 3 illumination durations (Factor C: 15 min/day, 30 min/day, 45 min/day) on plants from 3 genotypes represented by Romanian tomato varieties registered by the Vegetable Research and Development Station in Buzău (Factor A: Sonia de Buzău. Hera, and Coralina).

The determinations were performed using agrochemical analysis at the level of plants, crop substrate and fruits.

A. Results of the agrochemical analysis recorded before the treatment with monochromatic LEDs

A.1. Agrochemical analysis performed on plant samples. The first biochemical determinations were initially performed at the beginning of the experiment on the tomato seedlings of the three varieties studied (Sonia de Buzău, Coralina, and Hera), as well as on the potting substrate used during their development period. The results, obtained from the biochemical analysis of the supply of tomato seedlings in N, P, K (ppm) before starting the treatment with additional light emitted by the monochrome LEDs (average wave times determined at 3 repetitions / whole plant) are graphically represented in Figure 2.

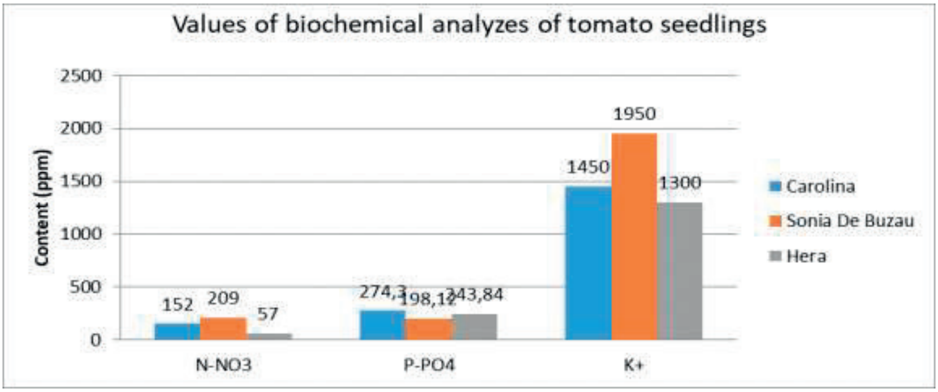

Figure 2. Analysis of tomato seedlings in the supply of N, P, K, before applying the LED treatment

The values obtained from seedlings analisys present a good supply of nutrients, which ensures their normal development in the culture environment. Depending on the tomato genotype, the values indicated an average nitrate content ranging from 57 ppm (for Hera) to 209 ppmN-NO3 (for Sonia de Buzău), high phosphorus content between 198 ppm (for Sonia de Buzău) and 274 ppm P-PO43 (for Coralina), and high potassium content, respectively 1300 ppm K (for Hera) and 1950 ppm K (for Sonia de Buzău).

A.2. Agrochemical analysis performed on substrate samples

Before starting treatment with additional light emitted by the monochrome LEDs, the nutrients and agrochemical indices were analyzed simultaneously, such as: pH, soluble salt content (%) N, P, K, as well as the dosages for N-NH4 +, N-NO3, P-PO_4^{3-} and K +, from the remaining culture substrates, after harvesting the tomato plants, from the experimental variants whose results are previously presented in Figure 2.

From the analysis, of the obtained results and presented in Table 1, resulted the fact that the substrate for the three tomato varieties shows a weak acid pH range between 6.3 and 6.4; the content of soluble salts characterizes poorly salinized soils that do not pose problems to crops; the nitrogen content presented medium values, the phosphorus in the substrate is high, as well as the potassium; so we concluded that the substrates can provide at that time, suitable conditions for plant growth and development

Table 1. Analysis of the substrate cultivated with tomato seedlings, before applying the LED treatment

Experimental Variant	pH	Soluble salts (%)	Content (ppm)			
			N-NH4,	N-NO3	P-PO4	K+
Substrate from **Coralina** seedling	6.4	0.176	43.65	9.5	30.48	67
Substrate from **Sonia de Buzău** seedlings	6.4	0.196	41.22	9.5	38.1	72
Substrate from **Hera** seedlings	6.3	0.274	41.22	19.0	49.53	68

B. Resultes of agrochemical analysis performed <u>after</u> treatment with monochromatic LEDs

B.1. Agrochemical analysis performed on plant samples. After 50 days of daily application of additional treatments analyzed by the experimental Factor **B** (lighting duration in 3 times: 15 minutes/day, 30 minutes/day, 45 minutes/day) and the experimental Factor **C** (monochrome color of the emitted light spectrum of LEDs, in 3 times: red, blue, white), the biochemical determinations were repeated, at the level of the developed plants, of the cultivated soil and of the fruits, compared to the

tomato plants from Control, which were not influenced by supplementary lighting with light emitting diodes (LEDs).
To perform them, plant samples were collected, weighed and subjected to many analyses: dry matter and mineral elements in non-metabolized forms. Time simultaneously, the substrate corresponding to the harvested plants was taken and biochemical determinations were performed by the same methods applied at the beginning of the experiment. The results obtained after 50 days of cultivation of tomato plants from the three varieties studied (Sonia de Buzău, Coralina, and Hera), are presented in Table 2 and Table 3, compared to the tomato plants from Control.

Table 2. Biochemical parameters determined for tomato plants, after intervals of 50 days of culture

Sample	Tomatoes Variety	Exposure time to LED light	N-NO3, ppm	P-PO4, ppm	K, ppm
CONTROL	Sonia de Buzău	-	684	202	215
	Hera	-	862	246	250
	Coralina	-	646	240	215
Red LED	Hera	15 min	513	200	215
		30 min	665	282	252
		45 min	646	270	262
	Sonia de Buzău	15 min	285	260	255
		45 min	190	200	225
	Coralina	15 min	266	185	215
		30 min	589	242	315
		45 min	266	215	205
White LED	Coralina	15 min	532	242	215
		30 min	570	252	225
		45 min	266	200	210
	Sonia de Buzău	15 min	304	242	240
	Hera	30 min	912	257	225
Blue LED	Coralina	15 min	608	242	245
		30 min	361	215	250
	Sonia de Buzău	15 min	456	205	220
		30 min	570	220	250
		45 min	494	229	245
	Hera	15 min	380	189	225
		30 min	456	215	240
		45 min	760	260	256

The cantity of nitrates **(N-NO3)** ensures the growth, development and flowering capacity for plants. The performed analysis of the **Sonia de Buzău** variety (Table 2), in terms of the influence of the exposure color, we can reveal that the blue color determined the highest absorption (values between 456 and 570 ppmN-NO3), and in terms of illumination the highest value of nitrates was recorded at 30 min exposure/day of 570 ppmN-NO3.
Regarding **Hera** variety, nitrates accumulated the most when using white LED treatment on 30 min/day, with the value of 912 ppm N-NO3, followed by the next high value (760 ppm N-NO3) after the exposure for 45 min/day to blue LED. (Table 2)
Concerning **Coralina** variety, the values of absorbed nitrates (Table 2) were higher when using blue LED lighting, at 608 ppm N-NO3, followed by one with red LED lighting (589 ppm N-NO3) and white LED lighting (570 ppm N-NO3). The highest value in the accumulation of nitrates was recorded in the plants exposed for 15 min to blue LED.
Regarding the phosphorus analysis **(P-PO4, ppm)**, the biochemical results presented in Table 2 for the 3 varieties of plants analyzed indicate that they do not show significant differences.Values range from 189 ppm (15 min/day exposure/Blue LED) to 282 ppm (30 min/day exposure/Red LED) for the HERA variety. For the other 2 varieties, the values are in the range of 200 and 260 ppm for Sonia de Buzău samples and in the range of 185 ppm and 252 ppm for the Carolina variety samples. The values of P-PO4 (ppm) obtained in the experiments are within the limits set out in the literature.
Potassium **(K+,ppm),** as an element of nutrition, determines a vigorous growth and development of plants, especially for the quality of plants. Potassium analysis in the case of Carolina

variety plants showed a minimum limit of 210 ppm when the exposure was in 45 min/day with white LED lighting, up to high values of 315 ppm when the exposure was in 30 min/day with red LED lighting. An explication for the lower accumulations of the K+ element (ppm), would be a possible blockage of the absorption due to the higher temperatures manifested in the culture space during the summer period. The flowering capacity of the tested tomato samples was negatively influenced by the lower supply of potassium, the Hera variety being the most sensible to this aspect.

Along with the analysis of tomato plants, the soils corresponding to them were also analyzed, the results are presented in Table 3.

Table 3. Biochemical determinations performed on the substrate cultivated with tomato plants, after intervals of 50 days of culture

Sample	Tomatoes Variety	Exposure time to LED light	pH	Soluble salts, %	N-NH4, ppm	N-NO3, ppm	P-PO4, ppm	K, ppm
CONTROL	Sonia de Buzău	-	6,9	0.1445	27.62	65.25	92.87	25.71
	Hera	-	6.4	1.0115	31.87	859.5	891.37	352.4
	Coralina	-	6.3	1.1993	114.75	544.5	659.25	781.5
Red LED	Hera	15 min	6.4	0.5924	14.87	216	188.5	25
		30 min	6.5	0.4479	14.87	157.5	154.3	26
		45 min	6.3	0.8525	63.75	256.5	24.76	28
	Sonia de Buzău	15 min	6.5	0.4046	17	42.75	116.2	39
		45 min	6.4	0.5202	34	171	150.49	30
	Coralina	15 min	6.5	0.4479	14.87	157.5	154.3	26
		30 min	6.5	0.4046	17	42.75	116.2	39
		45 min	6.6	13.438	61.62	859.5	661.03	40
White LED	Coralina	15 min	6.3	0.6358	19.125	225	192.4	41
		30 min	6.5	0.8236	14.87	477	230.5	42
		45 min	6.6	10.837	108.37	306	737.23	44
	Sonia de Buzău	15 min	6.5	0.5491	14.87	22.5	249.55	37
		30 min	6.4	0.4624	8.5	207	112.4	25
		45 min	6.5	0.7369	12.75	454.5	188.6	28
	Hera	30 min	6.6	0.4624	8.5	20.25	173.35	30
Blue LED	Coralina	15 min	6.5	0.5202	14.87	225	192.4	35
		30 min	6.4	0.5491	25.5	463.5	229.4	40
	Sonia de Buzău	15 min	6.5	0.6213	21.25	306	153.92	45
		30 min	6.6	0.5924	19.125	315	24.76	51
		45 min	6.7	0.5725	8.5	22.5	36.2	60
	Hera	15 min	6.5	0.5202	8.5	171	173.35	41
		30 min	6.6	0.5491	19.125	157.5	191.3	45
		45 min	6.5	0.5924	14.87	42.75	192.4	37

B.2. Agrochemical analysis performed on substrate samples. Based on the results of the analysis regarding the tomato plants and the analysis of the corresponding soils, polynomial regressions of degree 2 were performed on nitrogen (N), phosphorus (P) and potassium (K) levels (Figure 3, Figure 4 and Figure 5).

The regression of nitrogen (N) from the plant and soil showed a regression coefficient R = 0.1791 which is distinctly statistically significant (Figure 3).

In the case of phosphorus (P), the regression coefficient between soil phosphorus and phosphorus absorbed in plants was R = 0.1466, which is also classified as significant distinct (Figure 4).

Statistical analysis in the case of potassium (K), has a regression coefficient of R = 0.2347, which is also characterized as a distinguished significant (Figure 5).

From this statistical analysis, we can say that the presence of the three nutrients in the soil N, P, K have properly ensured the growth and development of plants through a sustainable absorption in tomato plants, taking into account scientific publications in the field (Davidescu &Davidescu, 1999).

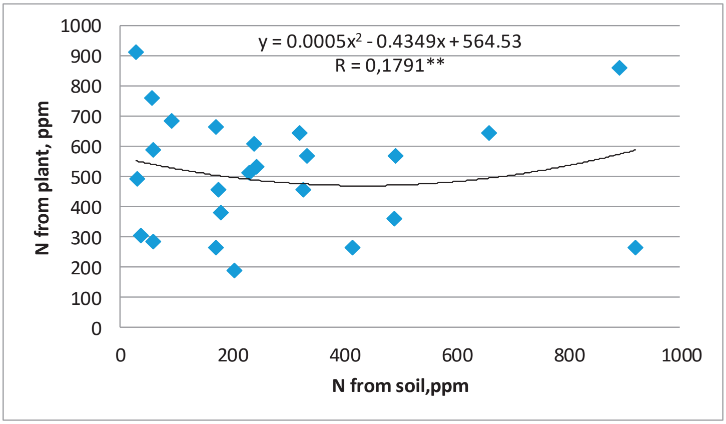

Figure 3. Statistical analysis of the influence of soil nitrogen content and nitrogen content absorbed by tomato plants

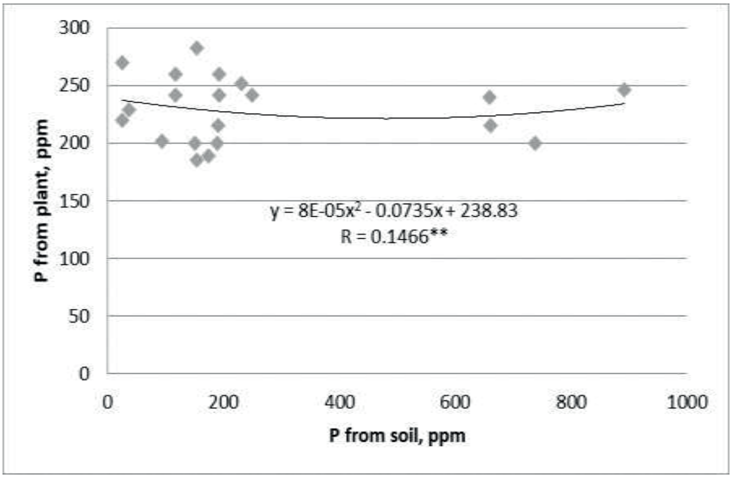

Figure 4. Statistical analysis of the influence of soil content on phosphorus and phosphorus content absorbed by tomato plants

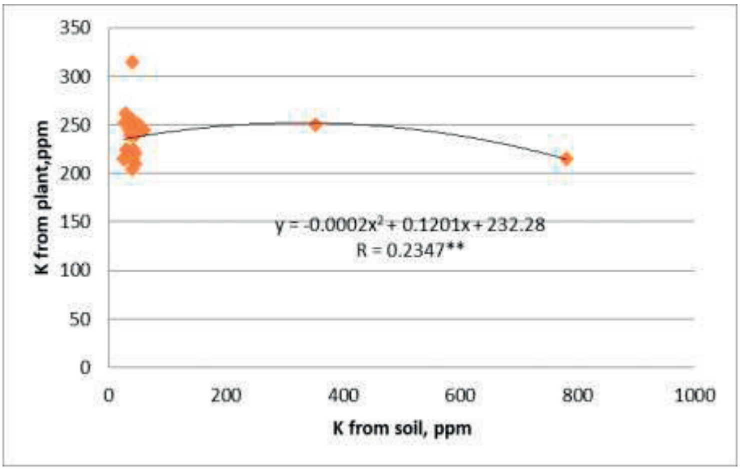

Figure 5. Statistical analysis of the influence of soil potassium content and potassium content absorbed by tomato plants

B.3 Agrochemical analysis performed on fruit samples. The flowering and fruiting period of the analyzed tomato varieties spread over a period of three months. The results obtained from the fruit quality analysis are presented in Table 4.

Table 4. Biochemical determinations performed on tomato fruits; average values.

Sample type	Tomatoes Variety	Exposure time to LED light	N-NO3, ppm	P-PO4, ppm	K, ppm	Carbohydrates, %	Acidty, %	Vit. C, mg/ 100g p.p.
Control	Coralina	-	273	282	1200	4.57	0.44	5.35
	Sonia de Buzău	-	200	225	1100	4.67	0.34	5.60
	Hera	-	210	215	1150	3.90	0.40	5.20
White LED	Coralina	15 min	283	262	950	4.65	0.42	5.37
		45 min	297	278	1020	4.70	0.45	5.40
		30 min	245	250	980	4.75	0.42	5.62
Red LED	Coralina	15 min	330	292	1150	4.60	0.40	5.40
		30 min	95.0	139.4	1050	4.75	0.40	5.25
		45 min	370	297	1120	4.65	0.42	5.45
	Sonia de Buzău	15 min	275	257	1150	4.70	0.40	5.50
		30 min	152.0	380	1150	4.80	0.40	5.37
	Hera	15 min	114.0	122.7	850	5.20	0.38	5.45
		30 min	171.0	179.0	825	5.15	0.39	5.42
		45 min	114.0	142.5	792	5.25	0.37	5.40
Blue LED	Coralina	15 min	270	270	1010	4.52	0.43	5.40
		45 min	275	280	1015	4.60	0.46	5.55
	Sonia de Buzău	15 min	237	252	970	4.70	0.45	5.40
	Hera	15 min	38.0	180.6	850	5.10	0.40	5.45

From the data presented in Table 4, it can be observed that the Hera variety did not register any fruits when exposed to white LED light and also to blue LED light except for the variant of exposure of 15 minutes/day.

The analysis of the fruit samples regarding the biochemical composition were also recorded in Sonia de Buzău with the exposure to white LED light of 15 minutes/day and 45 minutes/day. Also, we consider that Sonia de Buzău is a sensitive variety to blue light, fruiting being recorded only at exposure to 15 minutes of blue LED light.

Regarding the nitrate levels, N-NO3- it is observed that for all fruits the registered values are qualitatively good below the limit imposed by the Romanian legislation (Order no. 1050 / 12.10.2005) regarding the quality of fresh vegetables.

The phosphorus absorbed by the tomato samples is in the normal limits between 100 ppm and 200 ppm P-PO4, as specified by the scientific literature (Davidescu V and Davidescu D, 1999), values that ensure the good quality of the fruits for consumption.

The soluble carbohydrates (%) of the tested samples (Table 4) present values between 3.90% (for Hera Control samples) and 5.25% (for Hera samples, with exposure to red LED light for 45 minutes). The accumulation of carbohydrates was good in all varieties, ensuring the sweet taste of tomatoes (Gherghi, 1999). Acidity (%) varies between 0.34% for Sonia de Buzău control sample and 0.45% for Sonia de Buzău samples that were exposed to 15 minutes/day of blue LED lighting and Carolina samples that were exposed to 15 minutes/day white LED lighting (Table 4). The values of acidity are within the limits specified by the literature for tomatoes, the variation of values depends on the variety (Gherghi, 1999), ensuring a good balance between carbohydrates and acidity.

Vitamin C (mg/100g fresh product) levels varies between 5.20 mg/ 100g fresh product in the Hera control sample and 5.62 mg/ 100g fresh product in Sonia de Buzău sample exposed to 30 minutes/day at white LED lighting (Table 4). This indicator is within the limits provided by the literature for assessing the quality of tomatoes. (Gherghi, 1999; Gherghi, 1994; Davidescu D, and Davidescu V., 1981)

CONCLUSIONS

Agrochemical analysis of tomato plants, performed after 50 days of daily application of additional treatments with monochromatic LED light, analyzed experimentally, showed that they accumulated a large amount of P (P-PO4, ppm) and K salts. (K +, ppm), when exposed for 15 minutes/day with red LED light, in the case of plants of Sonia de Buzău (260 ppm P-PO4; 255 ppm K) and at the exposure of 30 minutes/day, at the plants of Hera (282 ppm P-PO4; 252 ppm K), while the values of N (N-NO3, ppm) from all experimental samples were below those of the Control, exceptions being registered in the plants of Hera treated with white LED (30 minutes/day) and blue LED (45 minutes/day).

Agrochemical analysis of substrates in the experimental versions showed lower pH values; The content of soluble salts in the tested substrates compared to the Control variants was the highest (13.438%) in the substrates of the red LED variant (45 minutes/day), provided to Coralina plants.

The nitrogen supply (N-NH4, ppm) of the substrates was determined at the low value of 8.5 ppm N-NH4, for the experimental variants of the plants from the Sonia de Buzău variety (exposure 30 minutes/day, with white LED and respectively after exposure 45 minutes/day at the blue LED) and Hera (exposure 15 minutes/day). Phosphorus in the substrates was best absorbed (24.76 ppm P-PO4) in Hera variety, the red LED variant (45 minutes/day) and in the samples from the variety Sonia de Buzău version with blue LED (30 minutes/day); the same aspect was found in potassium which was well absorbed from the substrates by all plants in the experimental variants.

Biochemical determinations performed on tomato fruits harvested at the end of 3 months of crop maintenance, indicated among the indices of maturity appreciation at harvest, differences recorded for carbohydrates (%) in Hera fruits, from 2 experimental variants exposed at red LED, which exceeded by 13.46% (45 minutes/day) and by 13.33% (15 minutes/ day) the values of the control. The correlation of the coefficients was established, and allowed the comparison of the variation for the data set and the regression coefficients between the NPK supply of the substrates and that of the absorption at the plant level. The database was established in electronic system, and the data were analyzed through the statistical program "Data Analysis" from Microsoft Office - Excel.

ACKNOWLEDGEMENTS

This work was supported by a grant of the Romanian Ministry of Research and Innovation, CCCDIUEFISCDI, project number PN-III-P1-1.2-PCCDI-2017-0301/no. 28PCCDI/2018, within PNCDI III.

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