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THE EFFECT OF LED-S EMITTED LIGHT TREATMENTS ON SPROUTING MUNG BEAN (*VIGNA RADIATA* L.)

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Abstract

Mung bean (Vigna radiata L.), is a plant species from Fabaceae family and represented a very good source of antioxidants and polyphenols, having also an important nutritional value. This paper presents the results obtained by treatments with white (W), red (R) or blue (B) light emitted of LED-s, on mung bean (Vigna radiata L.) sprouts. The parameters evaluated were the number and fresh weight of sprouts mung bean (Vigna radiata L.), obtained by application of the LED treatments. The reference was represented by sprouts mung bean (Vigna radiata L.), illuminated with sunlight. Biochemical studies included determination of concentration of polyphenols, proteins, flavonoids and antioxidant capacity. The white (W) LED treatments on sprouts mung bean (Vigna radiata L.), produced an important number of sprouts while the red (R) LED induced the high fresh weight of mung bean (Vigna radiata L.) sprouts. The content of polyphenols, flavonoids and the antioxidant capacity was significantly higher by treatment with white (W) light LED. The reference contains a higher content in proteins than the samples illuminated with LED emitted light.

Key words: *antioxidant capacity, flavonols, LED-s, sprouts, polyphenols, proteins, Vigna radiata* L.

INTRODUCTION

Mung bean (*Vigna radiata* L.), is an annual herbaceous plant from the major group of Angiosperms, included in genus *Vigna*, family *Leguminosae* (http://www.theplantlist.org/tpl1.1/record/ild-29556).
Archaeobotanical record from many archaeological sites of India, indicate that mung bean (*Vigna radiata*), was presented from 2500 BC to this days (Fuller, 2007). In our days, mung bean (*Vigna radiata*), is one of the most cultivated plant in India, Myanmar, China, Pakistan, Bangladesh, Cambodia, Thailand, Sri Lanka and Australia (Rawal & Navarro, 2019).
The quality and size of mung bean (*Vigna radiata* (L.) R. Wilczek), are depending of various abiotic (e. g., waterlogging and salinity), and biotic stresses (e. g., viral and fungal diseases) (Rawal & Navarro, 2019). This species presents a variable short-duration vegetable period from 70-110 days (Lambrides & Godwin, 2007) to 90-120 days (Lim, 2012) or 65-80 days (Rawal & Navarro, 2019), and is cultivated from 0 to 1850 m altitude (Lim, 2012). The mung bean is a species very abundant in nutritive elements (polysaccharides with antioxidant activities, radicals scavenging activity, immunoregulatory and immunomodulatory activities and peptides with antioxidant activity) and also in active principles phenolic acids (1.81-5.97 mg rutin equivalent/g - hydroxycinnamic and hydroxybenzoic acid), flavonoids (1.49-1.78 mg catechin equivalent/g - anthocyanins, flavonols, flavones, isoflavonoids), and tannins (1.00-5.75 mg/g) - Hou et al., 2019. The mung bean contains also balanced nutrients, including protein, dietary fiber, minerals, vitamins, and significant amounts of bioactive compounds (Gan et al., 2017). Furthermore, mung bean protein is easily digestible, as compared to protein in other legumes (Mubarak, 2005 and Yi-Shen, 2018) and high protein content with hypoallergic properties.
Mung bean is one of the most consuming plant in all the world. The seeds of mung bean are eaten whole, as flour (Lim, 2012) or sprouts (Lambrides & Godwin, 2007; Lim, 2012; Tang et al., 2014). The mung beans sprouts contents an increased vitamin C concentration, an enhanced total phenolic compounds and flavonoids, quercitin 3-O-glicoside and

antioxidant capacity 6 times higher than that of mung bean seeds.

As a result, it is useful to obtain sprouts of mung bean (*Vigna radiata* L.), through the method of care to reduce the negative influence of stressors of a biotic and / or abiotic nature.

The goal of our research, was to notice the effect of lighting with white (W), red (R) or blue (B) light emitted of LED-s and sunlight (S, reference) on mung bean sprouts (*Vigna radiata* L.).

MATERIALS AND METHODS

The biological material consisted of mung bean seeds (*Vigna radiata* L.), from two varieties: from China (TRS brand) M1 and Myanmar (RAPUNZEL brand) M2. Mung bean seeds (*Vigna radiata* L.) in the dormant phase present an oval shape, were colored in brownish green. The seeds from China had a larger diameter (0.4-0.5 cm) compared to those from Myanmar (0.3-0.4 cm). The main distinguish element of the two categories of seeds was the type of agriculture used to obtain them, respectively: organic agriculture for M1 variety or conventional agriculture M2 variety.

The experimental variants used in the experiment were the following:

- V1 = M1 + treatment by white color LED-s – emitted light ;
- V2 = M1 + treatment by red color LED-s – emitted light ;
- V3 = M1 + treatment by blue color LED-s – emitted light;
- V4 = M1 + treatment by sunlight, control (S)/reference variant;
- V5 = M2 + treatment by white color LED-s – emitted light;
- V6 = M2 + treatment by red color LED-s – emitted light;
- V7 = M2 + treatment by blue color LED-s – emitted light;
- V8 = M2 + treatment by sunlight, control/reference variant.

Groth conditions and plant material: Lighting treatment were performed in controlled environmental conditions.

The seeds of mung bean (*Vigna radiata* L.), were sterilised using a 2.5% sodium hypochlorite solution for 5 minutes; washed 10 minutes for 3 times with sterile distilled H_2O (Badea & Săndulescu, 2001; Cachiță-Cosma et al., 2004). The seeds were watered and germinated in sterile condition on gauze soaked in sterilized distilled H_2O (Enache & Livadariu, 2016), to obtain sprouts of mung bean. The seed were placed in food casseroles (transparent plastic, sterile and provided with a lid); and germinated under light LED treatment (white, red - Li et al., 2014 - or blue), The lighting emitted by LED-s or sunlight was performed for 8 days, photoperiod of 16 h, at a temperature of 23°C ± 2°C/photoperiod and 20°C ± 2°C/dark period. The technical characteristics of LED-s are: voltage 220 V, power 18 W and light flux 435 lm (Livadariu & Maximilian, 2017).

Morphological measurements (fresh weight) rates (number of sprouts/time) and quantification of proteins, flavonoids, polyphenols, antioxidant capacity was analyzed.

The protein extraction was performed by grinding the sprouts tissue in 50 mM potassium phosphate buffer, 0.05% β-mercaptoethanol, 0.5 mM (DIFP) diisopropyl fluorophosphat – protease inhibitor, pH = 6.8 (1.0 g/0.5 ml, dry weight/buffer) at 4°C for 24 hours. The extract was centrifuged 18.000 rpm for 20 min. and the supernatant was used for protein assay. The protein concentration was carried out using Bradford method (Bradford, 1976). For the polyphenols, flavonoids content and antioxidant capacity assay was used methanolic extracts. The polyphenols concentration was evaluated using Folin - Ciocalteu reagent (Mihailović et al., 2013). The results were expressed as mg gallic acid equivalent / g fresh weight. The antioxidant capacity was carried out according to Marxen et al. (2007), using DPPH (2,2-diphenyl-1-picrylhydrazyl) and a calibration curve with Trolox as antioxidant standard. The antioxidant capacity was expressed as mM Trolox/g fresh weight. The flavonoid compounds were estimated using Zhishen et al., 1999, modified method with aluminum chloride. The absorbance of the mixtures was measured at 510 nm. A calibration curve with rutin was used. The flavonoids concentration was expressed as mg equivalent rutin/g fresh weight.

Statistical procedures. Each experimental variant were consisted from twenty mung bean

(*Vigna radiata* L.) seeds/variety M1/M2. All analysis were performed in triplicate. The data have been statistically analyzed and the standard deviation of mean was calculated. The rate, the fresh weight of sprouts (A), polyphenols, flavonoids, proteins content, and antioxidant capacity were determined.

RESULTS AND DISCUSSIONS

A. Determination of the rate and the fresh weight of two variety of mung bean (M1 and M2) (*Vigna radiata* L.) sprouts by treatment with white (V1/V5), red (V2/V6), blue (V3/V7) LED-s or sunlight (V4/V8) - reference variant (control)

A1. Determination of the rate of mung bean (Vigna radiata L.*) sprouts*

According to the experimental data presented in Figures 1 and 2, the mung bean seeds (*Vigna radiata* L.) begin to germinate in the second day of the experiment.

In the second day, under the influence of the white light treatment emitted by LED-s (V1 and V5) the highest number of sprouts was obtained, both M1 (Figure 1) and M2 (Figure 2) varieties in comparison with all variants analyzed (V2-V4 and V6-V8).

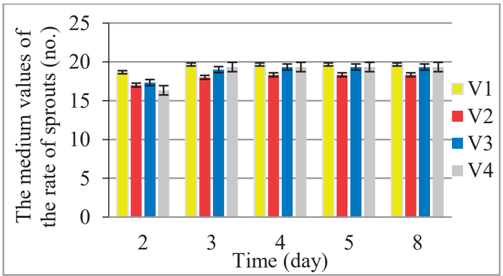

Figure 1. The rate of mung bean (*Vigna radiata* L.) sprouts (no.), for experimental variaty M1 illuminated by LED

Also, on the second day, the smallest number of sprouts, was registered: in the case of M1 seeds under the influence of sunlight treatment (V4) (Figure 1), and in the case of M2 seeds, under the influence of the blue light LED treatment (V7) (Figure 2).

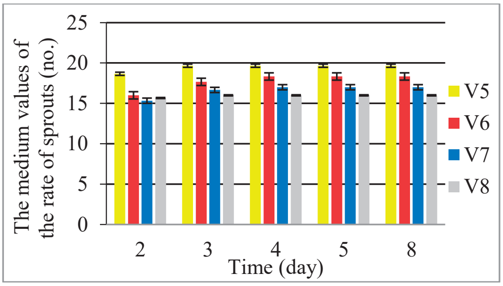

Figure 2. The rate of mung bean (*Vigna radiata* L.) sprouts (no.), for experimental variaty M2 illuminated by LED

On the third day, it can be observed the highest number of sprouts from M1 and M2 varieties, also under the influence of white light treatments emitted by LED-s (V1 and V5). But, unlike the second day, the smallest number of sprouts was recorded for M1 seeds under the influence of the red light emitted by LED-s (V2) and for the M2 seeds, under the influence of sunlight treatment (V8). In the fourth and fifth day were recorded minor differences in the number of sprouts, stabilizing on the eighth day. These results complement those obtained (Livadariu et al., 2019), the treatment with blue LED, induced a superior rate of sprouts in comparison with others variants, red and green LED-s light.

A2. Determination of the fresh weight of mung bean (Vigna radiata L.*) sprouts*

According to the graphic (Figure 3), it can be observed that the values of fresh weight of mung bean sprouts (*Vigna radiata* L.) have the lowest value (2.5 g) for the generated sprouts from M2 seeds, under the influence of sunlight (V8). The highest value (9.05 g) was registered for sprouts illuminated with red light emitted by LED-s, from M1 seeds (V2). Thus, it can be noticed a clear difference of the average values of the fresh weight of mung bean sprouts (*Vigna radiata* L.) between M1 and M2. Other authors Park et al., in 2019, found that red light-irradiated canola (*Brassica napus*) sprouts being significantly higher than those of sprouts exposed to white and blue LEDs.

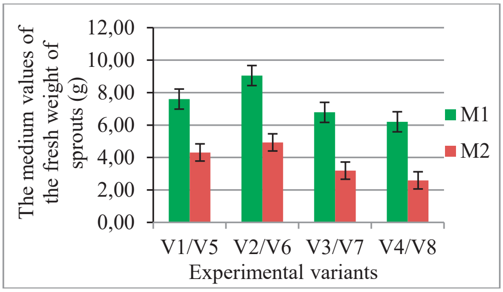

Figure 3. The fresh weight of mung bean (*Vigna radiata* L.) sprouts (g), for experimental variant from M1 variety and M2 variety

B. Biochemical analyses

B.1. Determination the protein content in mung bean sprouts illuminated with LED

The biochemical analyses regarding the content of proteins in mung bean sprouts illuminated with LED for M1 and M2 variety emphasized that the sample represented by reference variant (sunlight) had the higher concentration. The treatment of sample from M1 and M2 varieties illuminated with LED did not induce an increase of protein concentration (Figure 4).

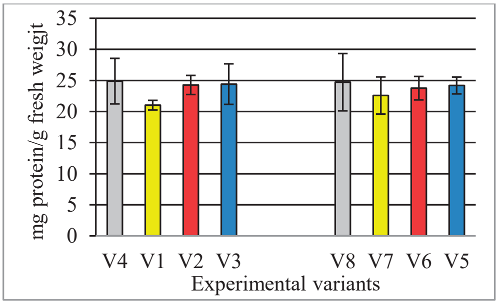

Figure 4. The protein concentration in M1 and M2 varieties illuminated by LED

The white LED produces a higher concentration in M2 variety (V7) while red LED induced a higher content in protein in M1 variety (V2). The values of proteins concentration are very close for M1 and M2 varieties illuminated with blue LED (V3, V5).

There are not data in the literature regarding the effect of different types of illuminated LED on sprouts. However, there are some information regarding the sprouts treatment with the light traditional bulb which induced a higher protein concentration in compared to those illuminated by LED light, by 17% respectively, to obtain plants with increased protein content the light should be used with an increased proportion of wavelengths 600-780 nm (as in the case of traditional bulbs) (Fiutak et al., 2018). Our previous study (Livadariu et al., 2019), on effect of LED treatment have shown that the illumination with blue light LED produced the highest protein concentration for hemp sprouts compared with green and red LED.

B2. Determination the polyphenols concentration in mung bean sprouts illuminated with LED

The higher concentration of polyphenols in mung bean sprouts was determined by illumination with white LED light for both varieties M1 and M2 (V1 and V5) (Figure 5).

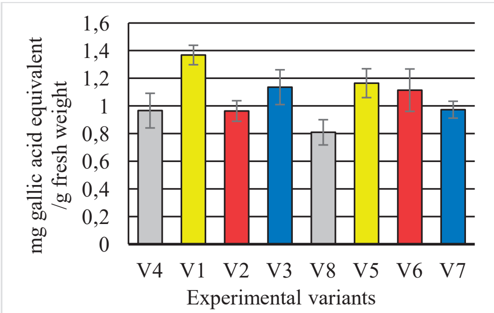

Figure 5. The polyphenols concentration in M1 and M2 varieties illuminated by LED

The effect of red LED illuminated the mung bean sprouts induced a higher concentration of polyphenols in M2 variety comparative with content of polyphenols in M1 variety, while the blue LED treatment produced a stronger effect in M1 variety. The white LED treatment induced an effect similar with blue LED illuminated mung bean sprouts. Similar results obtained by Matysiak & Kowalski, 2019, who mentioned that the phenols concentration was enhanced by illuminated with white LED lighting compared to the control in basil green leaves, lamb's lettuce and garden rocket leaves, but was unaffected in basil purple-leaves.

B3. Determination the flavonoids concentration in mung bean sprouts illuminated with LED

The treatment with white LED on mung bean sprouts determined a high biosynthesis of flavonoids for M1 (V1) and M2 (V5) varieties (Figure 6). Estimating the effect of type LED it can be observed that the white and blue light was similar revealing a higher content in flavonoids for M1 variety. The effect of red LED illuminated the mung sprouts was significant in flavonoids concentration for M2 variety. Other studies (Matysiak & Kowalski, 2019) emphasized that plants growth under blue LED light had a content in flavonols (a class of flavonoids) higher than in the case of leaves from basil, lamb's lettuce and garden rocket, as compared with white LED light treatment.

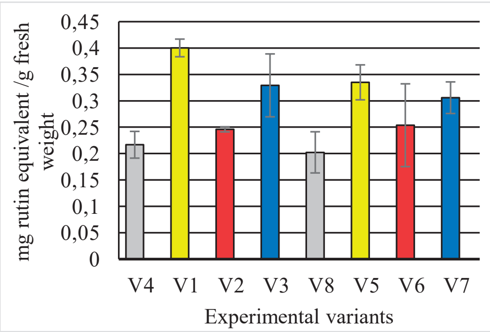

Figure 6. The flavonoids concentration in M1 and M2 varieties illuminated by LED

B4. Determination of antioxidant capacity in mung bean sprouts illuminated with LED

A significant increase in antioxidant capacity was observed by illuminated the mung sprouts with white LED (V1 and V5) for both M1 and M2 varieties (Figure 7).

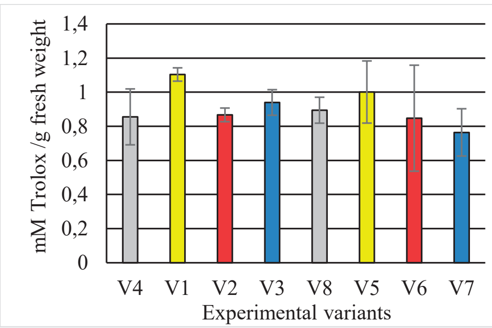

Figure 7. The antioxidant capacity in M1 and M2 varieties illuminated by LED

Comparing the effect induced by each LED type white, red and blue was observed the following: the white and blue LED produced an increase of antioxidant capacity for M1 variety. The treatment with red LED has positive effect for M1 (V2) and M2 (V6) variety of mung bean sprouts.

Comparing the effect of red LED on each mung bean variety we conclude that in M2 variety was stimulated a biosynthesis of polyphenols and flavonoids but the antioxidant capacity was similar for both varieties. In the similar manner, the effect of blue and white LED amplified the accumulation of polyphenols, flavonoids and antioxidant capacity.

Our results differ from those of Wu & al. (2007), that noticed the antioxidant capacity of pea seedlings, after 96 h of radiation by various LED lights, was significantly enhanced by red light radiation.

CONCLUSIONS

Spouts development, morphogenesis, growth, and secondary metabolite synthesis are significantly affected by light quality and the lighting spectrum. Regarding comparatively the M1 and M2 varieties, the highest average values of the number of sprouts were recorded under the influence of white lights emitted by LED-s, while the highest average values of the fresh weight of sprouts were recorded under the red-light treatment emitted by LED-s. In our study, white LED light was found to be suitable for biosynthesis of polyphenols, flavonoids and antioxidant capacity.

Analyzing the results obtained, we observed a direct correlation between the highest concentration of polyphenols, flavonoids and antioxidant capacity and the rate of mung bean sprouts induced by treatment with white LED.

The experimental results obtained from testing light treatments emitted by LED-s for achieving mung bean sprouts (*Vigna radiata* L.) from seeds obtained through organic agriculture (M1) or conventional agriculture (M2), recommend further research for growing sprouts, because, predominantly, there were recorded better experimental values under the influence of treatments with white, red or blue light emitted by LED-s, compared to the sunlight treatment.

REFERENCES

Badea, E. M., Săndulescu, D. (2001). *Bio Tehnologii Vegetale* (pp. 21). Editura Fundația Biotech, București.

Bradford, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal. Biochem*., 72, 248–254.

Cachiță-Cosma, D., Deliu, C., Rakosy-Tican, L., Ardelean A. (2004). *Tratat de biotehnologie vegetală, Vol. I*., pp. 105. Ed. Dacia, Cluj-Napoca.

Enache, I. M., Livadariu, O. (2016). Preliminary results regarding the testing of treatments with lightemitting diode (LED) on the seed germination of *Artemisia dracunculus* L. *Scientific Bulletin. Series F. Biotechnologies*, ISSN 2285-1364, Vol. XX. 52, 53.

Fuller, D. Q. (2007). Contrasting patterns in crop domestication and domestication rates: recent archaeobotanical insights from the Old World. *Ann. Bot.* 100(5), 903–924.

Fiutak G., Michalczyk M., Filipczak-Fiutak M., Witek M., Surowka K. (2018). The effect of artificial light on the growth of alfalfa sprouts. International Congress, Food Processing, Safety & Packaging, sept. 2018, Praga, Czech Republic, DOI: 10.4172/2157-7110-C6-093.

Gan, R.-Y., Lui, W.-Y., Wu, K., Chan, C.-L., Dai, S.-H., Sui, Z.-Q., Corke, H. (2017). Bioactive compounds and bioactivities of germinated edible seeds and sprouts: An updated review. *Trends in Food Science & Technology*, 59, 1–14.

Hou, D., Yousaf, L., Xue, Y., Hu, J., Wu, J., Hu, X., Feng, N., Shen, Q. (2019). Mung Bean (*Vigna radiata* L.): Bioactive Polyphenols, Polysaccharides, Peptides, and Health Benefits. *Nutrients*, 11(6), 1238.

Lambrides, C. J. & Godwin, I. D. (2007). Mungbean. In: Kole C. (eds). Genome Mapping and Molecular Breeding in Plants. Pulses, Sugar and Tuber Crops., Vol. 3, Chapter 4 (pp. 69). Springer, Berlin, Heidelberg.

Li, F.-M., Lu, Z. G., Yue, M. (2014). Analysis of Photosynthetic Characteristics and UV-B Absorbing Compounds in Mung Bean Using UV-B and Red LED Radiation. Journal of analytical methods in chemistry. 378242. DOI:10.1155/2014/378242.

Lim, T. K. (2012). Edible Medicinal and Non-Medicinal Plants, Volume 2, Fruits, Chapter *Vigna radiata* (pp. 952). Ed. Springer Netherlands, Springer Science+Business Media B.V., CBS Publishers, New Delphi, India, eBook ISBN 978-94-007-1764-0.

Livadariu, O. & Maximilian, C. (2017). Studies Regarding Treatments of LED-s Emitted Light on Sprouting *Fagopyrum esculentum* Moench. *Bulletin UASVM Animal Science and Biotechnologies*, 74(2), 102.

Livadariu O., Raiciu D., Maximilian C., Căpitanu E. (2019). Studies regarding treatments of LED-s emitted light on sprouting hemp (*Cannabis sativa* L.). *Rom. Biotechnol. Lett*., 24(3), 485–490.

Matysiak, B. & Kowalski A., (2019). White, blue and red LED lighting on growth, morphology and accumulation of flavonoid compounds in leafy greens. *Zemdirbyste-Agriculture*, 106 (3), 281–286.

Marxen, K., Vanselow, K. H., Lippemeier, S., Hintze, R., Ruser, A., Hansen, U.-P. (2007). Determination of DPPH radical oxidation caused by methanolic extracts of some Microalgal Species by linear regression analysis of spectrophotometric measurements. *Sensors*, 7, 2080–2095.

Mihailović, V., Matić, S., Mišić, D., Solujić, S., Stanić, S., Katanić, J., Mladenović, M., Stanković, N. (2013). Chemical composition, antioxidant and antigenotoxic activities ofdifferent fractions of *Gentiana asclepiadea* L. roots extract. *EXCLI Journal*, 12, 807–823.

Mubarak, A. E. (2005). Nutritional composition and antinutritional factors of mung bean seeds (Phaseolus aureus) as affected by some home traditional processes. *Food Chemistry* 89 (4), 489–495.