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PRELIMINARY RESULTS REGARDING THE TESTING OF TREATMENTS WITH LED ON THE SEED GERMINATION OF *Lycopersicum esculentum* L.

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Abstract

The present study discusses the preliminary results obtained from testing the influence of LED treatments over seed germination of three different Lycopersicum esculentum L. *varieties. The respective varieties have been chosen for their determined growth pattern, which would make them suitable for implementation within a vertical farming system. Speeding up the germination process and ensuring that most, if not all the seeds germinate is relevant in obtaining healthy and productive L. esculentum* L. *crops suitable for indoor farming, which will provide a sustainable solution for a round-the-year constant production which can meet the market request, no matter the climatic conditions specific to the area. The experimental results obtained show that treatments with light emitted of LED (white, blue, red and natural light), on the seed germination of Lycopersicum esculentum* L. *varieties (Buzău 4C, Rio Grande ST and Saint Pierre ST), may influences: the sprouts rate, the fresh weight of sprouts, the fresh weight of cotyledons, the fresh weight of hypocotyls, the fresh weight of roots, the length of hypocotyls and length of roots.*

Key words: *Lycopersicum esculentum* L., LED, seed germination.

INTRODUCTION

The present article discusses preliminary results regarding the testing of LED treatments on seed germination of *Lycopersicum esculentum* L.

Lycopersicum esculentum L. is an annual herbaceous plant species from the *Solanaceae* family, originating from South America, Peru, Bolivia and Ecuador (Popescu, 2008). The *Solanaceae* family is, from either an economical, industrial or nutritional point of view, extremely important, as it includes very valuable species, *Lycopersicum esculentum* L. being one of the most representative (Kimura & Sinha, 2008). Aside from being one of the most commonly consumed fresh vegetable around the world, the tomato (*Lycopersicum esculentum* L.) bears a fruit that has many nutritional qualities (Suarez et al., 2007). Therefore, it is only natural for scientists to be experimenting in improving the quality and the production rate of *L. esculentum* L., thus obtaining a remarkable number of mutants, which express a wide variety of selected traits (Kimura & Sinha, 2008).

Previous research conducted on *L. esculentum* L. has shown a very strong connection between productivity and the interaction between temperature and light, from seed germination to harvesting (Verkerk, 1955).

The intensive exploitation of arable land, the need for more and more space to satisfy the needs of the planet's population, call for sustainable solutions, like the concept of vertical farming (Despommier, 2009). Applying this modern agricultural concept requires the development of technologies and selection of species that will enable it.

Also, smart management of resources is important (resources such as energy), thus making LEDs extremely efficient (Yeh & Chung, 2009).

However, there are many inconsistencies when it comes to the physiological effects of LEDs over the course of the plant's development (Berkovich et al., 2017).

The industrial importance of *L. esculentum* L. crops is undeniable therefore it is desirable that the production be increased without affecting the quality of the final product. There are many aspects that press on food

industry and urge the development of modern agricultural concepts. The discussions surrounding the concept of Vertical Farming are increasing, as global population and food demand increase (Kalantari et al., 2017).
As far as lighting solutions go, previous studies have shown increased efficiency in the use of LEDs for growing sprouts and plants, such as pomegranate (*Punica granatum*). The obtained sprouts have presented an ideal development state that resulted in extremely efficient transplantations (Bantis et al., 2018).
Other studies conducted on *Cucumis sativus* have shown that the production of qualitative sprouts has increased while using LED supplementary illumination, while harvesting was conducted eight days earlier in comparison to a conventional, natural light based protocol (AGROBIZNES.MD, 2017).
Another study on the effect of LEDs on *Lycopersicum esculentum* L. seed germination was concluded with a recommendation of a certain balance between blue light and red light for a faster development (Yingchao Xu et al., 2017). Moreover, studies conducted on *Lactuca sativa* L. have demonstrated LED efficiency, not only from the yield point of view, but also when it comes to energy costs and quality of harvest (Poulet et al., 2014; Lin et al., 2013).

MATERIALS AND METHODS

The seeds used in order to obtain the preliminary results regarding the testing of germination under LED treatments have been selected as the adult plants have a determined growth, meaning they will not need any supplementary support during their vegetation period and should be suitable for a vertical farming system as well (Popescu & Zăvoianu, 2013).
The biological material used in the experiment consisted of seeds which have proceeded from three *Lycopersicum esculentum* L. varieties: Buzău 4C, Rio Grande ST, Saint Pierre ST - respectively 60 seeds from each variety, thus enabling the performance of 3 repetitions by 15 experimental variants (one variant contains 15 seeds from one of the tested varieties) as follows:

- V_1, V_2, V_3, V_4 – experimental variants for Buzău 4C variety;
- V_5, V_6, V_7, V_8 – experimental variants for Rio Grande ST variety;
- V_9, V_{10}, V_{11}, V_{12} – experimental variants for Saint Pierre ST variety.

The working method, in terms of the *Lycopersicum esculentum* L. biological material is compliant with the conditions of the *in vitro* method, thus meaning the seeds have been subjected to aseptization by means of Domestos solution (2.5 ml of Domestos, 97.5 ml of aseptized distilled water) for 30 seconds, followed by three washing sessions with aseptized distilled water (10 minutes for each wash). The seeds have been inoculated on aseptized gauze and placed in transparent containers. The gauze has been moistened with a share of 17 ml of aseptized distilled water upon inoculation, followed by another share, of 10 ml on the third day post inoculation.
The experimental device was made up of three sets of LEDs (Light Emitting Diodes), which have emitted light out of the white, blue and red light spectrum. The technical specifications of LEDs are: power 18 W, voltage 220 V, light flux 435 lm and dominant wavelength (Livadariu & Maximilian, 2017).
The light variants used in the experiment are as follows: W- white LEDs, R- red LEDs, B- blue LEDs, N- natural light.
The experimental variants have been exposed to the different types of lighting as follows:

- V_1, V_5, V_9 – white LEDs (W);
- V_2, V_6, V_{10} – blue LEDs (B);
- V_3, V_7, V_{11} – red LEDs (R);
- V_4, V_8, V_{12} – natural light (N).

The incubation of the seeds was conducted under the following conditions: temperature of 22°C ± 2°C with enforcement of light treatment for 16 h within a 24 h period.
For each inoculation, quantitative determinations (sprouts rate, fresh weight of sprouts, fresh weight of cotyledons, fresh weight of hypocotyls and fresh weight of roots) as well as morphometric determinations (length of hypocotyls and length of roots) have been conducted.

RESULTS AND DISCUSSIONS

The preliminary results regarding seed germination of *L. esculentum* L. under the influence

of LEDs show clearly noticeable differences in different aspects of sprout development.
The first aspect that should be discussed is the average value of seed germination (Figures 1, 2 and 3).
Significant differences can be noticed for the Rio Grande ST variety (V1, V2, V3, V4), as results show that blue LED lights (B) have had quite an impact in the encouragement of seed germination, in comparison with the red LEDs (R). The results for the natural light (N) are slightly under the ones for the blue LEDs, while for the seeds treated with white LEDs, even though in day 7 (D7) the number of germinated seeds was similar to the results in the red LED variant (R), in day 18 (D18), the gap is noticeably greater. Therefore, these results show that in this variety's case, blue LEDs (B) were the most efficient in stimulating germination, while the red LEDs (R) were the most inefficient.
For the Buzău 4C variety (V5, V6, V7, V8) tested in this experiment, the results for the germination rate (Figure 2) are not very different from the ones for Rio Grande ST variety (Figure 1).

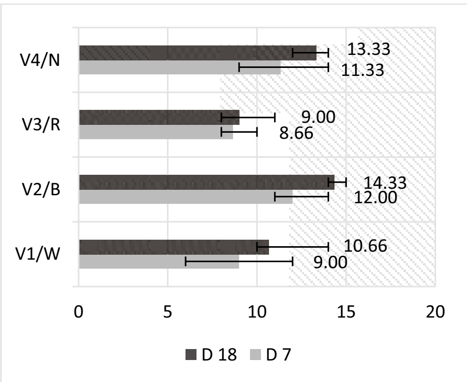

Figure 1. The average value of the rate of seed germination (no.) for the Rio Grande ST variety, in day 7 (D7) and day 18 (D18) post incubation

The results show that in this case as well, the blue LEDs (B) has represented one of the most efficient lighting method. An interesting observation is that the results for day 18 (D18) post inoculation, for the white LEDs (W) and the natural light (N), are the same. The only difference seems to be an increase in the germination speed, as on day 7 (D7) there were more germinated seeds in the variant exposed to white LEDs, in comparison to the one exposed to natural light. In a more general approach, the discrepancy between the blue LED lighting variant (B) and the rest of the lighting variants (W, R, N) is the most obvious, while there seems to be little to no difference in their influence on germination. However, the red LEDs (R) prove themselves to be, again, most inefficient.

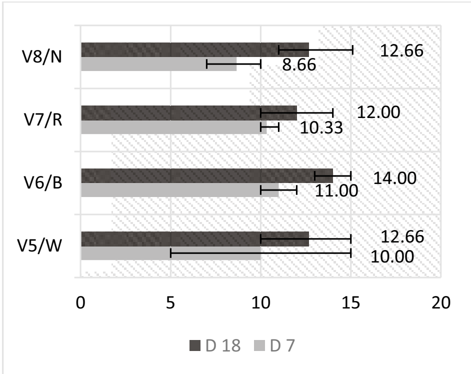

Figure 2. The average values of the rate of seed germination for the Buzău 4C variety, in day 7 (D7) and day 18 (D18) post incubation

As for the Saint Pierre ST variety (V9, V10, V11 and V12) tested (Figure 3), the germination rates for the natural light (N), red LED (R), blue LED (B) and white LED (W) lighting variants are very similar. However, in terms of numbers and end results (D 18), the white LED (W) light has been apparently most effective followed closely by the results of blue LED lighting.

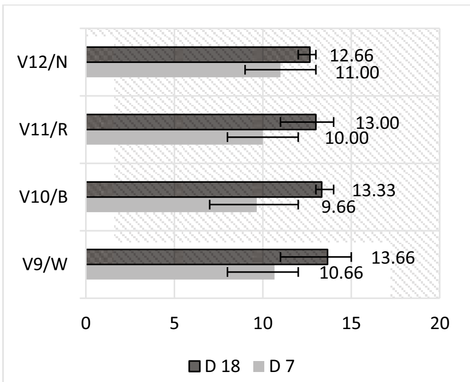

Figure 3. The average values of the rate of seed germination for the Saint Pierre ST variety, in day 7 (D7) and day 18 (D18) post incubation

Also, it seems that the germination speed was higher in the white LED variant - as suggested by the observations for day 7 (D7).
After germination, the results regarding the development of the sprouts show differences depending on the lighting variants (Figure 4). Therefore, as noticeable in Figure 4, for the experimental variants that represent the Rio Grande ST variety (V1, V2, V3 and V4), as well as for the experimental variants that represent the Buzău 4C variety (V5, V6, V7 and V8) the value of the fresh weight of the sprouts is highest under the blue LED lighting (B). However, for the Saint Pierre ST variety, blue LEDs (B) seem to have been the most inefficient, followed shortly by the natural light (N).

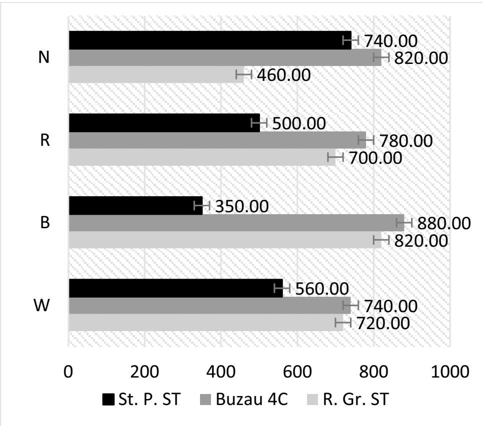

Figure 4. The average values of the fresh weight of sprouts (mg), varieties tested reported to light variants (W, B, R, N)

Moreover, the discrepancies seem to repeat themselves when it comes to the value of the fresh weight of cotyledons (Figure 5), blue LEDs (B) being most efficient for the first two varieties tested, while for the Saint Pierre variety, it proves itself most inefficient, in this case, natural light (N) taking the leading place.
There is an obvious similarity when it comes to the results regarding the fresh weight of the hypocotyls (Figure 6), between all tested varieties, as they all seem to prefer natural lighting (N). There is a small discrepancy between the results for red LEDs (R) and natural light (N) variant results, thus sugges-ting the two lighting options tend to have similar effects on the fresh weight of the hypocotyls.

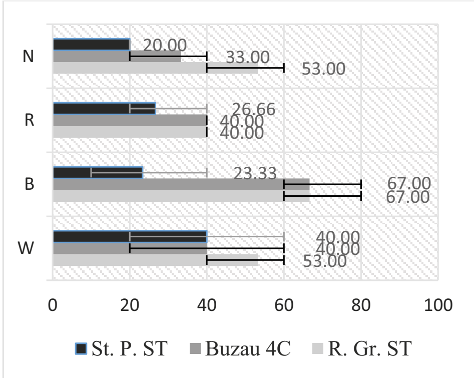

Figure 5. The average values of the fresh weight of cotyledons (mg), varieties tested reported to light variants (W, B, R, N)

Also, during the experimental observations, one has noticed that in the case of white LED lighting (W) and blue LED lighting (B), all the hypocotyls from all the varieties tested, in all their repetitions, have developed a purple coloration. There has been no sign of such coloration in any of the other experimental light variants.
Another interesting observation concerns the development of the roots, more precisely, adventive roots, in the case of plants treated under the blue LED (B) variant. Adventive roots have grown up to the middle of the hypocotyl length in some cases. This kind of root growth is not abnormal for *L. esculentum* L. However, the other experimental variants, tested under different types of lighting have not shown such an obvious particularity.

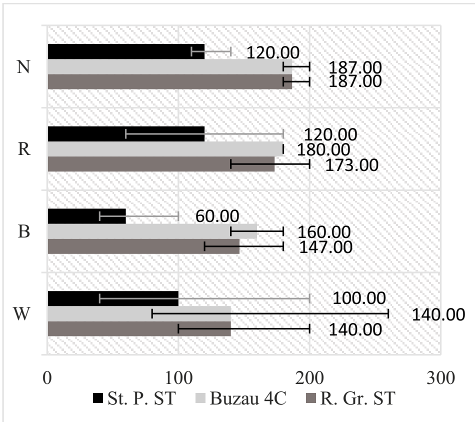

Figure 6. The average values of the fresh weight of hypocotyls (mg), varieties tested, reported to light variants (W, B, R, N)

Regarding the development of the roots (Figure 7), the outcome of the experiment shows that blue LED light (B) seems to encourage it, at least for the first two varieties tested, Rio Grande ST (V1 to V5) and Buzău 4C (V6 to V10).

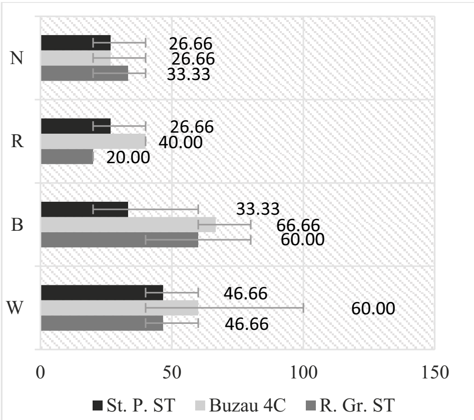

Figure 7. The average values of the fresh weight of roots (mg), varieties tested, reported to light variants (W, B, R, N)

The discrepancy is most obvious with the Buzău 4C variety, the fresh weight of roots reaching the highest value on day 18 post inoculation. Natural light (N) does a poor job in stimulating root growth for all tested varieties, with a slight discrepancy for the Rio Grande ST, which seems to have done a bit better than the other two. Quite equally inefficient when it comes to root growth stimulation is the red LED light (R) variant. White LEDs (W) and blue LEDs (B) show most potential in this aspect of the experiment.
The average values of the root length, presented in Figure 8, show that each variety has a certain preference when it comes to the development in length of the radicular system. These preferences are strangely different and further studies should be conducted over this aspect.
However, when it comes to the length of the hypocotyl (Figure 9), results show that the preference for the red LED (R) lighting variant is obvious for all tested varieties, especially in the case of the Rio Grande ST variety.

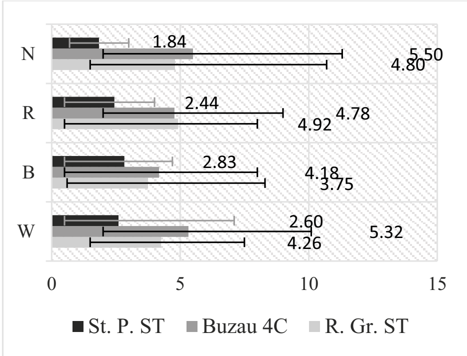

Figure 8. The average values of root length (cm), varieties tested, reported to light variants (W, B, R, N)

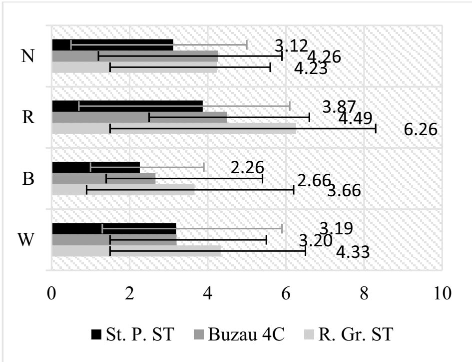

Figure 9. The average values of the hypocotyl length (cm), varieties tested, reported to light variants (W, B, R, N)

Therefore, the right combination of the different colours of the spectrum may provide most efficient lighting, thus enabling farmers to apply modern farming methods, for a fast, round-the-year, constant production of qualitative food.
However, further studies should be conducted in order to be able to draw clear conclusions, while other parameters should be taken into consideration, such as temperature variations or light intensity.

CONCLUSIONS

The experiment conducted on the three *Lycopersicum esculentum* L. varieties shows that some LED lighting variants may prove themselves very useful in different development stages (seed germination, sprout development).

The results indicate certain lighting preferences that each variety may have, depending on their state of development.

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