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Study of the influence of the basic spectra of discrete light sources on the seeds of greenhouse cultures

D Yu Donskoy¹, M A Vernezi¹, O I Katin¹, K I Goryanina¹, S G Studennikova¹ and M Petkovic²

¹Laboratory of local automation and embedded systems Don State Technical University, Gagarin Square 1, Rostov-on-Don 344000, Russia Federation

²University of Kragujevac, Čačak, Serbia

E-mail: dand22@bk.ru

Abstract. This article refers to studies conducted on the seeds of vegetable and green crops with low useful mass, which require light stimulation at all periods of development. Research was conducted using RGBW LEDs. There is a large number of scientific studies proving the effectiveness of the technology of photostimulation of seeds and seedlings of various crops. However, there is no consensus on what the positive effect of the variable light field on a biological object is based. This is due to the complexity of the process of photosynthesis, where the productivity of photosynthesis is considered as an integral response to the influence of external conditions. The study of the influence of various light modes on plants is necessary to search for performance criteria. The found efficiency criteria will provide an opportunity to systematize the many well-known results of the impact of variable light conditions on plants in order to identify plants as a biological object by optical properties, as well as to use to standardize technological lighting in greenhouse production.

1. Introduction

Existing methods of light stimulation of seeds and seedlings are almost the same. Usually, ultraviolet luminaires or “full-spectrum” LED arrays with a predominance of red and blue components of the spectrum are used. This is due to the fact that at the moment there is no experimental base on which it is possible to form an idea of the characterization of the influence of various light spectra on the seeds of vegetable and green cultures.

Existing studies often lead to the conclusion that the entire spectral range affects plants and the use of individual spectra does not provide the desired effect during germination and, conversely, can lead to plant degradation. Thus, the most suitable solution is to model modified sunlight using discrete light sources, but for this it is necessary to prove the correctness of this theory.

To find criteria for the effectiveness of the impact of different light spectra, studies are required with the same climatic indicators.

To carry out these tests, a setup was developed that forms the required ratio of spectral components using discrete light sources, while maintaining constant microclimate conditions for the purity of experiments (figure 1). [1-2]



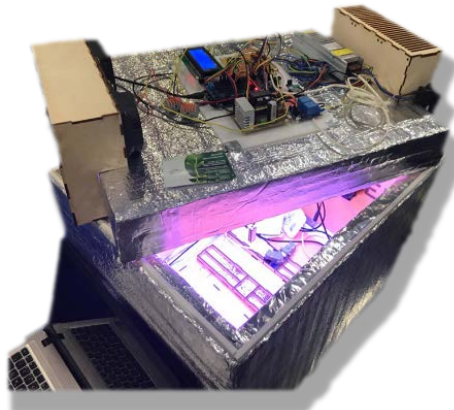


Figure 1. System for experimental studies on photostimulation of vegetable and green cultures

2. Method of increasing seed germination by photostimulation with discrete light sources

We considered the mathematical solution to this issue in the article “Simulation, identification and dynamic control of the luminaire of the synthesized spectrum” and gave an example of approximating RGBW LEDs to the spectrum of sunlight on the soil surface [3].

Nowadays, more modern LEDs with a wide spectral range are used (sometimes they are called full-spectrum). The use of these LEDs for approximation to modified sunlight allows us to reduce the total square error by 4.41% (figure 8). [4-5].

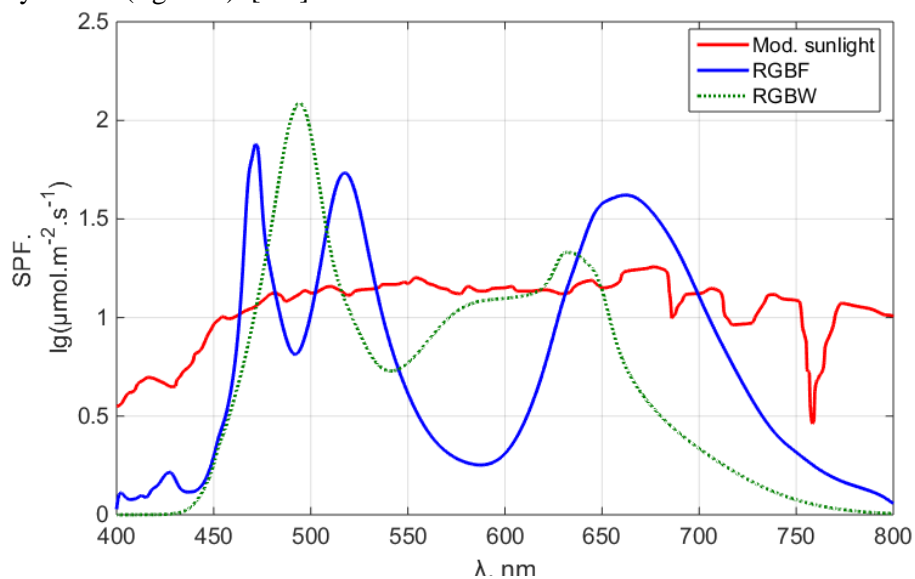


Figure 2. Comparison of the approximated spectra of discrete light sources to modified sunlight on the soil surface [6-7].

We also determined approximation coefficients for modified sunlight at a depth of 3, 6, 9 mm and compiled graphs of the obtained spectra (figure 9a, 9b, 9c, respectively).

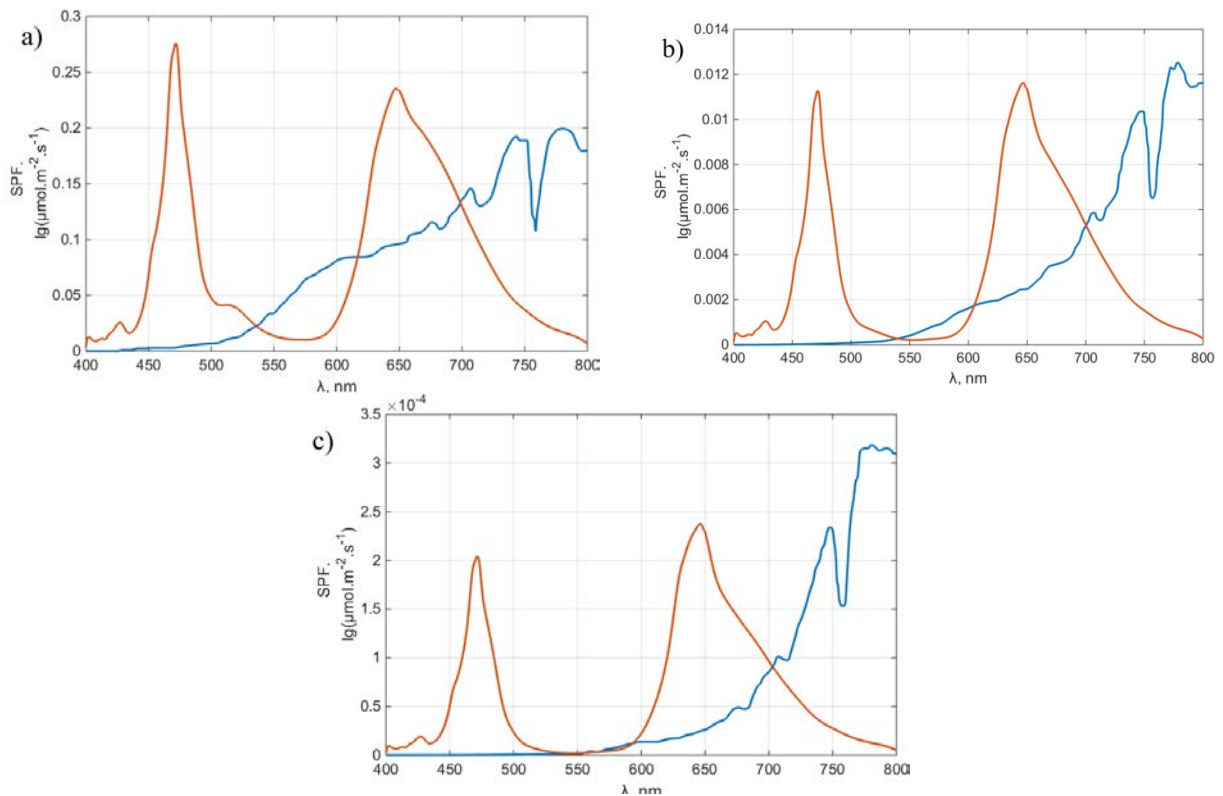


Figure 3. Graphs of approximation of RGBF LEDs to modified sunlight at a depth of a) 3mm, b) 6mm, c) 9mm.

3. The study of RGBW spectra on radish seeds

Experimental studies were carried out at a constant temperature of 27 ° C, substrate humidity of 100%, and light intensity of 1500 lux. The concentration of CO₂ throughout the test period was in the range of 600-1100 ppm, there was also no direct air flow to the seeds, which prevented weathering. In the role of the substrate was foam rubber ST 18/20 (10 mm) (figure 2).

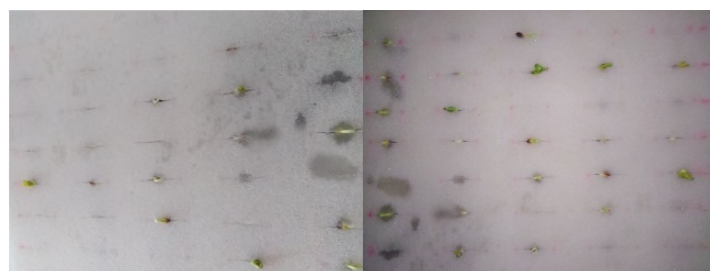


Figure 4. ST 18/20 (10 mm) with seeds during testing.

For the high speed of the first experiments, the object of the study was radish seeds, because the average time of their development to the seedling stage is about 3-4 days. All seeds from one batch. The spectral characteristics of discrete light sources can be seen in Figure 3.

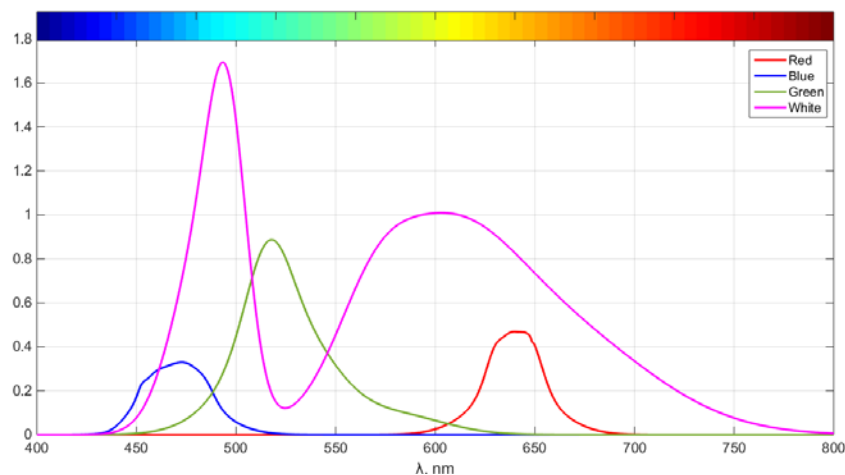


Figure 5. Spectral characteristics of RGBW LEDs.

When studying the effects of the blue spectrum of LED lighting, we obtained the following results. The average root length is 7.41 mm, the total sprout length is on average 14.8 mm, the average maximum diameter is 1.3 mm, and the color is rgb (166,162.63). The germination rate is 85%. An example of a seedling as a result of testing in Figure 4.



Figure 6. One of the radish sprouts when exposed to blue light.

When studying the effects of the red spectrum of LED lighting, we obtained the following results. The average root length is 8.1 mm, the total sprout length is on average 16.7 mm, the average maximum diameter is 0.78 mm, and the color is rgb (176,177.58). The germination rate is 56%. An example of a seedling as a result of the tests in Figure 5.



Figure 7. One of the radish sprouts when exposed to red light.

When studying the effects of the green spectrum of LED lighting, we obtained the following results. The average root length is 6.74 mm, the total sprout length is on average 10.92 mm, the

average maximum diameter is 1 mm, and the color is rgb (112,131,13). The germination rate is 73%. An example of a seedling as a result of the tests in Figure 6.



Figure 8. One of the radish sprouts when exposed to green light.

When studying the effects of the white spectrum of LED lighting, we obtained the following results. The average root length is 7.37 mm, the total length of the sprout is on average 15.1 mm, the average maximum diameter is 1.1 mm, the color is rgb (112,131,13). The germination rate is 84%. An example of a seedling as a result of the tests in Figure 7.



Figure 9. One of the radish sprouts when exposed to green light.

Thus, these studies showed how radish seeds behave under different exposure spectra. The most dense root and the best germination of seeds developing under the influence of blue LEDs, the greatest length is seen when preparing seeds with red LEDs, and average values are seen when exposed to white LEDs.

4. Results

Figure 9 shows that there is an exaggeration of 400 to 550 wavelengths, which can be corrected by using a light filter, but this was not available. The practical application of these methods of light stimulation of seeds of vegetable and green crops, while maintaining favorable microclimate conditions, increases the percentage of seed germination relative to conventional methods of germination up to ~15%. (figure 9) The overall quality of seedlings as a result of stimulation also increases, and the color index of seedlings with rgb is normalized (236,224,106). to color gradients rgb (130,157,40) and rgb (146,90,75).

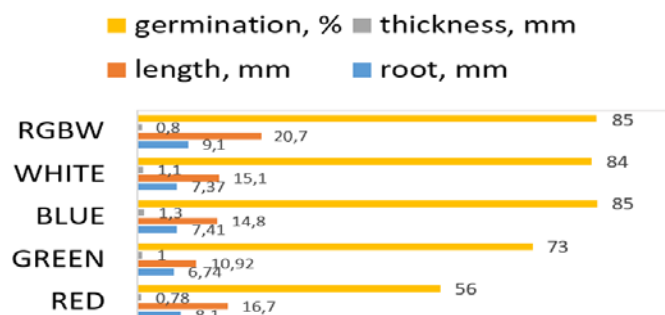


Figure 10. One of the radish sprouts when exposed to green light.

Acknowledgments

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