Ways to increase the efficiency of growing products in greenhouses

Sharofiddin B. Yusupov[1], *Suhrob* E. Qurbonazarov[2*], *Zinatdin* J. Saymbetov[3], and *Rinat* K. Kenesbayev[3]

[1]"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, 39 Kory Niyoziy, Tashkent, 100000, Uzbekistan
[2]Termez Institute of Engineering and Technology, 288-A Islam Karimov, Termez, 190100, Uzbekistan
[3]Karakalpak State University named after Berdakh, 1 Academic Ch.Abdirov, Nukus, 230112, Karakalpak

Abstact. Light plays a crucial role in plant life, as it determines the process of photosynthesis. The red spectrum, specifically radiation within the 600-700 nm range, has the highest quantum yield among all wavelengths of sunlight. This means that plants convert red light energy into work more efficiently, making it essential for a higher rate of photosynthesis. The red spectrum also significantly impacts plant growth and development, influencing seed germination, organ shape and size, and flowering speed. Phytochromes, which monitor photoperiod length, play a key role in regulating plant growth and development in natural light conditions. Many plants use seasonal signals, including photoperiod length, to initiate and complete flowering programs. Therefore, the red spectrum is particularly important for plant photoperiods, vegetable and garden crops, sweet pepper seedlings, and the efficiency of LED linear irradiators.

1 Introduction

Harvesting 2-3 times a year has become a traditional way of growing agricultural products in Uzbekistan, where growing plants from seedlings and running greenhouses plays an important role. The work carried out in this direction is an important opportunity to satisfy the needs of the population of our country for vegetable products and prevent the food problem emerging in the world [1-3].

In particular, it is important to create favorable conditions for the vegetative development of plants when growing vegetables, rice and horticultural crops. Melon seedlings are usually grown in vegetable and garden crops for the longest period - 80-90 days. The use of optical and phytotechnologies makes it possible to grow heat-loving crops and enrich vegetable varieties in northern regions where there is not enough heat and there are no conditions for a full harvest [4,5,6,8]. When planting from seeds.

Melon is a heat-loving plant, so when growing its seedlings it is necessary to maintain an average temperature of 24-36 degrees Celsius, as well as lighting.

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* Corresponding author: sukhrob.qurbonazarov@mail.ru

From plant physiology we know that for good growth and development of vegetables and garden crops, the process of photosynthesis must continue for 14-16 hours a day. The plant world absorbs well the blue and red spectra of natural visible light rays from the sun. In these spectra, plant photosynthesis continues at a moderate level. In the autumn-winter, winter-spring seasons, the growing season of melon seedlings lasts 60-90 days. The main reason for this is the lack of natural light; several artificial light sources and various radiation technologies can be used to compensate for natural light. Melon seedlings are grown in nurseries all year round in the autumn-winter, winter-spring periods and as a repeat crop [8].

Rational lighting of greenhouses; stable light flux ensures improved quality of plant growth and productivity; High luminous efficiency and long service life show its advantages over existing sources (Figure 1).

Fig. 1. Irradiation device for growing melon seedlings.

2 Materials and methods

The red spectrum is radiation in the region from 600 to 700 nanometers. It has the highest quantum output among all wavelengths of sunlight. This means that the plant is more efficient at converting such energy into work. Therefore, the red spectrum is more important than all others for high photosynthesis rates. It also makes a fundamental contribution to plant development. For example, it affects seed germination, the shape and size of organs, and the speed of transition to flowering.

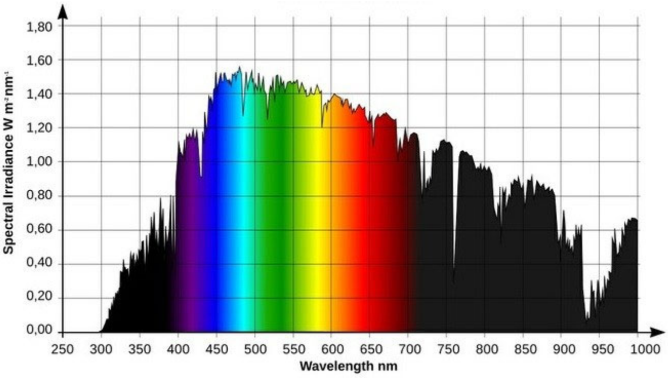


Fig. 2. Light spectrum of the Sun.

To see the wavelength range from 600 to 700 nanometers, the plant uses protein receptors. They are combined into a common group called phytochromes. Phytochromes are synthesized under dark conditions. That is, plants also need to sleep. After a series of transformations, phytochromes enter the nucleus from where the plant's preset genetic programs are launched. These receptors also detect far-red light emitted in the region from 700 to 800 nanometers. Despite the fact that it is outside the photo of active radiation, far red is no less important than ordinary red [9-11].

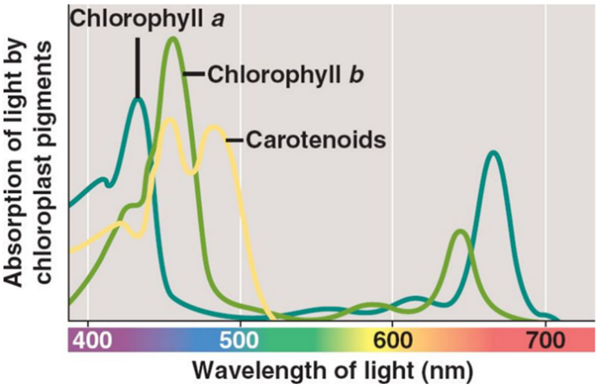


Fig. 3. Absorption spectrum of chlorophyll and carotenoids.

The graph of absorption of various light spectra shows that chlorophylls A and B most absorb region a in the zone from 425 to 460 nanometers. That is, blue color absorption coefficient in the red region is much lower. Based on this, a logical question arises: why is the main contribution of photosynthesis traditionally attributed to the red spectrum? The reason is due to the way the light collecting system works. The fact is that blue light is more energy intensive. That is, one quantum in the region from 400 to 500 nanometers will contain more energy than a quantum chic from 600 to 700 nanometers, which correspond to the red spectrum. The chlorophyll molecule, having received such a concentration of energy at once, cannot be used effectively enough. Therefore, the excess energy received is dissipated in the surrounding space due to heat. Normal plant development requires a synergistic approach to lighting. That is, the involvement of all three important spectra. Each of them affects the development of the plant. Which is directly related to the intensity of photosynthesis, but the red spectrum makes the greatest contribution to the intensity of photosynthesis. It is ironic that in a condition where only red is used as the only light source. The rate of photosynthesis turned out to be significantly less than under blue or green light alone. In pure red light, chlorophyll is produced worse, without which photosynthesis is impossible. The synthesis of carotenoids involved in capturing solar energy is also reduced, and the sensitivity of stomata to light worsens. This leads to an inconsistency between the intensity of illumination and the degree of openness of the substance at the crack, as a result of which the fixation of carbon dioxide is reduced. The density of stomata also decreases; their conductivity decreases; the amount of the enzyme rubisco, which continuously begins the carbon dioxide fixation cycle, decreases. All this leads to the fact that the red spectrum in its pure form acts on the plant as stress, suppressing photosynthesis. But what is noteworthy is that it is worth adding monochromatic red light and a little blue as most of the negative effects are neutralized. In 1995, with the participation of NASA scientists, an experiment was conducted with pepper, which showed that a small part of the blue increases weight gain. This also indirectly indicates an increase in the intensity of photosynthesis [12,13].

Red spectrum regulates the growth and development of the body with the help of phytochromes. Thanks to them, the plant perceives information about environmental conditions and chooses the appropriate strategy for survival. The key role of phytochromes in natural light conditions is to monitor the length of the photoperiod. Which, together with the temperature, provides the plant with important seasonal information. Many plants use seasonal cues to trigger their flowering programs on time and complete them successfully. Thus, the red spectrum is especially important for the generative stage of plant photoperiods. Phytochromes are extremely important in plant communities where there is a constant struggle for resources, particularly light. The red spectrum causes stem elongation and leads to apical dominance. That is, to such a development in which painful shoots are weakly formed. Resources are concentrated on the growth of the apex, in parallel with this, the leaf area increases with a decrease in their thickness and biomass. Recently, the experience of Dutch scientists using tomatoes as an example showed that the mass of fruits was also less in conditions where red made up more than 90% of the total photoactive radiation [13,14].

Far red light under natural conditions signals the plant about the presence of competitors for light. The influence of the green spectrum was said that the blue-red color is mostly absorbed by the upper layer of the leaf. While green penetrates deep into the leaf, since far red does not participate in photosynthesis, it penetrates and passes through the leaf with even greater ease. Photochromia is recorded in accordance with the ratio given to red, and if the proportion of red decreases, it means that something from above is taking away part of the light energy. A shading avoidance program is launched and this leads to a strong elongation of the stem. And the plants have the opportunity to outstrip their neighboring competitors in growth. If such light conditions persist and the plant then concludes that it was not possible to overtake its neighbors, after which another program is launched to accelerate flowering. Which allows you to get seeds in unfavorable conditions. Thus, in practice, it becomes possible to shorten the period before flowering begins under favorable conditions.

Experiments have shown that the red spectrum is responsible for the synthesis of carbohydrates. Blue light was used in an experiment in which coke dandelions were grown. In it, the researchers concluded that lighting with predominant red light better stimulates the synthesis of sucrose, that is, carbohydrates. This subsequently has a beneficial effect on the plant's rubber production. The basis for which sucrose is [15].

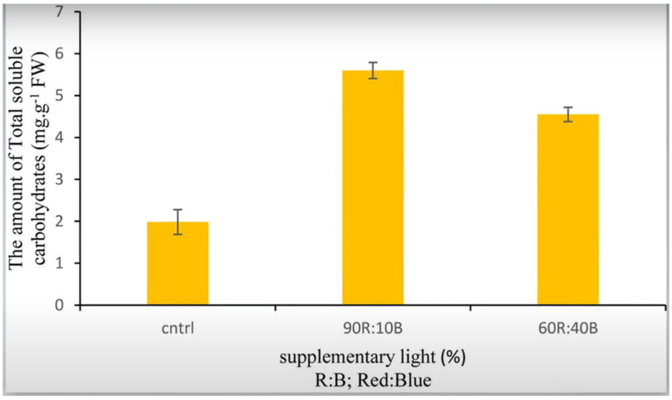


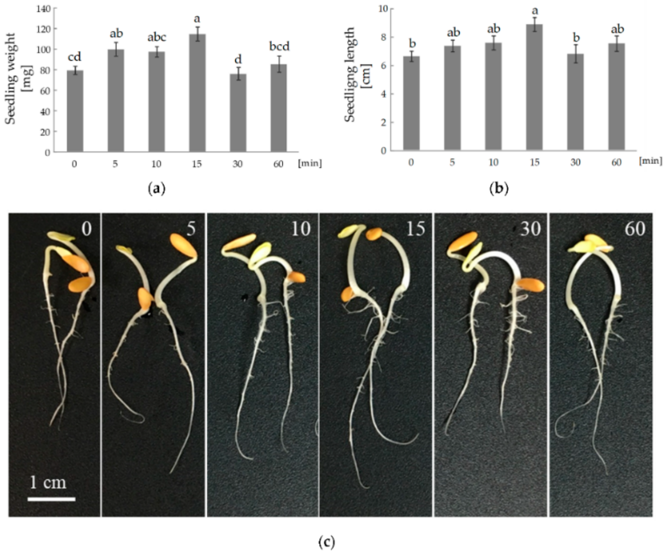
Fig. 4. Additional light spectra for better plant growth and development

3 Results and discussion

These data confirm another experiment conducted on cross lettuce at the Iranian University and published in 2020. In the study there were two options with LEDs where the ratio of red to blue was 90:10 and 60 to 40. And also, the control group with natural light accumulated the most carbohydrates in salad anti with a predominant red 90:10, and the difference was more than 100 percent of what can be obtained natural light.

At the stage of emergence of the embryo and seed, red light together with blue light participate in the process of hair removal, that is, it adapts the plant to life in the light. When the cotyledon leaves see the light for the first time, they are not yet able to synthesize phyto due to the lack of chlorophyll in them. Red light's effect on phytochromes triggers a number of processes and the leaves acquire the ability to photosynthesize along with a green color, so if the goal of cultivation is to increase the carbohydrate content of the plant, for example, the production of sweet fruits, then it is worth paying more attention to the red spectrum.

Some plant species require light treatment for their seeds to germinate. An interesting effect is obtained by training seeds with red and far-red light. The first such experiment was carried out back in 1952. Harry Borthwick in this work treated Grand Rapids lettuce seeds with alternating streams of red and far red. After which the similarities were analyzed. It is interesting that the last seeds irradiated with red light achieve almost one hundred percent similarity. A noticeably different reaction was observed in seeds treated with distant red last. This resulted in a much lower percentage of similarity to the natural environment. It is important to correctly assess the surrounding conditions; the plant already at the seed stage does this by constantly adjusting the survival program. So, during the last treatments, the distant red organism receives information about thickened phytocenoses. Where there is little light for normal development. Therefore, some of the seeds in the experiment refused to germinate under potentially unfavorable conditions. Harry Borthwick demonstrated that the red spectrum is perceived by the plant already at the seed stage. A team of scientists from Spain went further in a recent study. They also treated the seeds with red spectrum but did not stop at the germination stage.



(a)

(b)

(c)

Fig. 5. Effect of red light exposure (100 µmol m^{-2} s^{-1}) (0–60 min) of melon seeds on the fresh weight (a), length (b) and overall appearance (c) of 3-day-old seedlings. Data represent the mean ± SE from 45 measurements. Different letters indicate significant differences according to Tukey′s test ($p \leq 0.05$).

Melon and cucumber seeds showed wavelengths ranging from 650 to 670 nanometers after soaking for 12 hours. The options differed in the duration of light treatment from zero to sixty minutes. After this, the seeds were left in the dark for three days to prevent additional exposure to light. Red treatment had no effect on the percentage of germinated melon seeds. In all cases, the values ranged from 90 to 93 percent.

But the biomass and length of the seedling showed a significant difference compared to the control group. Irradiation for 15 minutes duration has great results in these two parameters. Weight increased by 43 percent and length by 33 percent compared to control.

4 Conclusion

The red spectrum is the most active in its influence of photosynthesis. They are capable of both raising it to the maximum and significantly suppressing it. The role of red is also great in regulatory processes, it determines the size and structure of the plant's leaf apparatus, controls flowering, synthesis of carbohydrates, at the seed stage this spectrum is capable of: adjusting the life of the future organism, increasing its productivity.

Based on the data obtained from the results of experiments, it is possible to increase the activity of solutions used in hydroponic greenhouses, which occupy leading positions in agri-food production, and accelerate the development of plants. This increases the efficiency of growing produce in hydroponic greenhouses.

Food shortages can be prevented and eliminated by improving the efficiency of agricultural food production, so we encourage agricultural food producers to cooperate.

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