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THE INFLUENCE OF THE SPECTRAL COMPOSITION ON THE ROOT DEVELOPMENT OF ORNAMENTAL PLANTS *IN VITRO*

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Abstract:
The results of studying the influence of spectral composition of light on rhizogenesis of ornamental plantmicrocuttings showed that the studied variant of the spectra of the led illuminators intensified the process of rhizogenesis of ornamental plant, led to a reliable increase of rooting ability of shoots, increased the number of roots on a rooted microcutting and accelerated their growth compared to those under the influence of fluorescent lamps. The maximum frequency of rhizogenesis of microcuttings was achieved with the following ratio of the light emission of red spectrum area 62%, green area 11%, blue area 27%. When using led illuminators, stronger and lower shoots are formed, compared to shoots obtained by illuminating plants with fluorescent lamps of white light.
Key words: *rhizogenesis, microcuttings, LEDs, spectral composition*

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INTRODUCTION:

Light is an important factor affecting both the growth of explants in tissue culture and their differentiation (Muratova S.A. et al., 2017). The duration of exposure and the emission spectrum play an important role. The processes of plant life are closely dependent on the intensity and spectral composition of light. Plants are able to recognize the intensity of light flux, its spectral composition and polarization plane (Shibayev, Pergolizzi, 2011).

The analysis of scientific literature shows that light of different spectral composition regulates growth and development, as well as photosynthetic processes and productivity of plants, both *in vivo* and *in vitro* (Voskresenskaya, 1975; Karnachuk, Golovatskaya, 1998; Belous, et al., 2012). It is known that different light spectra can cause different types of morphogenesis in plants. Adaptation to the light regime affects different levels of the autotrophic organism organization, the eventual result of which can be the optimization of all plant activities (Karnachuk, Golovatskaya, 1998; Tokhtar et al., 2016).

Recently, the literature has a lot of information about the successful stimulation of growth and development of different plant species *in vitro*, using led lamps and lighting systems based on LEDs (Maljarovskaja, 2013; Markova, et al., 2014; Nesmelova, et al., 2015).

The main advantages of LEDs, unlike incandescent or fluorescent lamps are high light output and long-term service, which provide significant saving in their application. Unlike other types of light sources, monochrome LEDs emit light in a relatively narrow band of the spectrum, which ranges from 20-30 nm of any emission color, making them convenient for fitting lamps with a special emission spectrum. At the same time, the use of LEDs in biotechnology today is at the stage of its development.

The purpose of our study is to study the influence of the spectral composition of light on the process of rhizogenesis and development of ornamental plants at the stage of rooting *in vitro*.

RESEARCH METHODOLOGY:

Biological objects of research were *Aronia mitschurinii* "Amit" (*Aronia mitschurini i*Amit), Dammeri cotoneaster (*Cotoneaster dammeri*), Canadian park rose "Hope of Humanity" (Park rose Hope of Humanity).

For the cultivation of plants *in vitro* at the stage of root development we used mineral-based nutriculture medium MS (Murashige, Skoog, 1962) with 2 times reduced concentration of major salts and with adding 20 g/l of sucrose, 50 mg/l of mesoinositol, vitamins of MS medium, 8 g/l of agar. The medium was added β-indolebutyric acid (IBA) at a concentration of 0.25 mg/l. For rooting we used the shoots, which reached the length of 1.5-2.0 cm.in the medium of breeding. Subcultivation of shoots was carried out in a wide-mouthed conical flasks of 250 ml capacity with 80 ml of medium.

Experimental plants were placed on the phyto racks X-bright FitoLed with light spectrum and emission intensity separately adjustable for each shelf. The racks are equipped with led emitters with wavelengths from 365 to 750 nm (power consumption for each shelf is adjustable from 0 to 80 W). The illumination level was set to 2400-3000 Lux.

At the stage of root development of ornamental microplants, we studied the influence of LED-based illuminators with the power ratio of red, blue and white light emitters (in%, respectively): variant 1 – 50% red light, 25% white light, 25% blue light, variant 2 –25% red light, 25% white light, 50% blue light, variant 3 –100% white light, variant 4 –25% red light, 50% white light, 25% blue light. The control plants were illuminated with Osram L36W/765 Cool Daylight fluorescent lamps of white light at illumination of 2200-2400 Lux.

Cultivation of plants was carried out in the culture room at a 16-hour light day and air temperature of 24±2^{0}C. Control and experimental plants were in the same conditions of cultivation, but were optically isolated from each other.

The number of rooted microcuttings was considered, the number of formed roots, their length and the length of shoots were measured every two weeks of culturing in the rooting medium. Statistical data processing was performed using Microsoft Excel.

RESULTS:

As a result of experiments it was determined that in all variants with led illuminators the root development of microcuttings was higher than under the fluorescent lights. The process of rhizogenesis with the use of LEDs was faster. After two weeks of cultivation, the frequency of control plant *Aronia mitschurinii* rooting with fluorescent lamps was 23.5%, while in variants 1-3 of the experimental plants it was from 62.8% to 65.4%. The maximum rooting frequency of the Aronia was 75.1% obtained in experimental variant 4 with the power ratio of the emitters of25% red light, 50% white light, 25% blue light. This variant was the best of all studied plants, giving the maximum frequency of rooting (Fig. 1). The frequency of rhizogenesis of microcuttings in variant with 100% white light LEDs was significantly higher than with the fluorescent lamps of white light (Fig. 1). The total frequency of rooting is also higher when phyto rack with led lamps is used for cultivation, although the difference was not so significant (Fig. 2). Aronia with high frequency (97.4-100%) is rooted in all variants of the experiment. For the park rose and Dammeri cotoneaster the maximum rooting frequency was obtained in the third (100% white) and fourth experiment (25% red, 50% white, 25% blue).

The use of led lamps has significantly affected the quality of the root system. So, the average number of roots per rooted Aronia microcutting in variant with50% red, 25% white, 25% blue light made up 6.65 roots, in variant with 25% red, 50% white, 25% blue lightit was 6.27 roots compared with 2,81 rootsof control plant in variant with fluorescent lamps. The root number of cotoneaster in experimental variants increased from 3.53 to 4.5 roots compared with the control plant with 2.9 roots per a rooted cotoneaster microcutting. Also the number of roots of the second order has increased. In all experimental variants the number of rose roots increased too(Fig. 3).

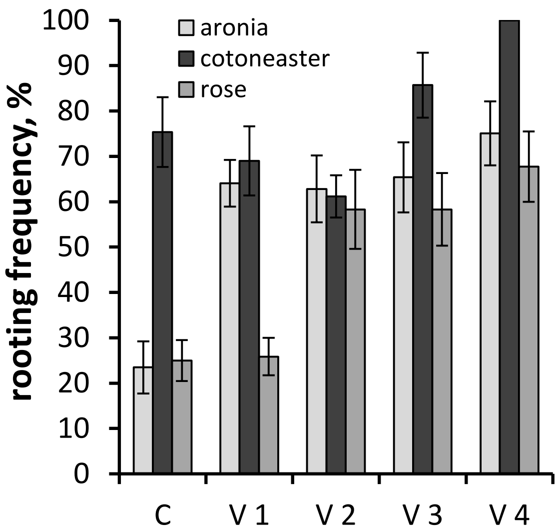

Figure 1. The efficiency of root development of microcuttings of ornamental plants after two weeks of cultivation in MS medium with 0.25 mg/l of IBA, depending on the spectral composition of light

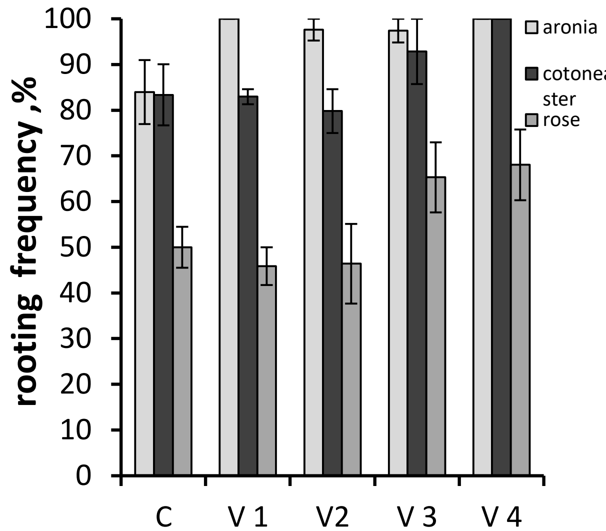

Figure 2. The efficiency of root development of microcuttings of ornamental plants after four weeks of cultivation in MS medium with 0.25 mg/l of IBA, depending on the spectral composition of light

In all cultures, the roots grew faster at a ratio of 50% red, 25%white, 25% blue and 25% red, 25% white, 50% blue compared to those with the predominance of white light (Fig. 3, 4).

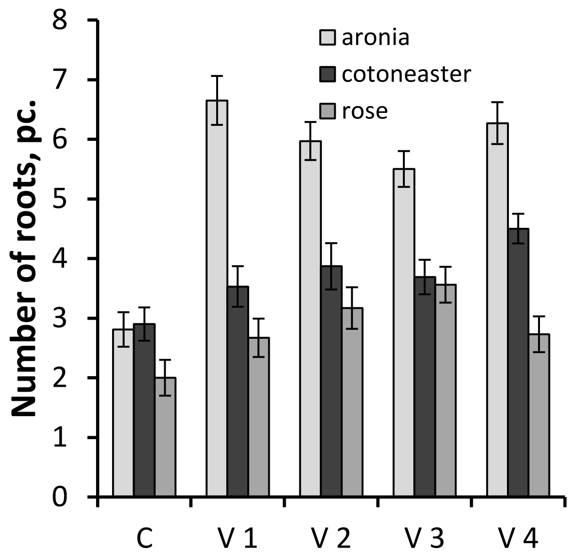

Figure 3. The root development of ornamental microplants at the stage of rooting depending on the spectral composition of light

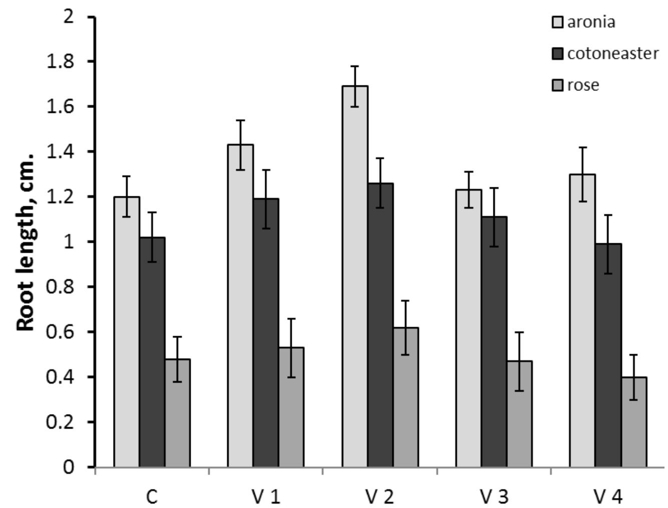

Figure 4. The growth of roots of ornamental microplants at the stage of rooting depending on the spectral composition of light

In the cultivation of ornamental plants on the shelves with different lighting biometric indicators of shoots (length of a shoot, length of internodes, number of leaves, length and width of leaf blades) were also different. The most obvious differences between the experimental and control variants were observed in the Dammeri cotoneaster (Fig. 5). The use of led illuminators has significantly improved the state of the microplants. The control shoots (with fluorescent lamps) were the most elongated. Stronger shoots formed under the LEDs. The average height of rooted microplants in variants with led lamps is significantly lower than in control variant. The average height of rooted microplants in variants with predominance of red or white light was 6.0 – 6.4 cm, which is 2.8-3.2 cm smaller in comparison with the control plant (9.2 cm). The predominance of blue light slowed down the growth of shoots, which led to the formation of the most undersized shoots (5.1 cm), with shortened internodes of plants. Other authors also pointed out the slowing growth of shoots under the influence of blue light. A blue honeysuckle Nymph showed a similar effect at the rooting of microcuttings (Nesmelova et al., 2015).

In studies conducted on the Caucasian lily (*Lilium caucasicum)*, it is shown that blue light caused inhibition of leaf growth, while the red region of the spectrum contributed to a more intensive leaf growth compared to white light (1.4 times). In the opinion of N.N. Protasova and V.I. Kefeli (1982), this difference in the growth and development of plants is due to the fact that the blue light caused the formation of significantly larger amounts of inhibitors such as abscisic acid, hydroxy-cinnamic acids, etc. in the leaves, in comparison with plants grown under the red light. This leads to the formation of shortened stems and thicker leaves.

In our studies, the leaf coverage (number of leaves) of the microplants in the experimental variants was at the level of the control variant (22.3 leaves per plant) or slightly higher than in the control: 26.0 leaves per plant in variant 2 with25% red light, 25% white light, 50% blue light and 27.8 leaves per plant in variant 4 with25% red light, 50% white light, 25% blue light.

Controlled

50% red light, 25% white light, 25% blue light

Figure 5. The development of micro plants of cotoneaster Dammeri with different spectral composition of light

CONCLUSIONS:

Thus, studies of the influence of LED illuminators with different light spectrum on the rhizogenesis of plants in culture *in vitro* have shown:

- at the stage of rooting all the studied versions of the spectra of the LED illuminators intensified the process of rhizogenesis of ornamental plants, which led to a reliable increase of shoots rooting and the yield of certified microplants;
- led illuminators, compared to traditional fluorescent ones, significantly increased both the frequency of rooted microcuttings and number of roots per a rooted microcutting;
- the most effective variant for increasing the frequency of rhizogenesis of microcuttings was the one with the ratio of the emitters of 25% red light, 50% white light, 25% blue light (the ratio of PAR power in the red/green / blue spectrum ranges for all variants is shown in fig. 1);
- the average number of roots on a rooted microcuttingin the experimental variant with 50% redlight, 25% white light, 25% blue light and in the variant with 25% redlight, 50% white light, 25% blue light in 1.3-2.4 times exceeds the control variant with fluorescent lamps;
- roots grew faster in the ratio of 50% red light, 25% white light, 25% blue light and 25% red light, 25% white light, 50% blue light compared with the predominant white light variants;
- the average height of rooted microplants in variants with LED lamps is significantly lower than in the control variant, the predominance of blue light maximally inhibited the growth of shoots, which led to the formation of the most robust plants with short internodes.

The study of mechanisms of morphogenesis and physiological functions regulations will allow using light of different spectrum with great success for optimization of the plant cultivation *in vitro*.

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