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IRRADIATING SET WITH UV DIODES AND MICROPROCESSOR SYSTEM OF AUTOMATIC DOSE CONTROL

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ABSTRACT

The article describes the development and testing of an irradiating set with UV diodes for pre-sowing treatment of conifer seeds equipped with an original microprocessor system of automatic dose adjustment for maintenance of the required dose of UV irradiation.

Keywords: microprocessor system, automatic dose adjustment, UV irradiation of seeds, conifers, UV diodes, UV irradiation dose

1. INTRODUCTION

Human impact on the environment is not always positive and it has become necessary to develop and to take special measures for the preservation of the Earth biological resources including conifers. At the end of 1993, the Convention on Biological Diversity came into force. The main provisions of the Convention are reflected in the Russian programmes "Biological Diversity of Russian Forests" (1995) and "The Forests of Russia" (1997). For implementation of these programmes, the Forest Code was adopted in 2006 which states that only certified seeds should be used for forest regeneration [1–3].

Among all methods of activation of seed growth processes, we selected pre-sowing treatment since this method is based on natural mechanisms and therefore does not cause harm to human health and is relatively cheap. Besides, the analysis of literature has shown that treatment of seeds of agricultural plants with UV irradiation (UVI) produces positive results, consisting of increase of germinability and decrease of seeds consumption as well as even sprouts [4–7].

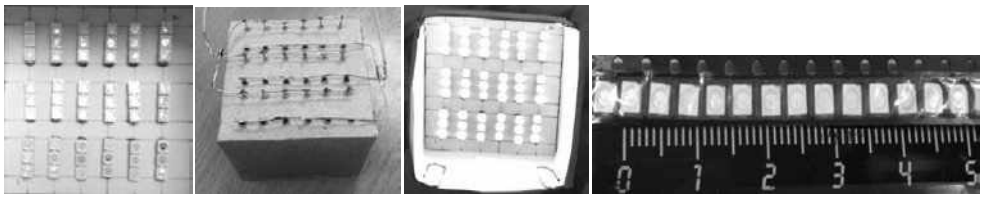
The most widely used sources of radiation for UVI are environmentally-dangerous low and high-pressure mercury lamps and capabilities of UVI using contemporary UV diodes (UVD), including using programming logical controllers, for maintenance of required dose of UVI has been insufficiently studied. This mainly relates to UVI of conifer seeds[1], especially Picea fennica.

It is known that the mechanism of UV radiation interaction with seeds provides significant acceleration of synthesis of functional substances by activating phenolic metabolism in plant cells [10]. Therefore, the studies of forest land capacity increase thanks to increasing of germinability of seeds by means of pre-sowing UVI of tree and bush seeds have large scientific and practical perspective. In the meantime, specific doses of UVI have regional nature to some extent since the changes occurring inside plant cells under UV radiation depend on the type of tissue, stage of development of biological entities, its genotype, breeding stock as well as duration of irradiation. Only low doses of UVI accelerate synthesis of ferments causing free-radical reactions [11].

[1] Conifers collect dust 30 times better than aspen and 12 times better than birch and extract 2 times more phytoncides than hardwoods. Therefore, it is more appropriate to use conifers for urban greening since they are evergreen, undemanding, more long-life than hardwoods and keep their decorative properties throughout the year [8–10].

Table 1. Technical Specifications of UV Diode

Technical parameters	Parameter value
Wavelength range, nm	395–400
Lens type	spherical
Body type	SMD3528
Radiant flux, mW	10
Diode voltage, V	3.0–3.4
Diode current, mA, less	15
Dimensions, mm	3.5 × 2.8 × 1.9



a) *b)* *c)* *d)*

Fig 1. Location (a), fixing and soldering (b), switched on state (c) and dimensions (d) of UV diodes of the irradiating set

The effect of UV radiation on seeds of Picea fennica is studied insufficiently. Therefore, development of environmentally-friendly (mercury-free) UV irradiating set based on UVD with microprocessor system of automatic control (MSAC) of UVI dose for pre-sowing treatment of seeds of this conifer is a relevant objective. Consequently, the goal of this work was the development of such irradiating set allowing to define the most efficient dose of UVI in terms of Picea seed germinability.

For this purpose, the following tasks were formulated: 1) to develop an UVD-based UV irradiating set with UVI dose MSAC; 2) to test this set to determine its efficiency for pre-sowing treatment of seeds of Picea fennica.

2. THE MAIN PART

In the studies by prof. D.A. Korepanov and his post-graduates regarding increase of germinability of the seeds of decorative crops, the *LH26-FS/BLB/E27* UV CFL manufactured by *Camelion* with broad radiation spectrum in the UV-*A* region (315–400 nm) was used [12–19]. For our experiments, we used *3528 UV SMD LED* UVD (radiation band of (395–400) nm) manufactured by *Hyelesiontek* (Table 1) and studied the impact of the right section of this region on germinability of the seeds of Picea fennica.

For this purpose, a relevant UV irradiating set for seed treatment was developed [19–21]. The dimensions of the UV irradiator of the set (Fig.1 and Fig.2) were (50×40×40) mm and its overall capacity was equal to about 1.6 W. For rather intensive and uniform irradiation, a module of 54 said low-output UVDs was used in it.

For measurement of irradiance on the working surface, the combined device TKA–PKM (Fig. 2) was used. With the suspension height of the irradiator of 2 cm (operating), it was equal to 1.6 W/m^2.

Then, provided that it is necessary to maintain the most efficient dose of UVI in the course of irradiation of seeds of different cultures, for instance, using programmable logical controllers, we have designed the UVI dose MSAC based on the *Arduino Uno* platform. The *ATmega328* microcontroller is installed on a board; its advantages are convenience of compiling a software algorithm and convenience of uploading the software in the microcontroller. The *Firmata* protocol is uploaded

Fig 2. UV irradiator and TKA–PKM

Table 2. Studied Doses of UV Irradiation

Exposure time	Dose of UV irradiation	Exposure time	Dose of UV irradiation
min	kJ/m^2	min	kJ/m^2
Seeds of **Picea fennica**, quality class 2		Seeds of **Pínus sylvéstris**, quality class 3	
18	11.9	18	11.9
22	14.5	25	16.5
26	17.2	30	19.8

Table 3. Experiment Results

Number of variant	Irradiation time, min	Germinability, %	Mould, %	Did not braird, %	Increase of germinability, %
	Seeds of **Picea fennica**, quality class 2				
Control	0	62	4	38	–
2	18	86	0	14	+24
3	22	74	6	20	+12
4	26	80	4	16	+18

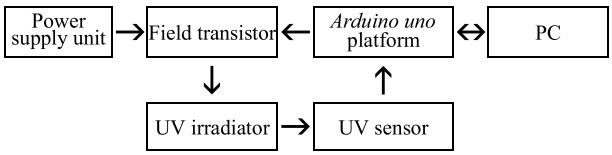


Fig 3. Structural diagram of the microprocessor system of automatic control (MSAC) of UV irradiation dose

to the latter for communication between the microcontroller and software installed on PC which (by means of *USB* interface) exchanges data with the *Arduino Uno* platform. All input data is stored in the program compiled on PC in the *Processing* programming environment. The PC (by means of *USB* interface) exchanges data with the *Arduino Uno* platform and controls the microcontroller [19–24].

For maintenance of the required dose of UVI, it is necessary to correct UVD operating time, by using an appropriate radiation sensor operating in the said spectral region, and by this sensor MSAC is tracking changes of irradiance (Fig. 3).

For signal amplification, field transistors are used (*STP16NF06*). Depending on the task transmitted by the microcontroller, the transistor controls the passing current thus activating the UV irradiator [25–27]. As a result, the seeds were irradiated by such compact UV set (Fig. 4).

3. RESULTS AND DISCUSSION

The tests of the energy-efficient compact and environment-friendly irradiating set with UV diodes were conducted in January 2017, in Udmurtia, using the seeds of Picea fennica and Pínus sylvéstris. The quantitative indicators of germination readiness and germinability of seeds were determined in accordance with GOST 13056.6–97 “Seeds of Trees and Bushes”. The results are shown in Tables 2 and 3. The test has shown that UV radiation at wavelength of (395–400) nm positively affects the seeds of Picea fennica increasing its quality degree from the 2nd to the 1st, and the developed UV irradiat-

a) *b)* *c)*

Fig 4. UV irradiating set: a – the seeds are ready for irradiation; b – UV diodes are switched on, in a moment the tray will be placed into the set; c – the seeds are being irradiated

ing set is energy-efficient and environment-friendly (mercury-free).

4. CONCLUSION

The energy-efficient environment-friendly UV irradiating set with UVI dose MSAC for pre-sowing treatment of seeds is developed.

The most efficient dose of UVI irradiation that increases the quality degree of seeds is found.

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