Chapter 8
Optimization of Spectral Composition and Energy Economy Effectiveness of Phyto-Irradiators With Use of Digital Technologies

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ABSTRACT

It is known that in the case of technology use of the supplementary lighting, an irradiation spectral composition heavily influences the effectiveness of the photosynthesis processes, development and productivity of vegetable crops. Hence, the definition of general points at development and projecting of modern phyto-irradiators is one of high-priority tasks in techniques development for plants growing in conditions of protected ground. The research is aimed at reviewing and assessing the effectiveness of existing sources of illumination used in modern systems of supplementary lighting and at deduction of general points of development and projecting of phyto-irradiators based on results of laboratory investigations with the use of modern digital technologies of monitoring and data analysis. The results of the comparative tests of light emitting diodes-based phyto-irradiators showed that the energy consumption per product kilogram is less than in the case of LED-irradiators. Based on the research results, general points were deducted for use at development of modern LED-phyto-irradiators.

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INTRODUCTION

First of all, a development of equipment and new techniques for vegetable crops cultivation in conditions of protected ground is oriented to reduction of operation costs and land productivity rise. In modern greenhouse facilities, an energy consumption decrease takes place mainly due to reduction of heat losses. With this purpose, constructions are used with limited indoor-outdoor air exchange; besides, systems are used with precise climate control.

Separately it is worth to consider systems of artificial illumination. It is well known that at use of the supplementary lighting technology, an irradiation spectral composition influences much the photosynthesis processes effectiveness and vegetable crops development and productivity (Tikhomirov et al., 2000; Vasiliev et al., 2017). Hence, the establishment of general points at modern phyto-irradiators development and projecting is one of high-priority problems in technologies development for plants growing in the conditions of protected ground.

Photo-synthetic apparatus of plants is a circumspect catalytic mechanism, action principle of which bases primarily on barriers overcoming of chemical transformations activation and photochemical reactions induction with use of radiant energy (Tyutereva et al., 2014). Now, the irradiation spectral composition influence on plants photo-synthetic apparatus functioning is well studied; that is why a special concern is attracted to researches aimed at study of non-photosynthetic pigments.

Studies conducted in the frame of non-photosynthetic pigments investigations show presence of a sophisticated photo-sensory mechanism at plants. Now, three major groups of photoreceptors are known: phytochromes, cryptochromes (phototropins), superchromes (photoreceptor UV-B) (Golovatskaya, 2005).

The photochromes (PHYA - PHYE) absorb long-wave part of the spectrum, i.e. red and far-red irradiation. Phototropins (PHOT1 - PHOT2) react on blue spectrum area. Cryptochromes (CRY1 - CRY5) show reaction on blue and ultraviolet irradiation. Superchromes (PHY3) absorb red and blue irradiation. As it turned out, photoreceptors allow triggering stress-defense mechanisms of plant photosynthetic apparatus under action of irradiation of high intensity. Also, they control processes of growth and development, blossom and vegetation periods (Golovatskaya, 2016; Chupackina et al., 2011).

BACKGROUND

The plants cultivation effectiveness at artificial illumination and influence of irradiation spectral composition on crops growth and productivity has been studied for quite long time. Being ones of the first in this area as early as in 1865, Russian scientists A.S. Famintsin and I.P. Borodin conducted systematic experiments on artificial illumination action on plants. As light source, petroleum-lamps acted. As object for watching, the water plant spirogyra was taken. In the course of the experiment, formation of starch was observed in chloroplasts.

In 1895 with use of voltaic arc, French botanist Bonnier sprouted seeds and rootstocks of herbs. In the same year by researcher F.W. Rane, first attempts were done of incandescent lamps use as artificial illumination for plants growing. In 1922, American scientist Harvey raised a plant based on completely artificial illumination. In USSR, this experiment was reproduced by Maximov with use of wolfram incandescent lamps.