Journal of Engineering and Applied Sciences 12 (Special Issue 1): 5740-5743, 2017
ISSN: 1816-949X

Improvement of the Irradiation Facilities Effectiveness

[1]Olga Yu. Kovalenko, [2]Svetlana A. Ovchukova and [1]Yuliya A. Pilshchikova
[1]Federal State Budget Educational Establishment of Higher Professional Education
"The Mordvinian State University named after N. P. Ogarev", Saransk, Russia
[2]Federal State Budget Educational Institution of Higher Professional Education,
"Mari State University", Yoshkar-Ola, Russia

Abstract: The study presents the upside potential for increasing the efficiency of lighting equipment, designed for irradiation of farm animals, poultry and plants. The ways of increasing the efficiency of irradiation facilities with the corresponding spectral composition, the radiation intensity curves, at the maximum values of the radiation sources effective efficiency, coefficient of performance and optimal arrangement of irradiators, the radiation flux adjustability are presented in the research, on the basis of fundamentally new approaches to the design of radiation sources and irradiation facilities, methods for monitoring and forecasting final products, according to the biological objects parameters.

Key words: Radiation sources, irradiation devices, irradiation facilities, efficiency, express analysis, parameters

INTRODUCTION

In accordance with the programs of agriculture development, the increase of agricultural production is facilitated by optical technologies. In optical technologies of agricultural production, Irradiation Facilities (IF) play the role of important technological factor. Irradiation facilities provide useful reactions of radiation receivers biological objects. Creation and introduction of effective radiation sources and irradiation facilities will allow to improve the quality and quantity of agricultural products as well as save the energy.

In the process of developing and creating the effective sources of radiation and irradiators, the researchers developed theoretical and practical approaches and research principles based on domestic and foreign experience of analysis and design of irradiation equipment, intended for irradiation of animals and plants.

MATERIALS AND METHODS

Main part: As a result of animal irradiation technologies, we proposed a new approach for providing more effective preventive irradiation of animals: extending the range of Ultraviolet (UV) radiation by adding to the spectrum of erythemic radiation with a wavelength of 280-320 nm and bactericidal radiation with a wavelength of 254 nm.

Experimental studies on irradiation of animals with the extended range, made it possible to formulate and to develop theoretical principles and approaches, implemented in the developed sources of radiation which are presented by Ovchukova (2001, 2006) and Kovalenko (2004).

Two irradiators, based on erythemal lamps, radiating into the lower hemisphere and germicidal lamps with a radiation flux, directed to the upper and lower hemispheres were developed, constructed and manufactured during 2004-2007.

The device described by Kostyuchenko *et al.* was differed by the use, except of the above lamps, sources of Infrared Radiation (IR) for heating young animals. The developed devices used the time-based application of various areas of the optical radiation spectrum in accordance with the spectrum of the bioobject relative spectral sensitivity.

RESULTS AND DISCUSSION

Experimental studies on the impact of combined irradiation on young cattle were conducted at the Mordovian State University (Saransk). Experimental samples of combined 6 lamp irradiators included 15 W ultraviolet lamps and 300 W infrared lamps. According to the principle of analog selecting, the experimental and control group were formed including 10-11 calves in each group. The radiation doses for each experimental group of

Corresponding Author: Svetlana A. Ovchukova, Federal State Budget Educational Institution of Higher Professional Education, "Mari State University", Yoshkar-Ola, Russia

calves in accordance with GOST R IEC 60335-2-27-2000 were the following: 152 J/m^2 for erythemic irradiation from lamps of the type LE-15 and 111 J/m^2 for erythemic irradiation due to the reflected radiation from lamps of the DBM-15 type to the lower hemisphere. The volume dose was 900 J/m^3 for bactericidal irradiation from lamps of the DBM-15 type. IR irradiation was from T30/CL 500 W lamps with irradiation directly under IR irradiator of 150 W/m^2. The control group was not irradiated. The experiment showed that weight gain of the calf for 20 days amounted to 10.56 kg for the control group and 11.67 kg for the experimental group; i.e., the weight gain of irradiated animals is 10.5% higher than that of non-irradiated animals. Studies were conducted against the backdrop of calve's dyspepsia. During the experiment, it was established that the duration of the dyspepsia is 1.4 times lower in the irradiated groups, than in the group of unirradiated animals. The obtained positive effect can be explained by the preventive and curative effect of combined radiation; the improvement of microclimate parameters due to infrared radiation; the decrease in microbial contamination due to the disinfecting effect of bactericidal radiation (Kovalenko *et al*., 2007).

Based on the results of experimental studies, the design of lamps with germicidal glass bulbs with erythemalumine-phosphor coating of a certain thickness, providing UF radiation with a wavelength of 280-320 and 254 nm was proposed (Kovalenko, 2008ab; Dadonov, 2008).

We considered the possibility of using the ultraviolet emitting diodes in irradiation facilities. For this purpose, the algorithms were proposed and calculations of modules with diodes with milliwatt UV radiation fluxes were carried out (Kovalenko, 2008ab). Calculations have been made, the design has been developed and the active model of the light device based on the LEDs with given light intensity curve has been developed (Kovalenko *et al*., 2007). In the next research, the results of the program realization of the module synthesis, according to the given light intensity curve were presented (Kovalenko, 2009a, b). The distribution of LEDs in the module is symmetrical, divisible by the number of sectors in each zone. This allows to ensure the manufacturability of such modules. The obtained results can be extended to a semiconducting irradiation device.

The constructive solutions, their use in irradiation lighting facilities and the study of their impact on farm animals with the aim of increasing the productivity are presented in the research by Kovalenko (2009a, b).

Studies on the improvement of low-pressure ultraviolet discharge lamps have been continued to obtain stable values of radiation fluxes for prototype models of lamps (Kovalenko, 2004).

For the purposes of irradiation in poultry farming, the irradiation facility was developed and tested on the basis of combined irradiator with erythematous, germicidal radiation sources and a replaceable LED module with blue-green or red LEDs (Kovalenko *et al*., 2007). The data obtained in the process of poultry experiment, indicated the stimulating effect of optical radiation from a combined IF on the physiological state and the productive quality of the youngsters of chickens parent flock (Pilshchikova, 2012).

In the course of the research, a mathematical description of the relative spectral sensitivity function of the poultry vision organs was presented, according to which the necessary radiation sources were estimated by the coefficient of radiation used by the chicken's organ of vision (Pilshchikova, 2012ab; Kovalenko, 2015, 2016a, b).

Production tests of the combined irradiation facility with erythematous, germicidal lamps and LED module, working together with the facility based on LB-40 discharge lamps, showed the effectiveness of the developed facility. Thus, in the process of the experiment with the young laying hens from the experimental group, there were obtained the following results: an increase in the livability of the poultry by 4% and increase in the yield of eggs by 9.8%, compared to the control (unirradiated) group (Kovalenko, 2016a, b). More complete results of the young hens research are presented in the research (Pilshchikova, 2014a, b).

Another direction is the research of the agricultural plants irradiation. It was carried out on the basis of the correspondence principle of the IF radiation spectral composition to a natural source of radiation the Sun. On the grounds of this principle, the lighting facility was theoretically developed on the basis of discharge lamps for pre-seeding treatment (Ivantsev, 1996). Subsequently, the lighting (irradiation) device was created based on LEDs of different color (Kovalenko *et al*., 2007; Boriskina, 2013). In the process of this direction development, special attention was paid to the mathematical description of the characteristics of lighting (irradiation) systems based on light-emitting diodes. For this purposes the software for calculation were created in the MATLAB R2012b (Afonin, 2014, 2016).

The question of replacement expediency of irradiators with the use of 400 W high pressure sodium vapor lamps on LED-irradiators, for irradiation of vegetables under glass was solved. Comparative calculations of the necessary number of irradiators of both species have been made while ensuring sufficient and uniform irradiation in the field of photosynthetic active radiation. The results of calculations show that irradiators with LEDs provide a 3.5 times lower power expenditures with a 1.3 times smaller number of irradiators in the same area (Ovchukova, 2012).

As a result of detailed analysis, it was found, that the principle of correspondence of the spectral composition of the IF radiation to the spectral sensitivity of the biological object was the most expedient. So to increase the yield of crop production, it is necessary to take into account the curves of photosynthesis, the form of which is not exactly established at the present time (Belov, 2014; Ovchukova, 2005).

For various biological objects, in the course of the theoretical analysis of the research results, the universal mathematical model was proposed for describing the dual curves of the bioobject spectral sensitivity, taking into account the concepts of the presence of two maxima, depending on the level of solar radiation in the corresponding frequency range (Mikayeva, 2008; Kovalenko, 2016a, b).

Deductions: At the heart of the source-bioobject system is the consideration of the coincidence rate of the integral and spectral characteristics of the given system components.

To increase the quantitative indicators of agricultural products and to save energy, it is necessary to solve the problem of ensuring the effective return of radiation sources and the efficiency of irradiators.

CONCLUSION

Thus, the basis for the creation of effective irradiators is the theory and practice of determining and applying the correspondence of spectral composition and radiation intensity curves of irradiators, at the maximum values of the effective radiation sources and the coefficient of performance of irradiators, the optimal location of irradiators in the facility and the possibility of radiation flux regulation.

REFERENCES

Afonin, V.V., 2014. Mathematical model for determining the colorimetric characteristics of the multicomponent LED system. Mod. Prob. Sci. Educ., 3: 46-53.

Afonin, V.V., 2016. Modeling the spectrum of solar radiation using light-emitting diodes. Photonics, 2: 72-77.

Belov, V.V., 2014. Estimated representation of photosynthesis. Bull. Intl. Acad. Agrar. Educ., 20: 7-10.

Boriskina, A.A., 2013. Light-emitting diode device of improved color rendition. Fundam. Res., 4: 1054-1058.

Dadonov, V.F., 2008. New possibilities of increasing the efficiency of erythemic lamps. Light Eng., 2: 43-44.

Ivantsev, A.M., 1996. Parameters of the lighting facility for pre-seeding treatment. Mechanization Electrif. Agric., 5: 1-15.

Kovalenko, O.Y., 2004. Irradiation of agricultural animals for increasing their productivity. Light Eng., 5: 1-20.

Kovalenko, O.Y., 2008b. Some aspects of improving of low-pressure ultraviolet discharge lamps for irradiation of animals. Bull. MEU., 4: 99-101.

Kovalenko, O.Y., 2008a. The derivation of the module with ultraviolet-emitting diodes for irradiation of animals. Mechanization Electrif. Agric., 12: 24-25.

Kovalenko, O.Y., 2009a. Lighting equipment for increasing the productivity of agricultural animals. Ph.D Thesis, Mordovian State University, Saransk, Russia.

Kovalenko, O.Y., 2009b. Software synthesis of the LED module. MSc Thesis, Mechanics and Energy Institute named after VP Goryachkina, Moscow, Russia.

Kovalenko, O.Y., 2015. Assessment of the efficiency of radiation sources for poultry farming. World Sci. Innov., 3: 54-57.

Kovalenko, O.Y., 2016a. Lighting facility with radiation in UV and visible spectral ranges for poultry. Photonics, 5: 102-111.

Kovalenko, O.Y., 2016b. The impact of radiation source parameters on the bioobject. Bull. Intl. Acad. Agrar. Educ., 30: 122-127.

Kovalenko, O.Y., A.A. Ashryatov, L.P. Avtoshina, P.A. Sarychev and O.V. Pivkin, 2007. Combined irradiation of young cattle animals. Mechanization Electrif. Agric., 9: 19-21.

Mikayeva, S.A., 2008. Fundamentals of the optical radiation impact on the bioobject. Eng. Phys., 2: 43-48.

Ovchukova, S.A., 2001. Application of optical radiation in agricultural production. Ph.D Thesis, Moscow State Agroengineering University, Moscow, Russia.

Ovchukova, S.A., 2005. New approach to the question of the impact of optical radiation on plants. Nat. Tech. Sci., 5: 121-125.

Ovchukova, S.A., 2006. Increasing the efficiency of optical radiation in agricultural production. Mechanization Electrif. Agric., 4: 18-20.

Ovchukova, S.A., 2012. Expediency of using LED irradiators in greenhouses. Bull. Intl. Acad. Agrar. Educ., 1: 27-30.

Pilshchikova, Y.A., 2012. Influence of combined radiation on young poultry. Master Thesis, Mechanics and Energy Institute named after VP Goryachkina, Moscow, Russia.

Pilshchikova, Y.A., 2014a. Increasing the efficiency of the irradiation facility. Ph.D Thesis, Saransk Cooperative Institute, Saransk, Russia.

Pilshchikova, Y.A., 2014b. Modeling of the relative spectral sensitivity of the biological object's organs of vision for evaluation of the radiation sources effectiveness. Mod. Prob. Sci. Educ., 4: 183-191.