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CLASSIFICATION OF AGRO-ELECTROTECHNOLOGY FOR GROWING ECOLOGICALLY CLEAN, DISEASE AND PEST-RESISTANT POTATOES USING ELECTROTECHNOLOGICAL EFFECTS

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Abstract

This article reveals the relevance of the production of protected soil products in Uzbekistan, experimental studies that showed the peculiarities of the mutual influence of microclimate parameters. Mathematical modeling of the temperature field of protected ground structures was carried out. The relevance of using an improved algorithm for controlling electrical equipment in protected ground as substantiated.

Keywords: Hot Water Supply, Emergency Discharge Control, Protected Soil, Mathematical Model, Meristem potatoes, microclimate, Photosynthetically Active Radiation (PAR).

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Original Article

INTRODUCTION

Potatoes are the “second bread” in our country. Usually it is propagated by tubers, but it is impossible to quickly increase the planting area, since potatoes are often affected by viral, bacterial and fungal diseases, which significantly reduces its productivity. Currently, the only way to rid potato planting material of viruses is its meristem cultivation, which also makes it possible to significantly reduce the time of reproduction of uninfected plants.

MATERIALS AND METHODS

The goal of the work is to increase the efficiency of light-emitting diode (LED) phytoinstallations for meristematic potatoes through scientific substantiation of the most effective doses of spectral components of the PAR zone, allowing to increase the yield of healthy elite planting material - meristematic potatoes and reduce energy consumption.

K. A. Timiryazev emphasized that the most important task of plant physiology is to find ways to “grow two ears where one grows.” Up to 95% of the crop yield is formed due to the absorbed PAR energy. For meristem potatoes, high yields are obtained with rapid development of the leaf surface at the beginning of the growing season.

RESULTS AND DISCUSSION

Biologists believe that a crop brought to our country from other regions of the globe retains a genetic memory of the climate conditions and the place of its primary growth. Potatoes were first cultivated in the countries of Peru, Ecuador, and Bolivia. In protected soil conditions, all microclimate parameters can be adjusted. Therefore, we studied only the effect of PAR zone doses on potato productivity. For comparison, we chose Tashkent. The analysis showed that in equatorial countries, where up to 4 potato harvests are obtained, radiation doses practically do not change throughout the year, while at the latitude of Tashkent they change during each month (Tables 1, 2, 3) [1, p. 23; 3, p. 252].

Table 1: Comparison of The Average Dose of Spectral Components of Solar Radiation in The PAR Zone for The Month of March

For April	Region	Radiation Dose						Total	Note
		Violet	Blue	Green	Yellow	Red	UFI		
Conventional Units	Tashkent	82	197,5	209	298,5	423,5	79,5	1 260	
	Peru	132	265	205,8	340,5	463	110,5	1 516,8	For 100%
%	Tashkent	5%	13%	14%	18%	28%	5%	83%	
	Peru	9%	17%	14%	22%	31%	7%	100%	

Table 2: Comparison of The Average Dose of Spectral Components of Solar Radiation in The PAR Zone for The Month of April

For April	Region	Radiation Dose						Total	Note
		Violet	Blue	Green	Yellow	Red	UFI		
Conventional Units	Tashkent	103	223	288	272,5	456,5	78,5	1 421	
	Peru	130,5	251,9	279,5	340	450	106	1 558,4	For 100%
%	Tashkent	7%	14%	18%	17%	29%	5%	91%	
	Peru	8%	16%	18%	22%	29%	7%	100%	

Table 3: Comparison of The Average Dose of Spectral Components of Solar Radiation in The PAR Zone for The Month of May

For May	Region	Radiation Dose						Total	Note
		Violet	Blue	Green	Yellow	Red	UFI		
Conventional Units	Tashkent	130	262,5	266,5	352,5	493,5	95,5	1 600,5	
	Peru	133,5	238	284	326	443	102	1 526,5	For 100%
%	Tashkent	9%	17%	17%	23%	32%	6%	105%	
	Peru	9%	16%	19%	21%	29%	7%	100%	

To simulate the spectral composition of equatorial countries, we propose an LED phytoinstallation using a PLC to provide meristem plants with the required doses. The developed PLC-based LED installation control systems make it possible to simulate the spectral composition of radiation for any area during the day and for the required months [2, p. 24; 4, p. 104].

Table 4: Study of The Influence of Doses of the Spectral Composition of Radiation from Phyto Installations On the Development of Meristematic Potatoes

Parameter	Scheme Peru	Scheme Tashkent	LB 80 (Control)
Actual operating time of the irradiation installation, h	2 080	2 240	2 400
Electricity consumption,%	87	93	100
Change in leaf area, %	126	116	100
Specific energy costs, %	43,5	48,2	100

Calculations have shown that the use of the proposed LED phytoinstallation with an imitation of the Peruvian spectrum makes it possible to reduce the readiness time of meristem potato plants by 4 days and thereby obtain approximately 15% more plants per year compared to the control. The expected economic effect is about 76 thousand rubles, the income from saved electricity is 148 thousand rubles, with a payback period of about 4 years [5, p. 52].

One of the main parameters of the microclimate in protected ground is temperature, which is maintained in the required ranges by controlling the intensity of water and air heating, the position of ventilation transoms, curtaining the energy-saving screen, and turning on circulation fans. Maintaining the set air temperature in greenhouses is achieved by coordinated control of the coolant temperature in several heating circuits.

Modern structures of protected soil can be represented as a body of finite dimensions of a regular geometric shape, formed by the mutual intersection of unlimited plates (Figure 1).

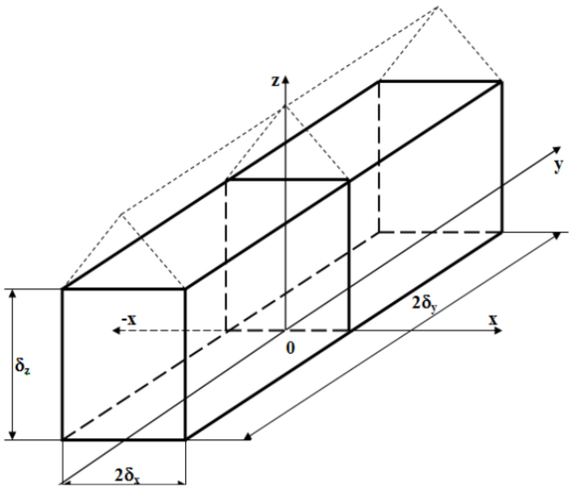

Figure 1: Construction of Protected Soil in The Form of a Body of Finite Dimensions

In most modern greenhouses, the ridge is separated from the main volume by a curtain mechanism (an energy-saving screen), which reduces heat loss in winter and protects plants from excess solar radiation in summer. Therefore, the greenhouse can be taken as a parallelepiped of finite geometric dimensions, having coordinates along the x, y, z axes [4, p. 7].

Let us move from dimensionless values of the temperature field to specific temperature values at any point in the working volume of the protected soil.

Considering that, we get $\overline{\Theta} = \overline{\Theta}_x \cdot \overline{\Theta}_y \cdot \overline{\Theta}_z$

$$t = t_д - \left[\frac{4}{\pi} \cdot \cos\left(\frac{\pi}{2} \cdot \bar{x}\right) \cdot e^{-\frac{\pi^2}{4} \cdot F_0}\right] \cdot \left[\frac{4}{\pi} \cdot \cos\left(\frac{\pi}{2} \cdot \bar{y}\right) \cdot e^{-\frac{\pi^2}{4} \cdot F_0}\right] \cdot \left[\frac{2 \cdot z}{l} - \frac{4 \cdot z \cdot a \cdot \alpha \cdot \tau}{l \cdot \lambda_w \cdot z} \cdot e^{-\frac{1}{4 \cdot F_0}}\right] \cdot (t_д - t_{нв})$$

Having carried out a series of mathematical transformations and converting the relative values $\overline{x} = \frac{x}{\delta}$ and $\overline{y} = \frac{y}{l}$ real bз we get:

$$t = t_д - \left[\frac{16}{\pi^2} \cdot \cos\left(\frac{\pi \cdot x}{2 \cdot \delta}\right) \cdot \cos\left(\frac{\pi \cdot y}{2 \cdot l}\right) \cdot e^{-\frac{\pi^2}{2} \cdot F_0}\right] \cdot \left[\frac{2 \cdot z}{l} - \frac{4 \cdot a \cdot \alpha \cdot \tau}{\lambda_w \cdot l} \cdot e^{-\frac{1}{4 \cdot F_0}}\right] \cdot (t_д - t_{нв})$$

where l, δ', z are the length, width and height of the greenhouse, respectively, m.

A control system using the model described by the expression allows

- Take into account the air temperature at any point in the working volume of the protected soil, receiving data from temperature sensors installed at certain points and in the geometric center of the greenhouse td;
- Close or open the energy-saving screen if necessary;
- Turn on circulation fans to blow warm air onto the glass roof of the greenhouse in order to remove excessive snow cover on the ridges, which reduces the illumination of plants below the permissible level.

In this case, the electrical equipment operates in an interconnected mode, taking into account natural light and other microclimate parameters in the greenhouse, which leads to savings in energy costs.

The conducted research allows us to draw the following conclusions:

1. The mathematical model makes it possible to determine with a high degree of accuracy the temperature in the working volume of a protected soil structure within the limits of a relative experimental error not exceeding 5%. The mathematical model can be considered adequate, since temperature calculations from it and temperature readings measured using instruments have a stable correlation within 95%.

2. The patterns of mutual influence of microclimate parameters in protected soil showed the following results. An increase in natural irradiation by 2 klx causes an increase in temperature of 2.5 ºC. An increase in temperature of 1 ºC reduces humidity by 2%. The concentration of carbon dioxide in protected soil also depends on the level of natural irradiation. When the latter is in the range from 1 to 2 klx, the CO2 concentration is 0.007%; a further increase in irradiance leads to a decrease in the CO2 concentration to 0.005%.

3. The operating algorithm of electrical equipment for maintaining the microclimate in protected ground structures with a usable area of 15,000 m2 makes it possible to reduce thermal energy consumption by 10% by consistently taking into account the mutual influence of the four main microclimate parameters. The algorithm provides for the input of marginal zones of microclimate parameters and the possibility of using the same equipment for different crops.

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When heating premises, one of the most effective ways to save energy is to save thermal energy at its final consumption facilities. This is possible by regulating the heat load by an automatic control system (ACP) in accordance with the outside air temperature.

The automatic energy saving system includes a programmable logic controller (PLC), which receives information from coolant temperature sensors in pipelines, air temperature sensors in the control room and outdoor air temperature. Based on sensor information and selected settings, the PLC regulates the coolant flow in the pipeline by sending a signal to the resistive position sensor of the shut-off and control valve (SVR) and thereby controlling its drive. Such an energy saving system leads to the use of modern automation equipment, which leads to quite high costs. Today, the use of standard automation resources that ensure sufficient quality of regulation and the lowest investment remains relevant [14, p. 10].

When the installation is operating, the control unit compares the current optical density of the aqueous medium, obtained as a result of processing signals coming from optoelectronic sensors, and the reference optical density of the controlled liquid. If the optical density of the medium does not exceed the permissible threshold value, the first valve is open and the second valve is closed. In this case, the water, passing through the purification filter, enters the reservoir.

In the event of an emergency reset at the control object, the current value of the optical density exceeds the permissible value, and control signals are sent from the control unit to close the first valve and open the second valve. As a result, the pollutant, together with the water, enters through the outlet into the settling tank for further disposal and does not pass to the purification filter and further into the environment. After the end of the emergency reset, the reference value of the current optical density of the controlled medium is restored, and the valves return to their normal position.

The performance of the installation (assessment of sensitivity and determination of the response threshold) was tested on emulsion samples containing 30, 40, 60 and 70% sunflower oil.

CONCLUSIONS

Thus, the considered installation makes it possible to determine the discharge of pollutants and direct it to a settling tank, which reduces the likelihood of damage to the filtration system and contamination of water sources, and also extends the service life of cleaning filters. The developed automatic installation using optical methods for monitoring the properties of the aquatic environment has great promise in connection with the development of modern optoelectronics and laser technologies. An industrial prototype of the installation can find application in solving problems of environmental monitoring in the oil and gas and agro-industrial complexes, in the chemical, light, and processing industries [2, p. 6; 3, p. 139].

Thus, the research and development of scientists from the Department of Automated Electric Drives on the scientific substantiation and use of advanced electrical technologies and electrical equipment in protected soil, on controlling the temperature of hot water supply at agricultural enterprises, on solving environmental problems for the prompt identification and elimination of emergency Discharges from industrial and agricultural wastewater systems undoubtedly contribute to the requirements.

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