Accelerating growth and development of green crops and seedlings due to electrical stimulation of plants

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Abstract. Artificial irradiation in protected ground structures is used for growing seedlings and for breeding purposes. Despite the increase in the cost of seedlings, additional lighting is effective, since it increases the yield by 20 ... 30% and accelerates its production by 10 ... 15 days [1]. Electrostimulation of plants of this development is carried out by intensifying plant growth by creating an optimal spectrum and regulating lighting depending on the actual natural illumination, automatic spectrum control for various plants, and irrigation system. The effectiveness of the development is to improve the useful properties of plants, reduce the cost of caring for them, which allows you to engage in a family business. The disadvantage of this installation is the need for high labor costs due to growing plants without taking into account the objective need for timely watering with foliar spray with a nutrient solution or timely feeding of the nutrient solution directly into the ground, depending on the soil moisture. In addition, the method does not provide for the cultivation of tomato seedlings in the presence of objective control of insufficient illumination in winter, requiring additional illumination for the required period of time with a certain duration for the effectiveness of the process.

1. Introduction

To date, priorities have been identified to provide the country's population with food. First of all, this is due to the departure from the long-term vicious practice of the Soviet era, in which the provision was carried out by some analogy of barter, in which the economic interstate relations of the USSR and Western European countries were carried out on the principle of exchanging raw oil and gas from Russia for food and engineering products from Europe. At the same time, our country was essentially losing its independence and was on the proverbial raw material needle [1-8].

Being in the grip of this vicious practice, and despite all the efforts, the country went deeper into the problem of reducing the availability of agricultural products.

In recent years, after the collapse of the Union due to the deterioration of relations with the EU countries, the Government of the Russian Federation has developed and adopted measures for the development of agriculture and agricultural engineering, along with the activation of the development of individual production in the direction of vegetable growing, gardening, in the form of personal farms, which has ensured the growth of gross agricultural production to the level of 70% in general across the entire spectrum of agricultural production and taking into account all forms of ownership, including individual producers, this made it possible to achieve self-sufficiency in both food products and saturation of the market (including foreign ones for individual products).
Along with the development of traditional technologies of field and farm production, in recent years, planting of green crops and seedlings at home (growing on windowsills) in the autumn-winter period has been widely developed [9].

As in all cases of agricultural field production, which base on the use of scientifically based technologies for the cultivation of agricultural crops, the cultivation of green crops and orchards is also based on the use of scientifically based recommendations. At the same time, it is necessary to keep in mind the presence of specific features when choosing technologies. In particular, the lack of illumination requires a certain electrical stimulation of plants, the need for regular irrigation due to the intense evaporation of moisture from the surface of the soil cover requires the use of special irrigation technologies. Certain weather conditions lead to changes in solar radiation, spectral composition and duration of illumination during the day and night, since the photosynthetic activity of plants depends on this. In the Pskov region, for example, in December-February, the usual solar radiation of 110-120 cal / cm² requires additional illumination by artificial means, especially in winter, although often energy-intensive [2].

The aim of the study is to intensify the growth and development of green crops and seedlings by optimizing the photosynthetic activity of solar radiation by artificial lighting in different periods of the day, and to control the irrigation technology taking into account the features of the developing root system.

The objectives of the study are to determine the optimal design and technological parameters and operating modes of the plant to reduce the maturation period and increase productivity by optimizing the illumination and automation of the irrigation system, taking into account the location of the root system and soil moisture.

2. Materials and methods
The object of the study is the results of electrical stimulation of the vital activity of green plants and seedlings, as well as other types of vegetable crops cultivated on the windowsills of residential premises. The research carrier out based on a mathematical analysis of the working processes of machines and their elements used to implement the research tasks accepted for development.

3. Results
At the Department of "Mechanization of Animal Husbandry and the Use of electric Energy in Agriculture" of the Velikiye Luki State Agricultural Academy, an installation for electrical stimulation was developed [3-4].

The system in a complex image, including an electrical device and an agro technical device for the cultivation of seedlings (and open or closed ground plantings) with elements of automation of technological processes, shown in figure 1.

The system of irrigation and additional illumination of seedlings (and ground plantings) works as follows.

Moistening of the soil (peat-sawdust substrate or other components) carries out by means of spray irrigation or irrigation directly into the root system of seedlings or soil plantings of tomatoes, the nutrient solution for which is supplied through distribution pipelines 13 and 14.

The humidity sensor 2 continuously sends a signal in the form of a voltage level to the analog input of the microcontroller 3. The voltage of this signal is proportional to the humidity recorded by the humidity sensor 2. When the soil moisture decreases (below a certain level), the voltage at the sensor output reaches a value at which the micro-controller 3 sends a signal to the base of the transistor that is part of the switching element. The transistor 5 opens, as a result of which it supplies current to the winding of the electromagnetic relay 4. The relay is triggered and its contacts close the power supply circuit of the contactor winding 7, as a result of which the contactor 8 is triggered and its contacts 9 closes the power supply circuit of the electric motor 10. The electric motor 10 drives the pump 11 and the soil moistener. The humidity increases, and when the required humidity level reached, the system turns off the power from the pump drive motor. The supply of the hydrating nutrient solution stopped.
The program embedded in the micro-controller 3 determines the irrigation rate.
Manually controlled valves 15 carry out the direction of the feed of the nutrient solution.
The lifting (lowering) of the boards carried out by a scissor-type mechanism 19, installed between the plastic pallets 16, as the plants grow, and carried out by a manual screw mechanism 20.
Lighting carried out by means of a device with LED linear aluminum multi-row lamps 17 and 18, each row of which automatically turns on depending on the current natural illumination of the plants.
The spectral composition of the light calculated for the additional illumination of plants with their changing biological state [5]. The system of supplementary lighting is switched on (turned off) by the microcontroller 3, which delivers information in the form of a signal switching element, resulting in a strict sequence of groups of led lamps 21, including the necessary exposure duration.
Seeds of dill "Bushy", lettuce "Odessa curly" and parsley "Italian giant «were chosen as seedlings. Dry seeds sown with a pinch thickly in the moistened soil "Microparnik" (5l), which contains an acidity of 6-7 pH, 150-250 mg/kg of nitrogen, 300-400mg/kg of water-soluble phosphorus and 350-450 mg/kg of water-soluble potassium.
The selected seedlings need at least 6 hours of daylight. In spring or autumn, it is enough to put pallets with crops on the most illuminated window, and in winter, additional lighting is already needed [5]. The developed plant electrical stimulation system will make up for the lack of sunlight.
The time to bring the system for additional illumination into working condition after connecting to the power supply network is not more than 10 seconds. The service life of the device is not less than 25,000 hours.
The device turned on when seedlings formed. The pallet placement distance is 0.6 m. The maximum height of the lamp with cold light is up to half a meter.
During the experimental studies, a certain light regime was observed and the spectral composition of light was changed, while the transition to a particular wavelength was carried out by switching a number of LEDs independently by turning them on [5-7].
The electrical parameters of the plant (illumination), as well as the parameters of seedlings (weight, growth) measured using the appropriate devices: LightMeterCEMDT– 1301 luxmeter, electronic scale Gomestarhs-3008, MOZHGA ruler, watering can.

4. Discussion
When the necessary growth and development achieved, 43 days after planting, they are cut, and then weighed (table 1).

| The name of the seedling | Height, cm | Average value by height, cm | Weight, g | Average value by weight, g | Total, g |
|-------------------------|------------|-----------------------------|-----------|--------------------------|---------|
| Salad "Odessa"          | 6.0-9.0    | 7.5                         | 3.0-5.0   | 4.3                      | 86.0    |
| Kucheryavets"           | 6.0-8.0    | 7                           | 1.0-3.0   | 2.1                      | 81.0    |
| Dill "Bushy"            | 1.0-6.0    | 3.5                         | 0.5-3.0   | 1.3                      | 48.0    |

At the first stage of the experiment (up to the middle), there is a slow growth of seedlings: the maximum growth reached 3 cm, and at the second stage (from the middle) to the end of the experimental studies - a relatively sharp increase: from 3.8 to 9 cm, which is 1.5 times higher than the initial growth, at the final stage, the plants are cut figure 2.

\[ \text{Figure 2. Plot of the dependence of the growth of seedlings under constant LED irradiation.} \]

At the second stage of development, plants react to additional illumination with greater intensity. This is due to the intensification of cellular development, in which there is a receipt and accumulation of biological mass, including trace elements, vitamins, carbohydrate mass, coarse fiber structure (fiber). On the basis of this analysis, it is advisable to establish the cut-off period of the stems.

5. Conclusion
Thus, the following conclusions can be drawn:

- On the basis of the completed work on the development of the design and technological scheme of the plant for electrostimulation of plant life, including seedlings, the following provisions can be noted
- The relevance of the problem for the Pskov region is determined and justified; the analysis is carried out and the list of necessary equipment for the development of an installation for electrical stimulation of plants is made;
- An electrical circuit has been developed for the complete volumetric cultivation of plants, taking into account the regulation of the illumination of seedlings, additional illumination of seedlings and automated watering;
• A simplified version of the installation for electrostimulation of plant life at home is made;
• The analysis carried out and the effectiveness of the performed studies for electrostimulation of plants based on the state of greens (dill, parsley, lettuce) in the process of electrostimulation of their vital activity was determined.

References
[1] Shilin V A, Gerasimova O A, Morozov V V and Shakhov V A 2019 Device for additional illumination of seedlings in mass production. Proceedings of the Orenburg State Agrarian University 1 45232
[2] Baranov L A and Zakharov V A 2013 Light engineering and electrotechnology (Moscow: KolosS) 344
[3] Shilin V A, Gerasimova O A, Solov'ev S V, Egorov M Yu and Maksimov G V 2019 Device for additional illumination of seedlings: utility model patent 193513 Ros Federation: IPC A01G9. Applicant and patent holder of the Velikiye Luki State Agricultural Academy 103412 07022019
[4] Tikhomirov A A, Lisovsky G M and Sidko F Ya 1991 Spectral composition of light and plant productivity (Novosibirsk: Nauka) 168
[5] Rakutko S A, Markova A E, Mishanov A P and Rakutko E N 2016 Energoekologiya svetokultury – novoje mezhdistsiplinarnoe nauchnoe napravlenie Energy ecology of light culture-a new interdisciplinary scientific direction 90 423
[6] Kulikova E G and Kuznetsova A M 2019 Assessment of the impact of light sources for growing plants of the nightshade family. Sursky vestnik 3 321
[7] Yuferev L, Sokolov A and Yufereva A 2014 - Resonant LED lighting system for closed ground Semiconductor lighting engineering 28 422
[8] State Program of the Russian Federation for the Development of agriculture and regulation of agricultural products, raw materials and food markets for 2013 (Moscow) 20
[9] Karpov V N 1999 Introduction to energy saving (St Petersburg: Piter) 120
[10] Kulas A A 2003 Ways to increase the shelf life of milk. Processing of milk 8 4223