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MODELING OF THE THERMAL REGIME IN THE CONDITIONS OF THE MANAGED AGROSYSTEM

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ABSTRACT

The aim of the study is to develop a resource-efficient irrigation technology for growing tomato plants under managed agrosystems. Objectives of the study: To assess the impact of MAS indicators (duration of light, greenhouse depth, seedling thickness, day and night temperature difference, soil salinity, irrigation rate) on tomato crop yields and conduct a national experiment; Development of irrigation regime for tomato plant in MAS conditions; Modeling of heat regime, moisture, micronutrient and fertilizer consumption in tomato plant cultivation under MAS conditions.

KEYWORDS: ***Managed agrosystem (MAS), recirculation, substrate, peat, construction, energy, chronological direction, differential function,***

INTRODUCTION

Water resources play an important role in the organization of food security in the world and in the development of agriculture. In particular, during the years of water scarcity, special attention is paid to the cultivation of more agricultural products on irrigated lands. In this regard, managed agrosystems (MAS) are characterized by consistently high yields as well as low water consumption. According to the FAO, the MAS area has now increased by 32.3% over the past five years and stands at 523,000 hectares. MAS areas are expected to grow by 8-11% per year and occupy 830-900 thousand hectares in 2030 [13,14].

Conferences dedicated to the sustainable development of agriculture in the world focus on improving the management of water resources in the context of MAS, the rational use of available land and water resources through the development of optimal irrigation, climate, fracture conditions. At the same time, the development of a science-based resource-efficient irrigation technology framework that provides sustainable high yields in MAS conditions with low water and material resources is a pressing issue. One of the important tasks in the study is to develop a technological basis for resource-efficient irrigation for MAS in Kibray district of Tashkent region and Kurgantepa district of Andijan region [21].

Section 3.3 of the Action Strategy for the five priority areas of development of the Republic of Uzbekistan clearly defines the work to be done on "Modernization and accelerated development of agriculture." According to him, special attention is paid to the consistent development of agricultural production, further strengthening the country's food security, expanding the production of environmentally friendly products, significantly increasing the export potential of the agricultural sector [12].

The dissertation research was approved by the President of the Republic of Uzbekistan on November 20, 2018 No. PK-4020 "On measures to create additional conditions for the development of greenhouse complexes" and March 20, 2019 No. PK-4246 "On measures for further development of horticulture and greenhouses in the Republic of Uzbekistan." [10,11], as well as other normative legal acts related to this activity.

RESEARCH METHODS

The research used the methodology of field experiments on the implementation of vegetable crops in the conditions of MAS, as well as methods of mathematical modeling, empirical generalization and mathematical statistics.

LITERATURE REVIEW

Growing vegetables is a topical issue in remote areas of the country, even in rural areas, even in the cold days of winter. It requires the production of high-quality plant products for consumption, low in heavy metals, nitrates and many other harmful substances. In the conditions of MAS, the production of environmentally friendly products using new technologies that save energy resources in soils remains an urgent task. [22].

It is possible to reduce the negative impact of crop production on the environment in protected soils, increase production efficiency by improving plant cultivation technologies using artificial light sources. In this case, it can be used in MAS to produce environmentally friendly products throughout the year [24].

This requires the analysis and results of scientific developments in the field of air temperature, soil salinity, location of seedlings, irrigation rates, duration of light in protected areas, which are potentially productive, economically viable, designed for year-round cultivation of vegetable crops in MAS conditions.

- The effect of artificial lighting devices on soil fertility, nutrient solutions to create favorable conditions for root growth environment and root consumption, increase productivity;
- To study the effect of light and temperature on MAS conditions in the cultivation of tomato plants and increase its productivity;
- The effectiveness of the use of vegetative devices to increase crop yields of artificial light for tomato plants;
- Selection of the most productive and disease-resistant varieties and hybrids for cultivation in MAS conditions [22,24,25].

The purpose of applying the results of the analysis is to achieve economic efficiency by using the technology of continuous, year-round cultivation of the product, saving energy and resources for the cultivation of tomato plants.

In hydroponics, the plant root system is located in special pots and is distinguished by the absence of substrate. In the saturation of plant roots, it provides at the expense of nutrient solutions that are in constant motion through the process of aeration and recirculation. In this Case, the solution on the container must be periodically renewed. When the pump is switched off, the plants can be supplied with the solution at the bottom of the container for only a few days [9,22,25].

Ionitoponics is cultivation on a substrate consisting of a mixture of two synthetic resins. It has not been widely used due to the high cost of ionized substrate [23].

In aeroponic cultivation, the plant is hardened to the stem and the root system is placed in a closed space. The nutrient solution is fed continuously to the roots. The application of these technologies requires the construction of a fully automated system. Therefore, this method is not widespread due to its relatively low reliability and technological difficulties in implementation [23,25].

Aggregate topology is the best developed and most common method of growing plants using soil substitutes. In this Case, mineral and synthetic substrates do not produce enough SO2, plants face a shortage of carbon dioxide during intensive cultivation, so when using the method of aggregation, additional equipment is required to feed plants with carbon dioxide (SO2) [23,25].

In the root-growing environment (IO'M) of hemoponics technology is used substrate organic materials - tree bark, peat (moss), wood shavings and peat with a high surface permeability. Years of use of the peat layer have shown that effective performance has been observed for 3 years from the year of use. Before the start of the growing season of the fourth year, the addition of fresh peat in the amount of 15-20% of the total peat volume does not lead to water retention in the upper peat layer for another 3 years and deterioration of aeration processes in the layer [23,25].

ANALYSIS AND RESULTS

Modeling and calculation of energy consumption of greenhouses of various designs.

$$q_{исс.ман}(t)+\sum_{i=1}^{N} q_{исс.ўз}(t)=q_{исс.таш}(t)+\sum_{i=1}^{N} q_{эн.ч}(t) \qquad (1)$$

Here: $q_{исс.ман}$ (т) – heat from a heat source, $q_{исс.ўз}$ (т) – greenhouse construction to absorb solar energy; $q_{шам}$ (т) – energy consumption due to ventilation; $q_{эн.ч}$ (т) – energy dissipation from greenhouse construction,

Here: $\sum^{Аж}{}_{ин} q(t)_{ин}$ – the amount of heat accumulated by the structural elements of the greenhouse; $\sum^{Аж}{}_{оут} q(t)_{оут}$ – the amount of heat consumed by the structural elements of the greenhouse; $Q^{pump}(t)$ – heating the greenhouse in the furnace mode; $Q^{\mathrm{int}\,ake}(t)$ – heat loss in the greenhouse.

The heat balance equation in a greenhouse. Уравнение теплового баланса в теплице

$$\frac{dQ}{dt}=\frac{kVdT_{исс}}{dt}=\sum_{i=1}^{n}q_{кир}+\sum_{i=1}^{n}q_{чик}\ , \qquad (2)$$

Here: Q– amount of heat in the greenhouse, количество тепла в теплице, Дж; T– greenhouse temperature, температура теплицы, К; В– greenhouse size, $м^3$; $q_{кир}$, $q_{чик}$, - heat inflow and outflow to the greenhouse, (Dj/s)

Heat balance equation for greenhouse air:

$$\frac{dQ}{dt}=q_{кир}+q_{чик}-q_{йук} \qquad (3)$$

Here: $q_{йук}$ - heat loss in the greenhouse, (Dj/s).

In other words, the air temperature in the greenhouse depends on the amount of energy absorbed, released and lost, ie:

$$T_{исс}=f(Q) \qquad (4)$$

Equation of heat flow through a conducting system (general form of the equation. (4.1.3,4.1.5)):

$$Q_{кир}+Q_{чик}=\lambda(T_{исс}-T_{таш}) \qquad (5)$$

Boundary conditions.

$$T_{таш}=\theta(t) \qquad (6)$$

$$T_{исс}\Big|_{t=0}=\overline{T}_{исс} \qquad (7)$$

Here: $T_{исс}$ – greenhouse temperature, К; $T_{таш}$ – ambient temperature, К; $\lambda(T_{исс}-T_{таш})$ - function linking the difference in air temperature indoors and outdoors; $T_{таш}=\theta(t)$ - preset dynamics of outside air temperature, К; $Q\Big|_{t=0}=Q_0$ - the given internal energy of the air in the greenhouse, Dj.

In constructing this simplest model, it was assumed that there were no inertial forces in heating the structural elements of the greenhouse. Although the function that associates temperature drop with heat consumption in a greenhouse is a very complex empirical function (various authors describe this function in different ways), its main feature is that zero heat consumption is maintained at constant temperature. In MAS, the temperature is variable, decreases with decreasing external temperature, and increases sharply with increasing. This means that with a small change in pressure in the system (4.1.4) the complex function can be approximated by a linear function [1,5,6,7]

$$q_{кир}+q_{чик}=\xi(T_{исс}-T_{таш}) \qquad (8)$$

Suppose that the shape of the greenhouse is of constant length, then

$$T_{исс}=f(Q) \quad \text{converted to конвертировано в} \quad T_{исс}=\frac{q}{V_{исс}}+T_{таш} \qquad (9)$$

Here; $B_{исс}$ – greenhouse size, $м^3$.

Let us rewrite the equations of the model and then solve them analytically, provided that the boundary condition (chronological direction of the ambient temperature) is set by a sinusoid (differential function). The method of solving this type of equation is known:

$$\frac{kVdT_{исс}}{dt}=\lambda(T_{исс}-T_{таш}) \qquad (10)$$

$$T_{таш}=\Psi\cdot\sin(\omega t) \qquad (11)$$

In the form of a single equation, the system has the following form:

$$kV\frac{dT_{исс}}{dt}=\lambda(T_{исс}-\Psi\cdot\sin(\omega t)) \qquad (12)$$

We are looking for a solution in the form of two functions

$$T_{исс}=(\upsilon\cdot\nu) \qquad (13)$$

next

$$\frac{d(\upsilon\cdot\nu)}{dt}=\upsilon\cdot\frac{d(\nu)}{dt}+\nu\frac{d(\upsilon)}{dt} \qquad (14)$$

$$kV\left[\upsilon\frac{d(\nu)}{dt}+\nu\frac{d(\upsilon)}{dt}\right]=\lambda\left[\upsilon\nu-\Psi\cdot\sin(\omega t)\right] \tag{15}$$

$$\upsilon\left[kV\frac{d(\nu)}{dt}-\lambda\nu\right]=-\lambda\Psi\cdot\sin(\omega t)-kV\nu\frac{d(\upsilon)}{dt} \tag{16}$$

ν Select the function, then:

$$kV\frac{d(\nu)}{dt}-\lambda\nu=0 \tag{17}$$

We differentiate according to the parts and find the solution as follows:

$$\nu=C_1\cdot e^{\frac{\lambda}{kV}\cdot t} \tag{18}$$

We get an arbitrary solution on a bit that corresponds to the state of integration constant.

$C_1=1$ Ва $\nu\neq 0$.

$$\lambda\Psi\cdot\sin(\omega t)=-kVe^{\frac{\lambda}{kV}\cdot t}\frac{d(\upsilon)}{dt} \tag{19}$$

$$\upsilon=-\lambda\Psi kV\int\sin\omega t\cdot e^{-\frac{\lambda}{kV}\cdot t}dt+C_2 \tag{20}$$

or finally,

$$\upsilon=\lambda\Psi kV\left[\frac{kV}{\lambda}\cdot e^{-\frac{\lambda}{kV}\cdot t}\sin\omega t-\frac{kV\omega}{\lambda}\cdot e^{-\frac{\lambda}{kV}\cdot t}\cos\omega t\right]+C_2 \tag{21}$$

or

$$\upsilon=\Psi k^2V^2\left[e^{-\frac{\lambda}{kV}\cdot t}\sin\omega t-\omega\cdot e^{-\frac{\lambda}{kV}\cdot t}\cos\omega t\right]+C_2 \tag{22}$$

As you know, $T_{ucc}=(\upsilon\cdot\nu)$

Thus, the solution is expressed as follows:

$$T_{ucc}=k^2V^2\left[\sin\omega t-\omega\cdot\cos\omega t\right]+C_2 \tag{23}$$

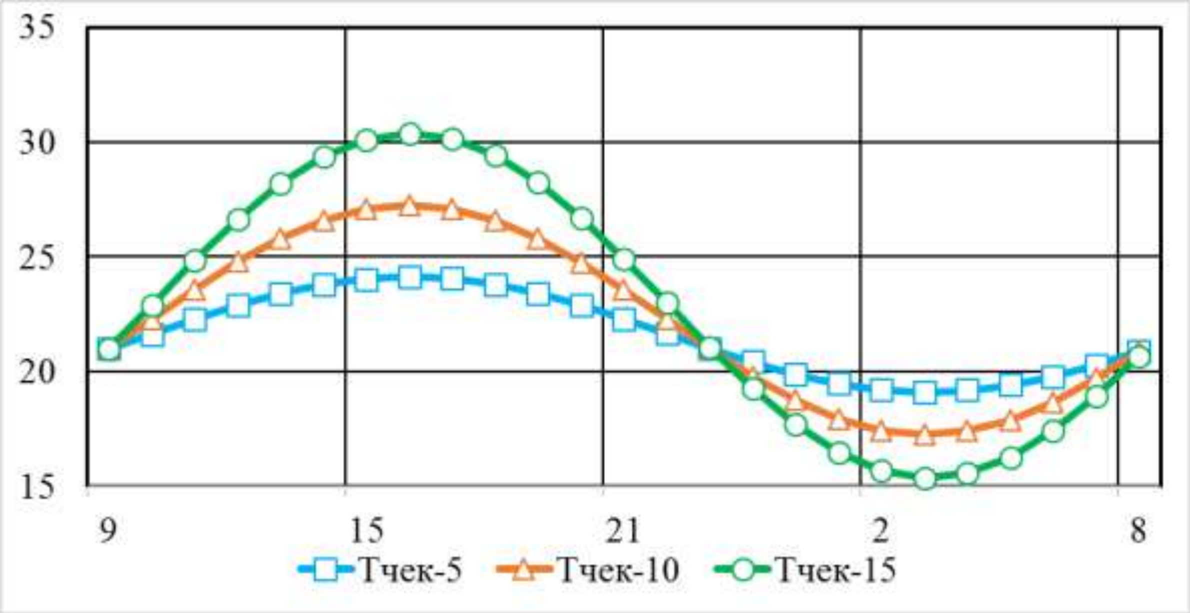
here: C_2– integral constants that can be determined from the initial condition (6).

$$C_2=\overline{T}_{ucc}+\omega k^2V^2 \tag{24}$$

Or easier,

$$T_{ucc}=k^2V^2\left[\sin\omega t-\omega\cdot\cos\omega t\right]+\overline{T}_{\text{Таш.}ucc}+\omega k^2V^2 \tag{25}$$

Graph of temperature change in the greenhouse under CAS conditions



4.1.1 graphics The change in temperature regime in the greenhouse is given by Tlim-5 (Tlim-5) ± 5 change from the optimum (+21 oS) temperature, Tlim10 ± 10 oS change and Tlim15 ± 15 oS change. In order to get a high yield from the tomato plant, it is preferable not to allow as large a change in temperature as possible. When Tlim-15, the plant falls into a state of stress, becomes ill or dies. Even if you get sick, you will have to pay extra to treat it. Therefore, when the temperature was Tlim-5, the yield was maximum and the costs were minimal [1,5,6,7].

DISCUSSION

BAT heat regime is one of the main factors affecting tomato plant yield. Tomato is a heat-loving plant, when the minimum temperature is in the range of +14 oC and the maximum temperature is in the range of +28 oC, favorable temperature conditions are created for the plant when provided with additional ventilation and protection from strong sunlight [E. Lyan22]. According to V. N Suvichnikov, when using the mathematical model developed in the conditions of BAT, internal and external factors are taken into account. Power supply, day length hours, outside temperature, solar radiation intensity, wind speed and other characteristic factors[16]. The values of external factors differ from the daily average value by location. The greenhouse complex was determined taking into account the parameters of the technological process and the regime of greenhouse conditions. The amount of heat energy consumed by BAT, energy consumption of power supply systems, total energy consumption of the power supply system, gross energy utilization factor from the level of influencing factors and the results of the analysis of the obtained dependencies are presented.

V.L. Sudakov used light sources. Plants develop under the influence of light, the process of photosynthesis is observed through the leaves and body, and dry matter is formed.

CONCLUSIONS

When using artificial lighting devices, it is possible to provide a light flux of around 450 - 475 nm by using energy-saving cold and hot diode devices together. A spectrum of light that does not have a sufficient level of radiation does not affect the productivity of the tomato plant and leads to excessive electricity consumption[15].

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