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ADAPTIVE MATHEMATICAL MODEL «TEMPERATURE - YIELD TOMATO»

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The influence of temperature on the yield of tomatoes is analyzed. An adaptive mathematical model, to predict the yield of different varieties of tomatoes, including air temperature in the greenhouse is proposed.

Adaptive mathematical model, yields, climate, greenhouses, and temperatures.

Department Biotechnical objects nowadays requires existing automatic control systems in greenhouses using new algorithms that would allow tailored, to suit the biological component. The use of adaptive mathematical model, to determine the level of productivity will consider the real yield of vegetables. Thus, the mathematical model of the production process will be more clearly close to their real values.

Building a mathematical model yields of tomatoes having some difficulties. Thus, it is impossible to construct a mathematical model for the different varieties of tomatoes because they have yields at different temperatures varies, there is a need to build an adaptive mathematical model. We consider an adaptive algorithm specification model parameters at each step of obtaining information about an object for nonlinear function relatively unknown model parameters [3, 4].

Supervisor - PhD, Professor V. Kozyrskiy

The purpose of research - determine the effect of temperature on the yield of tomatoes and construction of adaptive mathematical model so that its parameters are constantly korehuvalysya, considering the influence of other factors microclimate on yield of plants.

Materials and methods research. Sources of the impact of environmental factors on growth and yield of tomatoes. Research Methodology is based on heat and mass studied processes in the facility in greenhouses and affect the performance of growth and development of plants

With the variety of factors that affect the yield is most significant heat and mass transfer processes. Analysis of the literature [1, 6] shows that all of the factors that affect the plant can be brought to light, heat, water, nutrients and carbon dioxide. All these factors the plant absorbs from the environment, processes, and then assimilates partially formed harvest. It is natural that all the energy and mass flow entering the plant zasvoyuvavsya plant in optimum quantities. At the same affect plants and very small and very large portions of water, nutrients, heat, etc.. Take into account that each of these factors is complex and multi, and a simultaneous combination results in a very complex system, which leads to the formation of the crop as a whole [2, 5].

Light - is one of the major factors limiting plant growth and development. Tomato is very demanding of lighting conditions. The minimum illumination at which a possible vegetative growth of plants 2 - 3 thousand lux. In light below this threshold decay asymilyantiv to exceed their breath coming from photosynthesis. In the presence of sufficient sunlight accelerates plant growth: they still flower and fruit. In the bleak, even warm weather, delayed flowering and fruiting occurs later. When solar radiation 8 MJ (2.22 kW • h) a day and the usual content of CO_2 in the air (0.03%), tomato yields in the range 40 - 150 g from one bush per day, depending on the temperature [7] that for photosynthesis of tomato to within 20 - 25 º C. (Table).

Influence of temperature on the yield of greenhouse tomatoes.

Air temperature, ^0C. (x_i)	16	19	22	25	28
yield of tomatoes, *г.* (y_i)	114	134	146	151	147

Studies. Consider the statistics depending on the yield of tomatoes *(y)* the air temperature *(x)* [3] (see table). Preliminary examination of the table suggests that the model of this relationship is the sum of two exponentials. For convenience, the coefficients a_1, a_2, a_3, a_4 replacement into a, b, c, d:

$$y = a \cdot e^{-b \cdot x} + c \cdot e^{-d \cdot x}, \quad (1)$$

where *a, b, c, d* - the unknown model parameters.

Finding the values of $a_1, ..., a_4$ determine rate of growth of vegetables depending on the temperature.

Based on the statistics table to find the unknown parameters *a, b, c, d*. Function (1) is nonlinear in *b* i *d*. Let us know the initial values a_0, b_0, c_0, d_0. Suppose that $a = a_0 + z_1$; $b = b_0 + z_2$; $c = c_0 + z_3$; $d = d_0 + z_4$. Substituting these values in the conditional equation, we decompose the function y_k in series with powers of z_1, z_2, z_3, z_4 and limit expansion in powers of the first amendment:

$$y_k(a_0, b_0, c_0, d_0) - y_k + \left(\frac{\partial y_k}{\partial a}\right)_0 z_1 + \left(\frac{\partial y_k}{\partial b}\right)_0 z_2 + \left(\frac{\partial y_k}{\partial c}\right)_0 z_3 + \left(\frac{\partial y_k}{\partial d}\right)_0 z_4 = 0 \quad (2)$$

or

$$\left(\frac{\partial y_k}{\partial a}\right)_0 = e^{-b_0 x_k};$$

$$\left(\frac{\partial y_k}{\partial b}\right)_0 = a_0 e^{-b_0 x_k} (-x_k);$$

$$\left(\frac{\partial y_k}{\partial c}\right)_0 = e^{-d_0 x_k};$$

$$\left(\frac{\partial y_k}{\partial d}\right)_0 = c_0 e^{-d_0 x_k} \cdot (-x_k).$$

The system of equations (2) can be written as:

$$A \cdot z = b\,, \tag{3}$$

Where $b_k = y_k - y_k(a_0, b_0, c_0, d_0)$

$$A = \begin{pmatrix} e^{-b_o x_1} & -x_1 a_o e^{-b_o x_1} & e^{-d_o x_1} & -x_1 c_o e^{-d_o x_1} \\ e^{-b_o x_2} & -x_2 a_o e^{-b_o x_2} & e^{-d_o x_2} & -x_2 c_o e^{-d_o x_2} \\ \dots\dots\dots & \dots\dots\dots & \dots\dots\dots & \dots\dots\dots \\ e^{-b_o x_4} & -x_4 a_o e^{-b_o x_4} & e^{-d_o x_4} & -x_4 c_o e^{-d_o x_4} \end{pmatrix}$$

As is known, the solution of the system of conditional equations (3) has the form:

$$z = (A' \cdot A)^{-1} A' b\,; \tag{4}$$

Solving the system,we will find $a = a_0 + z_1$; $b = b_0 + z_2$; $c = c_0 + z_3$; $d = d_0 + z_4$.

Denoting *a, b, c, d* through a_0, b_0, c_0, d_0, do a second iteration, again we find that the vector *b*, and the matrix *A* and solve the system (4).

In our case, given the data in the table are:

$$\begin{aligned} b_1 &= 134 - a_0 e^{-b_o 19} - c_0 e^{-d_o 19}; \\ b_2 &= 146 - a_0 e^{-b_o 22} - c_0 e^{-d_o 22}; \\ b_3 &= 151 - a_0 e^{-b_o 25} - c_0 e^{-d_o 25}; \\ b_4 &= 147 - a_0 e^{-b_o 28} - c_0 e^{-d_o 28}; \end{aligned} \tag{5}$$

The matrix *A* has the form

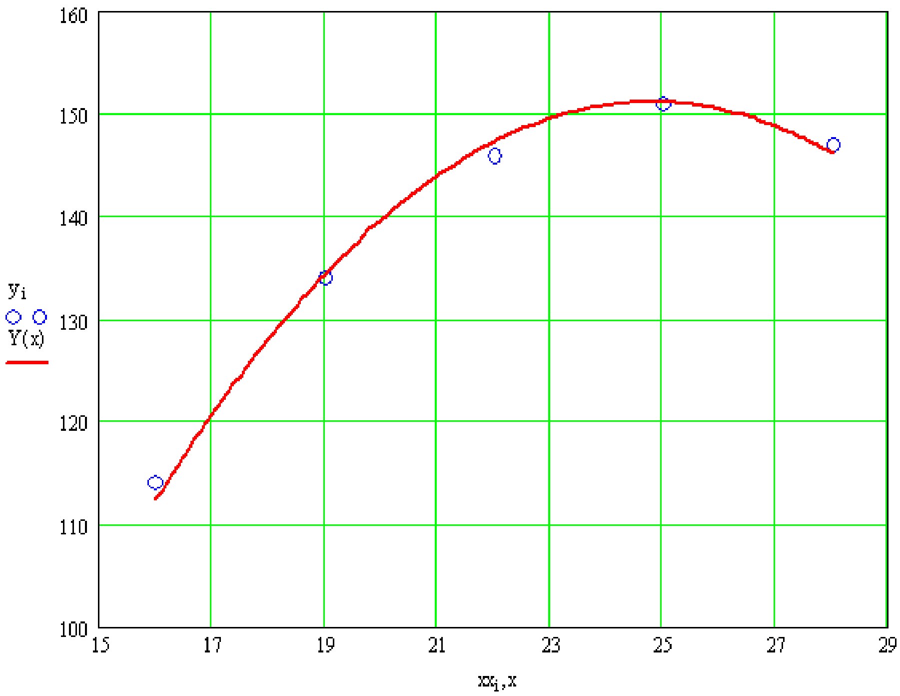
$$A = \begin{pmatrix} e^{-b_o 19} & -19 a_0 e^{-b_o 19} & e^{-d_o 19} & -195 c_0 e^{-d_o 19} \\ e^{-b_o 22} & -22 a_0 e^{-b_o 22} & e^{-d_o 22} & -22 c_0 e^{-d_o 22} \\ e^{-b_o 25} & -25 a_0 e^{-b_o 25} & e^{-d_o 25} & -25 c_0 e^{-d_o 25} \\ e^{-b_o 28} & -28 a_0 e^{-b_o 28} & e^{-d_o 28} & -28 c_0 e^{-d_o 28} \end{pmatrix} \tag{6}$$

Solving the system of conditional equations (4) taking into account (5), (6), we obtain z_1; z_2; z_3; z_4, ie $a = a_0 + z_1$; $b = b_0 + z_2$; $c = c_0 + z_3$; $d = d_0 + z_4$. Assuming that $a = a_0 + z_1$; $b = b_0 + z_2$; $c = c_0 + z_3$; $d = d_0 + z_4$ and repeating the solution of the system of conditional equations (4), we obtain a new approach of unknown *a*, *b*, *c*, *d*.

The process continues until the approach while vector b is not within the specified accuracy of 5% in *y*.

$$|y| \le y_i \cdot 0{,}05. \qquad (7)$$

The end result is to obtain the coefficients of the model *a*, *b*, *c*, *d*. Given these factors, we substitute them in equation (1) and obtain the necessary mathematical dependence of the yield from plants in a greenhouse temperature (Picture).



The dependence of the yield of tomatoes on the air temperature in the greenhouse:

ooo - research value; ------- results of approximation by the expression (1)

Adaptive mathematical model to predict the yield of tomato plants, given the level of air temperature in the greenhouse. The coefficient models are constantly adjusted at each change of model parameters. As noted earlier, by changing the intensity of solar radiation and yield will vary, so you should consider the yield of tomatoes, and given the intensity of solar radiation.

Conclusions

The proposed adaptive mathematical model to predict the yield of different varieties of tomatoes, given the level of air temperature in the greenhouse. Odds adjusted model, at each change of model parameters, an adaptive algorithm refines the model parameters at each step of obtaining information about an object.

Found that for these conditions with increasing temperature up to 25 º C is the growth of the crop, then any increase in temperature did not give any increase in yield both in quantitative and qualitative terms, moreover, it is fading.

References

1. Bryzgalov V.A. Ovoshchevodstvo zashchishchennogo grunta / V.A. Bryzgalov, V. A. Sovetkina, N. I. Savinova. – M.: Kolos, 1999. – 352 p.

2. Poluektov R.A. Modeli produktsionnogo protsessa sel'sko-khozyaystvennykh kul'tur / R.A. Poluektov, E.I. Smolyar, V.V. Terleyev, A.G. – SPb.: Topazh. 2006. – 290 p.

3. Razrabotka i analiz metodov polucheniya matematicheskikh modeley mekhanizmov regulyatsii serdechno-sosudistoy sistemy / G. YA. Minchuk, I. P. Drozd, I. A. Yanovich i dr. // V Mezhdunar. nauch. – tekhn. konf. – tezisy dokl. – Zelenyy Mys, 1996. – 86 p.

4. Sovetov B. YA. Modelirovaniye sistem / B. YA. Sovetov, S. A Yakovlev. – M.: Vyssh. shk. 1998. – 260 p.

5. Tornli Dzh.G.M. Matematicheskiye modeli v fiziologii rasteniy / Dzh.G.M. Tornli; per. s angl. D.M. Grodzinskogo. – K.: Nauk. dumka, 1982. – 312 p.

6. Shishko G.G. Teplitsy i teplichnyye khozyaystva: Spravochnik / G.G. Shishko, Potapov V. A.; Sulima L. T.; Chebanov L. S. – K.: Urozhay, 1998. – 424 p.

7. The Effect of Temperature and Mean Cumulative Daily Light Intensity on Fruiting Behavior of Greenhouse-grown Tomato: [Electron. resource]. / Sezgin Uzun / / The University of Ondokuz Mayıs, Faculty of Agriculture, Department of

Horticulture. In 2007. - 132 (4). - P. 459-466. - Mode of access: by Zh.: Http://journal.ashspublications.org/content/132/4/459.full.pdf

The analysis of the influence of temperature on the yield of tomatoes. The proposed adaptive mathematical model to predict the yield of different varieties of tomatoes given the level of air temperature in the greenhouse.

Adaptive mathematical model, yields, microclimate, greenhouses, temperature air.