On prognosis of growth of plants during control by lighting

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Abstract
We describe a model to estimate efficiency of control of growth of plants during control by lighting. Consideration of the model gives a possibility to analyze dependence of the above growth on several factors. We obtain conditions to accelerate and decelerate of the considered growth. Also we introduce an analytical approach to make prognosis of the considered growth.

Keywords: Modeling of growth of plants, changing of speed of growth of plants, influence of lighting, analytical approach for modeling

Introduction
Effect of light on a plant could be divided on photosynthetic, regulatory-photomorphogenetic and thermal [1-7]. Light acts on growth through photosynthesis, which requires high levels of energy. At low quantity of light plants grow worse. Increasing of continuance of lighting leads to acceleration of growth of many plants. At the same time, the numerical values of the parameters of additional irradiation depend on the type of plant, the period of its development, as well as on the lighting parameters [3-7]. We described a model that gives a possibility to make prognosis of growth of the considered plants. Based on consideration of the model we obtained several dependences of growth of plant on lighting. We also consider an analytical approach to analyze the considered model.

Method of solution
To obtain the required results we consider saving energy law. For our case the considered law takes the form

\[ \frac{dL}{dt} = \alpha(t)L^2 - \alpha(t)\beta(t)L^2 - \gamma(t)L^4. \]  

(1)

The initial condition could be written as: \( L(0) = 0 \), because the initial linear dimension \( L(t) \) of the considered plant is zero. Functions \( \alpha(t) \), \( \beta(t) \), \( \gamma(t) \) describe the parameters of the considered processes; surface of crown (at consideration of a tree) is proportional to \( x^2 \); volume of plant is proportional to \( x^3 \). Term \( \alpha(t)L^2 \) in the equation (1) describes the energy obtained as a result of photosynthesis. The next in the same equation describes the energy consumption for the needs of photosynthesis. The third one describes the cost of transporting nutrient solution to all parts of the considered plant, which is proportional to the volume of the plant and height, since it is associated with overcoming gravity. The right term in the equation (1) shows the cost of increasing the mass of the plant. Now we present the equation (1) to the integral form

\[ L = \int_0^t \alpha(\tau)L^2d\tau - \int_0^t \alpha(\tau)\beta(\tau)L^2d\tau - \int_0^t \gamma(\tau)L^4d\tau \]  

(2)

Next we solve the equation (2) by the method of averaging of function corrections [8-10]. To use the method for calculation of the first-order approximation of the linear dimension of a plant \( L_1(t) \) we replace the considered function by the average value \( \delta_1 \) in the right side of equation (2).
The solution leads to the following result

\[ a_2 = \frac{1}{\Theta} \left\{ \frac{4}{3} \left[ (\Theta - t) L_2^2 (t) \right] \right. \]

\[ \left. \times \gamma (t) d t - \frac{4}{5} \left[ (\Theta + \beta (t)) \left[ (\Theta - t) L_2^2 (t) \right] \right] \right\} , \]

\[ a_4 = \frac{2}{\Theta} \left[ \frac{1}{2} (\Theta - t) \gamma (t) L_2^2 (t) d t - \frac{1}{(\Theta - t) \gamma (t) L_2^2 (t) d t} \right] , \]

\[ a_6 = -\frac{1}{\Theta} \left[ (\Theta - t) \gamma (t) \left[ (\Theta - t) L_2^2 (t) \right] \right] d t , \]

\[ \times \alpha (t) \left[ (\Theta - t) L_2^2 (t) \right] d t \]