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THE USE OF MATHEMATICAL MODELING METHODS TO ASSESS THE PRODUCTIVITY OF AGRICULTURAL PLANTS

ВИКОРИСТАННЯ МЕТОДІВ МАТЕМАТИЧНОГО МОДЕЛЮВАННЯ ДЛЯ ОЦІНКИ ПРОДУКТИВНОСТІ СІЛЬСЬКОГОСПОДАРСЬКИХ РОСЛИН

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Modern agronomic sciences use in their research various methods of quantitative assessment of patterns of growth and development of agricultural plants. These are statistical methods, various mathematical methods, as well as artificial intelligence. Mathematical models can become an effective means of integrating a large complex of theoretical ideas about the vital activity of agroecosystems. The significant interest observed recently in the problems of modeling agrocenoses is also connected with the growth of the practical value of models [1, p. 91].

Mathematical models of the growth and development of agricultural crops are based on ideas about the interaction of biological processes between themselves and the environment, and combine mathematical ideas about the main physiological processes occurring in plants. Each of the models developed for many cultures is unique in terms of a number of processes underlying it [1, p. 94].

The modern quantitative theory of the photosynthetic productivity of crops allows us to consider the process of crop formation as a complex set of a number of physiological processes.

Many dynamic models of the productivity of various agricultural crops are known, which allow evaluating the growth of plants during the growing season as a result of the main physiological processes.

Existing models of productivity of vegetable crops can be combined into three groups, in which the accumulation of plant dry mass is considered as:

1) function of general photosynthesis and respiration;
2) according to the structure-stock ratio;
3) the function of nitrogen content in above-ground organs.

Thus, in the model of the formation of plant productivity, the influence of changing weather and soil conditions on the response of crops to nitrogen fertilizers during the season is evaluated. In this model, the accumulation of dry biomass is considered as a function of nitrogen content in the aerial part. The total nitrogen in the plants and the weight of the above-ground mass are set as initial values and then calculated daily. The increase in dry biomass is estimated by the maximum possible increase, taking into account the limiting conditions. Maximum daily growth is calculated using a logistic equation as a function of maximum yield. The model has a well-defined soil block that describes the movement of moisture and nitrates in the soil under different conditions, the absorption of nitrates from the soil by the roots (it is assumed that nitrogen is in the soil only in nitrate form). The absorption of nitrogen by plants is determined from the logistic equation, taking into account the concentration of nitrates in the soil, their availability to the roots, and the total nitrogen contained by the plants. The model can be used for yield calculations depending on the dose of nitrogen fertilizers, the method of their application, the age of plants, soil and weather conditions.

The productivity of agricultural crops is determined by a set of agroclimatic indicators that characterize the agroclimatic resources of the territory. Indicators of agroclimatic resources should comprehensively reflect:

1) the extent to which agricultural crops are provided with these resources;
2) the ratio of resources to plant needs;
3) the degree of use of these resources.

The most adequate display of agro-climatic resources can be realized in agro-ecological yield categories, which are based on the principles of maximum productivity and compliance of environmental conditions with the needs of plants [1, p. 95].

According to the first principle – maximum productivity – plants and phytocenoses in natural conditions have the maximum productivity in the existing conditions, as well as the maximum efficiency of the use of photosynthetically active radiation (PAR). According to the second principle – suitable conditions – maximum productivity and high yields are ensured by creating conditions that satisfy the needs of plants. The principle of conformity of conditions is implemented by anthropogenic influence [2, p. 80]:

– the change of environmental conditions in accordance with the needs of agricultural crops is implemented through the use of appropriate agrotechnical measures;

– achieving a better compliance of biological properties of plants with environmental conditions by means of selection;

– placement of agricultural crops, their individual varieties and hybrids in accordance with the soil and climatic conditions and taking into account the microclimatic features of the territory;

– purposeful and justified protection of plants from diseases and pests.

Proposed by Tooming H. G. [1, p. 92] the system of reference crops allows a much deeper approach to the solution of issues of assessing the conformity of climatic resources to the biological requirements of various agricultural crops. This principle has found wide use.

Based on the concept of maximum productivity by H. R. Tooming and the results of crop formation modeling obtained in the works of A. M. Polevoy [1, p. 96], a model for evaluating the agroclimatic conditions of crop formation of crops was developed, which is intended for evaluating the productivity of the climate of Ukraine. For a more detailed assessment of agroclimatic conditions, a ten days is taken as a model step.

The model has a block structure and contains five blocks:

- block of input information;
- block of indicators of solar radiation and wet – temperature regime;
- the function block of the influence of the development phase and meteorological factors on the productive process of plants;
- block of soil fertility and supply of plants with mineral nutrition;
- block of agro-ecological yield categories.

The application of mathematical models to predict the growth rate of crops has several problems. First, most of the existing models do not sufficiently simulate the physiological processes underlying plant phenology. Secondly, the models focus on varieties and agrometeorological conditions of a certain region for which they were developed, and cannot give satisfactory results when applying the same models to new territories. Unfortunately, most of the available models have not found practical use due to the difficulty of determining the parameters of those physiological processes that are taken into account in the model.

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