National Academy of Sciences of Ukraine
Institute of Plant Physiology and Genetics

DEVELOPMENT OF ECOLOGICAL AND GENETIC RESEARCHES OF CEREAL CROPS IN THE CONDITIONS OF CLIMATE CHANGE

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Development of economic-mathematical modeling in ecological and genetic researches of cereal crops in the second half of the 20th century

- The economic-mathematical models have been developed to determine the efficiency of cereal crops cultivation – M.E. Braslavets, J. Frans, J. Jeffers, R.G. Kravchenko, K.D. Liuis, B.K. Skirta, J. Thornley and others;
- The optimization processes of cereal crops in agroecosystems were studied – V.M. Dudkin, H.A. Elmet, E. Hedy, W. Kandler and others.

The computer programs for ecological and genetic researches of cereal crops, developed by Ukrainian scientists using economic-mathematical modeling (1990s)

- The method and computer program «IOPEKOL» for ecological and economic optimization of cereal crops are developed (Luhansk Scientific-Research Institute of Soil Protection Against Erosion of the NAAS);
- The computer program «ASOT» as the automated system of optimization of technologies of cultivation of cereal crops is created (Ukrainian Scientific-Research Institute «Agroresources»);
- The computer program «AGRO» for definition of the effective measures directed on reduction of radioactive influence at cultivation of cereal crops in radiation-contaminated zones is developed (Ukrainian Scientific-Research Institute of Agricultural Radiology of the NAAS).

Application of economic-mathematical models in ecological and genetic researches of cereal crops in the second half of the 20th century

Developed at the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine and the Institute of Cell Biology and Genetic Engineering of the National Academy of Sciences of Ukraine together with Moldovan scientists:

- the Nonlinear economic-mathematical models;
- the Correlational economic-mathematical models;
- the Regression economic-mathematical models;
- the Multivariate economic-mathematical models – cluster, factor and discriminant.

Application of correlation models

The correlation models have been developed for effective prediction and management of the processes of creating the most probable combination of genetic traits of cereal crops.

To determine the correlation between genetic traits of cereal crops and establish the influence reactions to stress factors arising under climate change conditions, the following correlation methods were used:

- - the genomic correlation method, which determines the interaction of the formation of individual cereal crops organs, which is determined by the multiple action of hereditary factors or the interaction of genes;
- - the morphological correlation method, which consists in establishing the interaction of different cereal crops organs in the process of embryonic development;
- - the functional correlation method, which is the result of the interaction of different characteristics of cereal crops – the dependence of the development and state of organs on their functioning.

Application of regression models

The regression models was developed to establish the level of adaptability of different genotypes of cereal crops to environmental conditions - the complex influence of air temperature and lighting, using which we obtained:

- - the results of adaptive reactions of cereal crops, which provided a trace of the relationship between their sensitivity and ability to actively adapt;
- the conclusions about the inverse relationship between the sensitivity and level of resistance of cereal crops genotypes to the stress factor - a decrease in air temperature from normal to lethal.

Using multivariate models to establish genetic mechanisms of radiation transformation of cereal crops based on the impact of low doses of radiation on their structural and functional organization and adaptive potential in climate change conditions

- Thanks to the use of the constructed cluster, factor and discriminant models, it was established that under the influence of irradiation, internal population differentiation of cereal crops occurs not only in terms of the level of general adaptability, but also in terms of the organization of the processes of general ontogenetic development, that is, structural and functional organization.
- The practical significance of the use of multidimensional models lies in the fact that its can be aimed at increasing the overall adaptability of cereal crops by changing the organization of ontogenetic development processes.

Development of researches of Ukrainian, American and Chinese scientists in the field of biomedical engineering at the beginning of the 21st century

Creation and testing of economic-mathematical models (A.B. Achasov, S.A. Balyuk, S.Yu. Bulygin, M.M. Kotova, R.V. Ternova, D.O. Timchenko):

- the imitation economic-mathematical model «WEPP» (Water Erosion Prediction Project);
- the dynamic economic-mathematical model «WEPS» (Wind Erosion Prediction System);
- the dynamic economic-mathematical model «EuroSEM» (European Soil Erosion Model).

The imitation economic-mathematical model «WEPP» (Water Erosion Prediction Project), which is used to calculate the processes of water erosion in the soil when growing cereal crops:

- creates the possibility of its use in any soil and climatic conditions;
- characterized by successful physical and mathematical formalization of erosion processes;
- provides high reliability of forecast results, which confirms the possibility and feasibility of its use to predict soil erosion.

The dynamic economic-mathematical model «WEPS» (Wind Erosion Prediction System), which is used to plan soil protection technologies against wind erosion when growing cereal crops:

- creates an opportunity to predict soil losses;
- contributes to the effective calculation of the intensity of soil particle movement and damage from wind erosion when growing cereal crops;
- ensures the effectiveness of soil protection policy at the regional and national levels.

The dynamic economic-mathematical model «EuroSEM» (European Soil Erosion Model), which was developed to better describe erosion phenomena in agroecosystems with cereal crops, includes:

- parameters describing the physical and hydrological properties of the soil;
- soil moisture condition;
- characteristics of cereal crops;
- downpour parameters.

Using the achievements of geoinformation technologies in ecological and radiological researches of cereal crops at the beginning of the 21st century

At the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine and the Institute of Cell Biology and Genetic Engineering of the National Academy of Sciences of Ukraine:

- Using the technical capabilities of the «ARCGIS» software, a model-analytical geoinformation system has been developed that analyzes and provides forecasts of the migration of pollutants in cereal crops. The main information components of the model are the physicochemical and biochemical characteristics of pollutants, as well as natural and anthropogenic environmental conditions, in particular the nature of the surface, slope angles, mechanical and chemical composition of soil rocks, characteristics of cereal crops, etc.
- Based on the American computer programs «NOAA», «LANDSAT» and the French computer program «SPOT», aerospace imaging technologies have been improved, the existence of which is possible in real time, which has ensured the expansion of areas of application of geoinformation technologies for ecological, radiation researches of cereal crops in conditions of climate change.

The advantages of modern geoinformation technologies

- The presence of powerful tools for visualizing information about the growth and development of cereal crops, which is displayed in the form of designed diagrams and graphs that are conveniently perceived by users;
- Ensuring automation of the analysis process and obtaining results based on the display of data on the cultivation of cereal crops, thereby increasing the efficiency of the decision-making procedure;
- Optimization of the process of decoding space and aerial photography data, the use of pre-created plans and schemes, which significantly saves financial and time resources;
- Modeling and forecasting ecosystem pollution, establishing the relationship between pollution levels and public health, monitoring harmful substances and their sources, informing the public and planning measures to reduce the risk of negative impacts of harmful substances on their health.

Conclusions

- Thus, in the second half of the 20th century, key discoveries in the field of computer technologies contributed to the formation of a new direction of practical application of the achievements of theoretical science. In particular, the use of economic and mathematical models in ecological and genetic research of cereal crops has expanded in Ukraine. At the beginning of the 21st century, the defining feature of the development of biomedical engineering in Ukraine was the cooperation of Ukrainian scientists with foreign scientists. For example, at the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine and the Institute of Cell Biology and Genetic Engineering of the National Academy of Sciences of Ukraine, together with Moldovan scientists, nonlinear, correlation and regression models were developed for the effective growth and development of cereal crops under climate change. Thanks to these international studies, the use of the achievements of molecular genetics and system engineering – genetic and ecological – became the most effective in Ukraine.
- An example of effective international cooperation was the confirmation by Ukrainian scientists of the effectiveness of geoinformation software products developed by American and French scientists. In particular, to analyze and provide forecasts of pollutant migration in ecosystems. Thanks to their practical application, a significant contribution was made to the further development of biomedical engineering in Ukraine.
- The priority direction of researches of Ukrainian scientists in the combination of the use of geoinformation technologies and remote sensing technologies has been proven, which ensures the expansion of the areas of their application in ecological and radiological studies of cereal crops in the conditions of climate change. This will help predict and prevent natural disasters and reduce the risk of negative effects of harmful substances on people's health. Invented on the basis of careful experimental researches and confirmed by theoretical developments, a completely new phenomenon – predicting the migration of pollutants in ecosystems, thanks to the use of these innovative technologies, has become an impetus for the development of world biomedical engineering.

Thank you for your attention!