MODERN APPROACHES TO AUTOMATION OF THE RATIONAL CHOICE OF ADAPTIVE AGRICULTURAL TECHNOLOGIES

Abstract: the work was carried out on the basis of the laboratory of agricultural systems of the North Kazakhstan station, and the research on the rational choice was carried out on the basis of the laboratory of agricultural systems of the Kursk Federal Agricultural Research Center.

The investigation was based on the results of the authors’ own research, as well as the analysis and generalization of current scientific literature. As a result of the generalization, the most effective conditions for the application of such technologies, contributing to the rational use of available resources were identified. Criteria, standards, and requirements for the effectiveness of the most important technological methods of modern agricultural technologies were formulated. Approaches to automation and an algorithm of their rational choice were developed. The work on designing scheme and the structure of the database support system for agricultural producers on the rational choice of highly adaptive technologies for the cultivation of key crops was carried out.

Keywords: automation, agricultural technology, resource support, rational choice.

Аннотация: работа проводилась на базе лаборатории агросистем Северо-Казахстанской станции, а исследования по рациональному выбору проводи-
лись на базе лаборатории агросистем Курского федерального аграрного научного центра.

Исследование проводилось на основе результатов собственных исследований авторов, а также анализа и обобщения современной научной литературы. В результате обобщения выявлены наиболее эффективные условия применения технологий, способствующих рациональному использованию имеющихся ресурсов. Сформулированы критерии, стандарты и требования к эффективности наиболее важных технологических приемов современных агротехнологий. Разработаны подходы к автоматизации и алгоритм их рационального выбора. Проведена работа по проектированию схемы и структуры базы данных системы поддержки сельскохозяйственных товаропроизводителей по рациональному выбору высокоадаптивных технологий возделывания ключевых сельскохозяйственных культур.

Ключевые слова: автоматизация, агротехника, ресурсное обеспечение, рациональный выбор.

Introduction. The peculiarity of adaptive landscape farming is the multivariance of agricultural technologies, due to the variety of crops grown and the soil and climatic conditions of Russia. To date, a significant amount of research results has been accumulated, the analysis of which allows us to reasonably approach the process of adaptation of crop cultivation technologies in relation to various regions of Kazakhstan. Domestic agricultural producers need to more actively use this information to increase production efficiency, and scientists – to transfer new knowledge and improve existing approaches to the design of scientifically-based agricultural technologies, should more actively develop and disseminate modern information technology products in the form of expert decision support systems for the most important agricultural technologies issues.

The aim of the research is to develop modern approaches to automation, the algorithm and database structure of the Support System for Agricultural Producers for the rational selection of highly profitable adaptive technologies for the cultivation of
grain crops in relation to the conditions of Kazakhstan, based on the generalization, analysis and systematization of experimental data.

**Conditions, materials and methods.** The work was carried out on the basis of the laboratory of agricultural systems of the North Kazakhstan station on the basis of the results of our own scientific research, as well as analysis and generalization of modern scientific literature on the rational choice of adaptive cultivation technologies for 10 crops (winter and spring wheat and barley, winter rye, spring oats, sowing peas, millet sowing, buckwheat, corn for grain) for various conditions of Kazakhstan.

The research on the rational choice of adaptive cultivation technologies for 10 grain crops (winter and spring wheat and barley, winter rye, spring oat, pea, millet, buckwheat, maize) for different conditions of the Russian Federation was carried out on the basis of the laboratory of agricultural systems of the Kursk Federal Agricultural Research Center.

The development of software for the rational selection of adaptive agricultural crop cultivation technology for computers is the final stage in the process of optimizing zonal agricultural technologies, implemented through obtaining, analyzing, and summarizing new knowledge about the patterns of yield formation and the quality of products obtained depending on soil, climatic and material conditions within the general concept of resource conservation in agricultural production.

During the study, we used a systematic approach, a logical and mathematical analysis of the accumulated material, a method of expert assessments, the theory of database management systems, and a methodology for designing information systems.

The object of the research was adaptive agricultural technologies of grain cultivation. Based on the results of the agricultural census conducted in 2016, the following crops are the largest sown areas in the country: wheat (27.8 million ha), barley (8.4 million ha), oats (3.0 million ha), corn for grain (2.9 million ha), rye (1.3 million ha), buckwheat (1.2 million ha), peas (1.1 million ha), millet (0.4 million ha). Therefore, they were taken as the basis for the implementation of the goal.
The methodology for the formation of a rational choice of adaptive agricultural technologies consisted in sequentially overcoming the factors limiting crop yields and quality indicators of products while observing the principles of resource conservation and environmental technologies.

By the term «adaptive agrotechnology» we mean a complex of effective agrotechnical methods of cultivating an agricultural crop, aimed at preserving or improving soil fertility and obtaining a high level of high-quality and biologically safe products with optimal labor and resources, taking into account soil-climatic, landscape and material-technical conditions prevailing in a particular territory.

The need for an adaptive approach to the selection process of agricultural technologies is due to several reasons:

— a variety of soil and climatic conditions in the regions of Kazakhstan;
— differences in the level of provision of agricultural producers with material resources;
— development of new and improvement of existing principles for the formation of the structure of sown areas and crop rotations in modern conditions of a market economy;
— development of a new generation of agricultural machinery and implements, allowing to take into account the features of the relief and the condition of crops, contributing to an increase in labor productivity;
— the emergence of new varieties and hybrids of agricultural crops, types of fertilizers and chemical plant protection products, approaches to their use, new ideas about the placement of micro- and macroelements across soil layers, their migration, etc.

The algorithm for choosing adaptive agricultural technologies is based on the consistent overcoming of factors limiting the formation of the most profitable crop yields with high quality indicators while observing the principles of resource conservation. Such factors include the natural climatic zone, soil type, humus content, degree of erosion, acidity, crop rotation, fertilizer and tillage systems, weediness, etc. Moreover, the number of such factors may increase depending on the typical condi-
tions and biological requirements of cultivated crops. Therefore, for the most accurate construction of the adaptive agrotechnology selection algorithm, it is necessary to create an appropriate database that includes normative and reference information that contributes to the rational selection of highly profitable adaptive agrotechnologies based on a phased selection of agrotechnical methods, taking into account the following approaches:

- optimization of the maximum possible number of technological methods for various groups of crops with scientific justification for the appropriateness of each;
- determination of technology output indicators (projected yield level, production cost, energy intensity) based on their simplified calculation;
- the use of a simplified modular structure of the database of the decision support system for the rational selection of highly profitable adaptive technologies for the cultivation of grain crops, which avoids listing a huge number of options for the machines, pesticides and fertilizers used.

Results and discussion. As a result of the analysis of the accumulated experimental material of many years of field experiments of the North Kazakhstan region of the agrarian scientific center and generalization of data from other research institutions in various regions of Kazakhstan, as well as the practical results of many agricultural enterprises, the most effective conditions for the rational choice of adaptive technologies for cultivating grain crops for the first time were revealed the use of available resources of agricultural producers, on which developed approaches to the automation of a rational choice of adaptive agricultural technologies. Based on the latter, a database structure was proposed, and then an algorithm for the agricultural producers support system for the rational selection of highly profitable adaptive technologies for grain cultivation.

The structure of the normative and reference database of the agricultural producers support system for the rational selection of highly profitable adaptive technologies for the cultivation of grain crops is presented in three blocks: initial information, regulatory information, and calculation algorithms.
Due to the fact that the scope of the «Support System...” is Kazakhstan, the analysis and synthesis of data from long-term and short-term field experiments on the development and optimization of technologies, or individual methods of cultivating grain crops, can be carried out for all regions of Kazakhstan. Naturally, each of them is characterized by a significant variety of both soil-climatic and landscape conditions, which should also be taken into account when forming the block of initial information.

The block of computational algorithms is represented by three algorithms: a rational choice of adaptive technology for cultivating crops (for selected conditions), indicative calculations of the economic and energy efficiency of agricultural technologies.

Algorithms for calculating the economic and energy efficiency of agricultural technologies are automated using generally accepted methods.

The algorithm was tested on the basis of the Register of grain cultivation technologies [7] by comparing the solutions proposed by the corresponding program with the opinion of four expert scientists of the North Kazakhstan station on the same initial data. In this case, the combinations of initial data were divided into «obvious», that is, those for which the decision of all expert scientists coincided, «non-obvious», for which the choice of optimal agricultural technology was different, and «acceptable», which scientific experts identified as acceptable options for agricultural technology. The results of testing the algorithm showed that in 95% of cases the program found solutions that coincided with the opinion of expert scientists for «obvious» options, in 100% of cases the recommendations of the program did not find unacceptable solutions, in 90% of cases for «non-obvious» options the program found solutions, which expert scientists rated as acceptable. For example, for the buckwheat culture for food purposes according to the predecessor of «row crops», with the planned yield level of 16c / ha, the average level of effective soil fertility, strong weediness of the field, the use of plowing, the average resistance of the variety to lodging and shedding, provision per 1 ha of crops 5.5 people чel h of live labor, N30P30K30 kg a.a. mineral fertilizers, 50 kg of fuels and lubricants, 0.5 kg of herbicides, 0.1 kg
of fungicides, the presence of 2 units per 100 ha of crops tractor, 1.5 units plows, 0.5 units cultivators, 0.8 units roll reapers, 1 unit The harvester algorithm, due to the limited material resources, gives a recommendation on the use of basic technology, despite the possibility of applying intensive technology that matches natural resources. Such a solution is optimal from the point of view of expert scientists.

Conclusions. As a result of the research, the structure of the database «Support system for agricultural producers for the rational selection of highly profitable adaptive technologies for the cultivation of grain crops» was designed and developed, the development of which in production will contribute to the generation, optimization and implementation of existing agrotechnological solutions, taking into account the variability of soil-climatic and landscape conditions of agricultural territories, as well as the logistics of producers. Modern approaches to automation and an algorithm for the rational selection of adaptive technologies for the cultivation of leading crops are proposed, which facilitate object-oriented selection of the most appropriate agricultural technologies, optimization of the application rate of mineral fertilizers and pesticides, and the need for fuels and lubricants to reduce the negative impact on agroecosystems and the environment, and also increase the profitability of production.

As a result of the generalization, we determined the most effective conditions for the application of technologies that contribute to the rational use of available resources, formulated criteria, standards and requirements for the effectiveness of the most significant technological methods of modern agricultural technologies, as well as approaches to automation and an algorithm for their rational choice, designed the schemes and structures of the support system database agricultural producers on the rational selection of highly profitable adaptive technologies are cultivated.

The structure of the database «Support Systems...» was represented by three blocks: a block of initial information, a block of normative information and a block of calculated algorithms. The work to fill the blocks of initial and normative information, as well as to create an algorithm for rational selection of the optimal adaptive technology of crop cultivation, a key stage in this study, was done. The introduction of the created development into the process of agricultural production will allow ag-
ricultural producers to use available soil and climatic potential of the territories, materia- and technical resources in the most effective way in order to obtain highly profit-
able sustainable crop yields.

**Список литературы**


