Application of digital technologies in the selection of technologies for the cultivation of grain crops

V V Alt¹,², E A Balushkina² and S P Isakova²

¹Novosibirsk State Technical University, Novosibirsk, Russian Federation
²Siberian Federal Scientific Center of AgroBioTechnology, Russian Academy of Sciences, Krasnooorsk, Novosibirsk region, Russia
e-mail: isakova.s.p@yandex.ru

Abstract. The important aspects for the choice of agricultural technologies in crop production, the influence of the existing composition and condition of the machine and tractor fleet on the efficiency and competitiveness of the economy are shown. The relevance of solving the problem of automated selection of technologies and technical means is shown. A brief analysis of software in the field of automated formation of agricultural technologies and technical support is given, taking into account many factors affecting the solution of the problem.

According to 2019 data the Novosibirsk Region ranks third place in the Siberian Federal Region in terms of gross grain harvest in farms of all categories. The first and second places are occupied by the Altai Krai and the Omsk Region [1] (figure 1). According to preliminary data, 2 million 651 thousand tons of grain were collected in 2020 in the initial weight.

![Figure 1. Gross harvest and grain yield in the Siberian Federal Region according to Rosstat data for 2019.](image)
The main grain production areas from the 5 agro-landscape districts of the Novosibirsk region are the north-forest-steppe, central-forest-steppe, south-forest-steppe and steppe regions. The natural and climatic features of the farm location zone determine its specialization. In accord with it the technologies of cultivation of agricultural crops, the structure of sown areas, crop rotation schemes, types and volumes of mechanized work performed, the composition of the machine and tractor fleet (MTP) of the agricultural enterprise are determined [2, 3].

The level of grain yield is determined by the amount of summer precipitation and the nature of their distribution. Also, the instability of climatic factors over the years has great influenced. It is caused by a wide range of fluctuations in soil moisture reserves, the amount and distribution of precipitation and the dynamics of the temperature regime during the growing season of plants. Weather conditions have a significant impact on crop yields (in some areas, the contribution of climate to the yield dispersion ranges from 22 to 81%), therefore, the decrease in yield occurs mainly in dry or waterlogged years, or years of severe frosts [4]. The availability of precipitation during the spring sowing period is important for the choice of technology and the timeliness of the application of a complex of technological operations. Therefore, it is necessary to clearly understand what technology is needed in order to increase grain production [5, 6].

The effective cultivation of grain crops is largely determined by the applied agricultural technologies and their technical support. The use of extensive technologies prevails at various levels of intensification of technologies for the cultivation of grain crops in the Novosibirsk region. Most agricultural organizations cannot purchase more expensive, but with greater productivity and reliability of foreign equipment due to limited financial resources [7].

It is obvious that the presence of modern machines for complex mechanization of crop production is an absolute promising aspect for the selection and high energy and economic efficiency of agricultural technologies in crop production, along with careful consideration of the most significant climatic, agroecological, production and other factors. They should have the capabilities for comprehensive automation of agricultural technological processes, which determines their integration with information technologies, including the level of preparedness of equipment for automation as an object of control based on digital and intelligent technologies, etc. [8].

Consequently, the objectively existing wide variety of factors, conditions, peculiarities of production of farms and their forms of ownership, the existing composition and condition of the machineries and tractors fleet have a decisive influence on the efficiency and competitiveness of the economy, substantiate the relevance of solving the problem of automated selection of technologies and technical means, the development of the necessary software.

Today digital technologies are already being used: in the planning of maintenance and repair work; in accounting for completed work, fuel consumption, movement of spare parts; in recording and keeping records of cumulative operating time to optimize the calendar timing of setting machines for maintenance and repair; to provide information and reference materials for all interested users of agricultural machinery; to monitor the technical condition of machines, determine the residual resource based on information transmitted by built-in monitoring sensors, etc.

Various software products, including web-oriented ones, are being developed in the field of automated formation of agricultural technologies and technical support.

At the Irkutsk State Agrarian University (Borkhoshkin O V) has developed a software package that provides the use of various crop cultivation options in the complex. The number of these options depends on the definitions of agricultural practices, their resource provision, soil and climatic conditions of fields, varieties and the level of programmed yield [9].

At the Kurgan Research Institute (Stepnyh N V, Zargaryan A M, Zhukova O A) has created a knowledge base, formalized mainly in natural verbal language in the form of agronomic reference. It is posted on the institute's website and includes the following information: description of crops; characteristics of soils; terms of sowing crops; seeding rates; characteristics of varieties; description of methods of tillage, sowing and harvesting; recommendations for calculating fertilizer doses; description of weeds; description of crop diseases; description of pests and other materials [10].
In the works of Gostev A V, Pyhtin A I and Lyubitsky N I each agrotechnological technique (in the process of adapting agrotechnologies to the prevailing natural and climatic features of the landscape) is evaluated according to the expediency of its application to current conditions, taking into account knowledge about the history of field management and its current state. The scientifically-based selection of the most rational fertilizer system for the cultivated crop is a multi-stage process. It consists in the selection of organic and mineral fertilizers, as well as meliorants based on the analysis of current soil-climatic and agrotechnological conditions using the calculated method of element balance based on the supply of nutrients in the soil and the economic removal of nutrients by agricultural crops. The selection of the most optimal method of basic tillage is also carried out on the basis of an analysis of soil-climatic and agrotechnological conditions (taking into account the granulometric composition of soils, soil density values, the method of soil treatment for the previous crop, the likelihood of erosion processes, field contamination, etc.). Thus, key agrotechnological techniques are formed (fertilization, as well as basic tillage, which are subsequently superimposed with such agricultural practices as seed pickling, sowing, plant protection measures and harvesting) with the help of the developed algorithm [11].

The computer program “Designing technologies for growing crops” was developed by Stepnykh N V, Nesterova E V, Zargaryan A M. It is intended for the development of technological maps and crop production planning. With its help, calculations of enlarged cost standards for related technological operations are carried out. Standard technological maps are taken to create enlarged standards. They set scientifically based parameters of technological operations (seeding rates and seed depth, doses of fertilizers and plant protection products, and others). Using the database information, the web application calculates and generates a table on the economic efficiency of crop cultivation technologies according to the following indicators: material and monetary costs, cost, profit, profitability, marginal income, break-even point for crop yield. The obtained indicators allow us to compare and choose the most effective technologies. To develop a crop production plan, the program “Designing technologies for growing crops” should be used, in which technological maps are calculated and tables of the production plan are created on their basis (gross harvest, crop area, yield, need for seeds, fertilizers, plant protection products, fuel, electricity, wages with accruals, costs, profit) [12].

As can be seen from the analysis of the available software tools for automated selection of technologies and technical means in crop production, many factors that significantly affect the solution of the problem are taken into account. However, it is also necessary to take into account specific phytosanitary and production conditions of the economy and significant environmental factors of the given territory. It is necessary to solve individual tasks for choosing a variety of cultivated crops in relation to specific soil-climatic and natural conditions, the method of sowing (planting), optimal timing of work, effective schemes for the use of fertilizers, chemicals, the choice of complexes of machines that ensure high-quality and high-performance performance of work, the choice of the most rational forms of organization of production work and accounting for the costs of performing the entire complex of work [13, 14].

Thus, for the effective cultivation of grain crops, it is necessary to have modern technical means of computer-aided design and monitoring of agricultural technologies, through the development of flexible algorithms and the creation of software tools based on the theory of data processing and knowledge.

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