# Agroclimatic peculiarities of the farm at annual work planning: Web-application

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**Abstract.** The article considers external factors such as weather, climate, and soil composition that affect agricultural production and crop yields. The author studies technologies, sequences of various technological operations and timing of their implementation depending on agro-climatic conditions of the farm and biological requirements of cultivated crops. The article considers technologies for the cultivation of crops considering factors that are variable in time and space. It is worth considering the soil and climatic potential and the level of the farm, and the regularity of interaction of machine and tractor fleet, arable land, and human resources. The author raises questions of efficiency in the choice of technology system for a particular farm through the application of information systems of smart agriculture. The article has a structural scheme of the process of selection of technologies and technical means of grain crops. The author shows the feasibility of developing a web-oriented software complex of automated selection of agro-technologies and machine and tractor fleet of the farm, providing accounting and operational processing of information characterizing factors, conditions, and features of production. The analysis of scientific and methodological components of grain crop cultivation technologies helped in the formation of the structural scheme of the web-oriented software complex. The article presents the results of the program complex. Automating the technology selection process, creating an annual work plan, and calculating economic indicators can be achieved through implementing the program complex. Producers of crop products can use the program complex as a decision support system.

## 1 Introduction

The key feature of agricultural production is its dependence on natural external factors such as weather, climate, soil composition and so on. Unfavorable weather phenomena effect yields, increasing the risk of crop loss and, as a result, the volume of sales of products and hence profit. Changes in crop yields from year to year reach 30-50% of the average annual level, and every ten years 2-3 years are unproductive [1]. Severe frosts, insufficient snow cover on the fields, droughts, hail and other natural phenomena can cause significant damage to crop production [2, 3].

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Another feature of agriculture is the biological nature of the inputs, and outputs used. Agroclimatic conditions of the farm location and biological requirements of cultivated crops largely determine technologies, sequence of technological operations and terms of their fulfillment. Violation of these conditions leads to an increased risk of yield loss. Delayed sowing or early sowing, as well as damage from diseases and pests, violation of harvesting dates leads to a significant yield shortfall and increased costs [4, 5, 6].

The spatial extent of production complicates control, and untimely or low-quality work entails additional risks. Grain crop farms, as a prospect of production development consider modern farming systems. They are characterized by the efficiency of natural resources use because of the integrated consideration of soil, natural-climatic, phytosanitary and production conditions of the farm. But low implementation of such farming systems is because of the lack of information about the possibility of their application in the conditions of a particular farm [7, 8, 9].

Annual work planning includes crop selection, determination of cultivation technology, sowing and harvesting dates, necessary crop care operations, etc. The cultivation technologies of crops and agricultural production are primarily determined by the agrotechnical requirements of a scientifically based farming system. The technology-oriented processes of crop cultivation rely on the effective supervision of equipment and tractor units [10].

The distribution of phytophages in soil layers depends on the methods of cultivation during crop cultivation and predecessors, and the number of weeds and their viability depends on the depth of tillage and the thickness of wrapped layers [11, 12]. The agroclimatic features of the farm location and soil factors, such as field contour and relief, and the length of the race, influence the composition of the machine and tractor fleet.

The choice of a variety of technologies is associated with several factors that are variable in time and space. It is necessary to consider the soil-climatic potential and farm level, as well as the regularity of interaction of machine and tractor fleets, arable land, and human resources [13].

The formation of cultivation technology is to consider the factors affecting the yield and quality of the resulting products (Figure 1). Environmental and economic requirements for production are of great importance. The adaptation of technological operations to the natural and production conditions of a specific farm involves considerations such as the equipment available, the level of production intensification, the availability of seeds and means of protection, and other relevant factors.

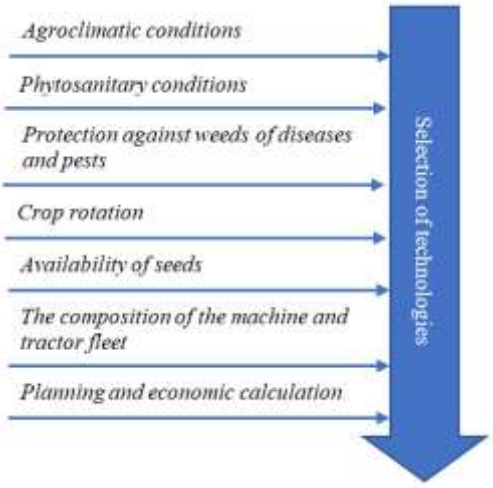


**Fig.1.** Influence of various factors on the choice of technologies.

Decision-making on the choice of technology system for a particular farm involves analyzing large amounts of data. Improving the efficiency of such decision-making involves the introduction of information systems for smart agriculture.

Introducing digital technologies in the agricultural sector allows for increasing productivity, reduce costs and reduce labor requirements [14, 15]. Digitalization of all agricultural systems is possible through introducing innovative (emergent) technologies (artificial intelligence, robotics, internet of things, drones, etc.) and new hardware, software, mobile applications, sensor technologies, and big data processing systems [16, 17, 18].

The purpose of the research is to analyze the factors influencing the choice of cultivation technologies for grain crops, and to develop a software package to support decision-making in the development of an annual work plan for crop production.

## 2 Research methodology

The object of research is the processes of systematization, accumulation and dissemination of data and knowledge in the selection of technologies and technical means in the production of grain crops. The author used information and analytical methods, system approach, logical and mathematical analysis of materials, methodologies for the development of algorithms, database structure, and software.

## 3 Research results

An enlarged structural diagram (Figure 2) can depict the technical means selection process for cultivating grain crops.

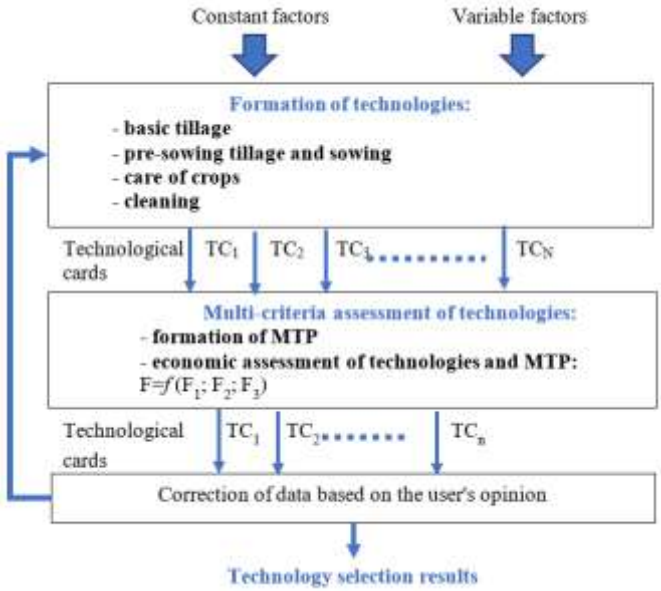


**Fig. 2.** Structural scheme of the process of technology and technical means selection.

Permanent factors include the agroclimatic zone of farm location, production orientation, the configuration of fields and their area, the composition of the farm's machine and tractor fleet, crops, crop rotation, etc. The variable factors include agroclimatic characteristics of the zone (amount of precipitation, temperatures, crop varieties, the need to use protection and

fertilizer, etc.). Variable factors include agroclimatic characteristics of the zone (sum of precipitation, temperatures), varieties of crops, the need for the use of protective equipment and fertilizers, etc. [19].

In the study's course, to automate the selection of technologies and technical means, the author created a structural diagram of software as a Web-based software package for the selection of technologies and technical means (Figure 3).

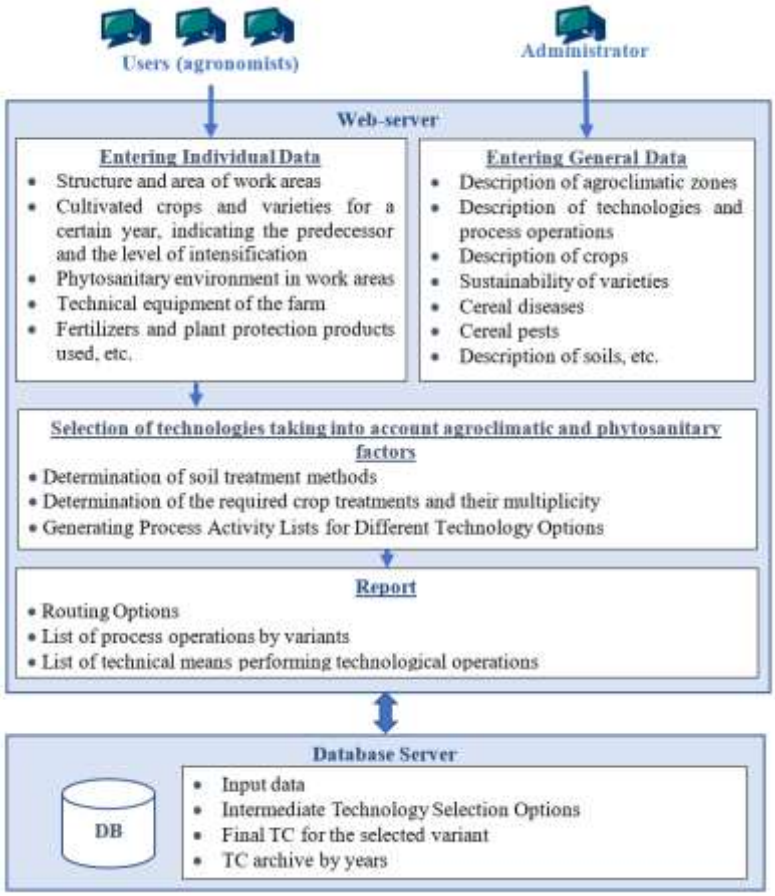


**Fig. 3.** Structural diagram of Web-oriented program complex on the selection of technologies and technical means.

To select technologies for grain crops cultivation, the user (agronomist) needs to enter initial data individual for the farm: agroclimatic zone of farm location, number of working plots with their description, year of harvesting, predecessor for each working plot, varieties of cultivated crops, etc. The selection of technologies should be based on the register of technologies stored in the database (DB) about the natural-climatic zone, soil composition and level of intensification.

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To select the variant of technical means use it is necessary to enter the following data: availability of equipment (tractors, combines, agricultural machines), mechanizers, cost of fuel and lubricants, tariff rates, information on faulty equipment (if necessary), agro-climatic terms of technological operations, etc. The tractor fleet is calculated for the variants of technologies got at the selection stage.

Calculation of tractor fleet is carried out for technology options got at the selection stage.

Web-application forms variants of machine and tractor fleet utilization, considering agro-climatic conditions of farm location, relief of fields, and availability of personnel. The selection of the variant is based on the economic-mathematical model. The criteria of optimality are the minimum of direct operating costs, the minimum of mechanizers and the minimum of fuel and lubricants [20].

The author tested the work of the software on the example of the north-forest-steppe zone of the Novosibirsk region (Russian Federation) with plakorny lands, sod-podzolic, and sod-podzolic gley soils. The program complex because of work has received a variant of selection of technologies for wheat cultivation with normal level of intensification for four working plots with different forerunners (Table 1) and has formed a variant of use of machine and tractor fleet, considering agroclimatic conditions of farm location, relief of fields and availability of personnel (Table 2). The outcomes of equipment selection lead to the creation of technological maps, along with several schedules, such as cost summaries, machinery usage, and a calendar schedule for job execution.

**Table 1.** Result of the selection of technology options by the application.

| Technology options | Technology Description |
|---|---|
| **2022/Normal/Wheat/Grain** | |
| Spring wheat by grain | Plowing to a depth of 20-22 cm |
| | Cultivation |
| | Sowing spring. The timing of sowing spring crops is early |
| | Herbicidal treatment - spraying crops against cereal weeds |
| | Spraying with insecticides against pests of generative organs of grain crops |
| | Field Skid and Pens Breakdown |
| | Direct combing with straw digging |
| **2022/Normal/Wheat/Perennial** | |
| Spring wheat on perennial herbs | Plowing to a depth of 20-22 cm |
| | Cultivation |
| | Sowing spring. Sowing time of spring crops - average |
| | Herbicidal treatment - spraying crops against cereal weeds |
| | Spraying with insecticides against pests of generative organs of grain crops |
| | Field Skid and Pens Breakdown |
| | Direct combing with straw digging |
| **2022/Normal/Wheat/Row** | |
| Spring wheat on row crops | Plowing to a depth of 20-22 cm |
| | Cultivation |
| | Sowing spring. Sowing spring. The timing of sowing spring crops is late |
| | Herbicidal treatment - spraying crops against cereal weeds |
| | Spraying with insecticides against pests of generative organs of grain crops |
| | Field Skid and Pens Breakdown |
| | Direct combing with straw digging |
| **2022/Normal/Wheat/Steam** | |
| Spring wheat steamed | Harrowing with steam and chick harrows |
| | Cultivation |
| | Sowing spring. The timing of sowing spring crops is early |
| | Herbicidal treatment - spraying crops against cereal weeds |
| | Spraying with insecticides against pests of generative organs of grain crops |
| | Field Skid and Pens Breakdown |
| | Direct combing with straw digging |

*Labeling the technological maps in the format Year/ Intensification level/ Crop/ Predecesso

**Table 2.** Option for using the machine and tractor fleet.

| **Tractors/combines are required for the selected technology option:** | |
|---|---|
| JD 8335R | 4 |
| JD 9470R | 4 |
| JD 4730 | 3 |
| Acros-595 Plus | 2 |
| JD W650 | 2 |
| **as well as agricultural machinery** | |
| Kverland RM100 8 | 3 |
| Carrier 1225 | 2 |
| Rapid-800 | 2 |
| Rapid-600 | 1 |
| JD 625D | 2 |
| Degelman 7000 | 1 |

Table 2 presents an example of forming a flow chart for one work area.

**Table 3.** Example of forming a flow chart.

| **Process operation** | **Sq., ha** | **Start date-End date** | **Days** | **Machine-tractor unit** | **Count** | **Costs, RUR** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Salary** | **Fuel and lubricants** | **Maintenance and repair** | **Depreciation** | **Overall** |
| Plowing | 800 | 06.05.2022 15.05.2022 | 10 | JD 8335R Kverland RM100 8 | 3 | 150960 | 2046,528 | 960,3422 | 63082,36 | 217049,2 |
| Cultivation | 800 | 16.05.2022 25.05.2022 | 10 | JD 9470R Carrier 1225 | 1 | 10368 | 60,18 | 121,7628 | 11043,98 | 21593,92 |
| Sowing spring. Early | 800 | 16.05.2022 25.05.2022 | 10 | JD 9470R Rapid-800 | 1 | 32960 | 80,58 | 182,5201 | 16322,47 | 49545,57 |
| Herbicidal treatment | 800 | 26.05.2022 05.06.2022 | 11 | JD 4730 | 1 | 9856 | 11,22 | 326,6704 | 48020 | 58213,89 |
| Spraying with insecticide | 800 | 06.06.2022 15.06.2022 | 10 | JD 4730 | 1 | 9856 | 11,22 | 326,6704 | 48020 | 58213,89 |
| Field Skid and Pens Breakdown | 80 | 01.09.2022 15.09.2022 | 15 | Acros-595 Plus | 1 | 2496 | 47,124 | 96,6674 | 14016,67 | 16656,46 |
| Direct combing | 800 | 01.09.2022 15.09.2022 | 15 | JD W650 JD 625D | 1 | 24960 | 107,1 | 188,0387 | 28102,56 | 53357,7 |

## 4 Conclusion

Realization of the program complex will automate the process of technology selection, formation of the annual work plan, and calculation of economic indicators.

When working with the software package, there is an opportunity to analyze several options of technologies and technical means, which will allow the agronomist, as a decision maker, to choose one or another option. The program complex allows:

- choose technologies of grain crops cultivation in soil and climatic zones considering the limitations (crop, level of intensification, precursor, soils, agrotechnical terms, moisture conditions and the sum of temperatures of the vegetation period);
- select variants of technical means use for different technologies of crop production in the enterprise;
- calculate operating costs;
- determine the quantitative composition of the required equipment and mechanizers to perform the required amount of work;

- form technological maps with the selected variant of technical means.

We can use the software system in crop production as a decision support system.

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