Increasing gross grain harvest in the southern forest-steppe zone of the Novosibirsk region

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Abstract. The article analyzes the features of grain production in the Novosibirsk region of Russia. The authors analyzed the development of innovative technologies in farms. Unfortunately, extensive technology is still the most common. In the Novosibirsk region, 60% of agricultural enterprises use extensive technology and create 49% of the gross grain harvest with an average yield of 14.3 hundredweight/ha, 20% of farms create 26% of the gross grain harvest with a yield of 23.3 hundredweight/ha, 11% of farms create 21% of the gross grain harvest with a yield of 33.4 hundredweight/ha. The authors chose the Novomayskoye farm in the southern forest-steppe zone of the Novosibirsk region as a model. The simulation results were tested in practice, they showed that the transition to intensive technology with direct seeding (No-till) required an increase of 1.5 times the technical support and costs for mineral fertilizers and plant protection products, i.e. from 6 thousand rubles/ha of wheat crops to 9 thousand rubles/ha (in 2020, 1 USD≈65 Rub), but this allowed to reduce fuel consumption by 30–35% and the need for machine operators by 1.7–2 times.

1. Introduction

Production intensification is an economic process based on advanced achievements and more effective use of technical, material, labor, and information resources, as well as a higher level of production organization. Scientists show their interest in scientific and technical progress in crop production in many publications [1 –4]. The growth of crop yields and increase in their production is influenced by:

- selection of the technological map and the set of available resources [5–7];
- costs that a farmer can afford [8–11];
- management decisions, including the use of operational information [12, 13];
- formed machine and tractor fleet [14–17].

Thus, the change in cultivation technology leads to changes in resource requirements for production and production volumes. The purpose of this paper is to analyze this transition and justify the need for new wheat production technologies for the southern forest-steppe zone of the Novosibirsk region of Russia.

2. Materials and methods

2.1. Features of grain production in the Novosibirsk region of Russia
The Novosibirsk region is located in Russia in the South-East of the West Siberian plain. According to the Ministry of agriculture of the Novosibirsk region in 2019, the farms of the Novosibirsk region sown area was 2225.7 thousand hectares, including cereals and legumes sown 1416 thousand hectares. When sowing these crops, 271 thousand tons of seeds were used, their air-conditioning capacity was 97.3%. The share of original and elite seeds in the total volume of sown seeds – 8.2%, reproduction seeds – 47.5%. The gross harvest of grain in weight after completion in farms of all categories was 2431.5 thousand tons (97.5% compared to the level of 2018) with a yield of 17.2 hundredweight/ha [18].

In the southern forest-steppe zone, about 24% of agricultural enterprises have an area of grain crops from 6 to 16 thousand hectares, they specialize in the production of grain crops and dairy and meat cattle breeding. These are fairly large agricultural enterprises with a population of 2000 cattle, including a herd of 950 dairy cows. The size of the field is from 60 to 120 ha, the length of the rut is more than 1000 m, the distance of transportation is 33 km.

Extensive (herbicide-free) technologies are a system for obtaining grain with the maximum use of available soil fertility without restoring it. Normal technologies maintain a level of chemicals that allows the development of soil protection systems of agriculture, the average level of soil cultivation, they can eliminate the deficit of mineral nutrition elements that are at a critical minimum, and give a satisfactory product quality (i.e., a yield of 18–22 hundredweight/ha).

Intensive technologies are used to obtain the highest possible yield of high quality in the prevailing meteorological conditions in a given field. Their implementation requires continuous management of the production process of agricultural crops, which will ensure optimal mineral nutrition of plants and protection from harmful organisms and lodging. For intensive technologies, it is necessary to use intensive varieties and create conditions for more complete realization of their biological potential (then it is possible to yield more than 32 hundredweight/ha). These technologies can be based on dump plowing, on the basis of free-fall loosening, and on the basis of minimal and zero tillage. The element of intensive "No-till" technology is direct seeding.

The authors also highlight a haphazard technology that is used in some farms of the Novosibirsk region, it has no scientific justification and regularities in the stages.

Let's analyze the use of these technologies in the Novosibirsk region (table 1).

Table 1. Grouping of agricultural organizations and farms in the Novosibirsk region on the use of advanced technologies for the production of cereals and legumes.

| Technologies                        | Agricultural organizations, number | Farms, number | Application of technologies on acreage tons of ha |
|-------------------------------------|-----------------------------------|---------------|-----------------------------------------------|
| Extensive                           | 255                               | 686           | 1277                                          |
| Normal                              | 72                                | 108           | 402                                           |
| Intensive                           | 30                                | 16            | 281                                           |
| Intensive with elements of precision farming | 3                                 | 0             | 24.8 (ha)                                     |
| Unsystematic                        | 55                                | 98            | 213                                           |
| Total                               | 412                               | 908           | 2173                                          |
| Of them, with the "No-till"          | 32                                | 20            | 126.0                                         |
In total, in the Novosibirsk region, most of the acreage is cultivated using extensive technologies. Although there is the use of intensive technologies with elements of precision farming.

2.2. Methods
The prediction method of the variations of annual field work complexes is the basis of the method for substantiating the perspective compositions of a machine and tractor fleet of model farms. The principle of forming annual field work complexes is described in the authors’ article [19].

Calculations can be performed for a model of agricultural enterprises that contains characteristics typical for most farms in the Novosibirsk region. The southern forest-steppe zone affects the choice of crop rotation, productivity and recommended technological maps of crop production.

Part of the values are given in the Russian Rubles (in 2020, 1 USD≈65 Rub).

3. Results and discussion
The Novomayskoye farm of the Krasnozersky district of the Novosibirsk region was taken as a model. The farm has the following structure of acreage: total crops – 20529 ha, including cereals – 15822 ha: spring wheat – 12493 ha, spring barley – 932 ha, spring oats – 953 ha, legumes (peas) – 1444 ha, annual grasses – 790 ha, perennial grasses – 1878 ha, pairs – 2039 ha. There are 4 John Deere tractors of the ninth series, one HewHolland and one K-744R tractors, 18 MTZ-80 and MTZ-82 tractors, 4 sowing complexes and 3 trailer sprayers in the machine-tractor fleet for grain cultivation. Over the past four years, the yield of wheat was from 17 to 24 hundredweight/ha. With such a yield, it is impossible to create after harvesting the necessary layer of crushed straw to cover the field to protect the soil from moisture loss.

The farm used normal technology, but it was necessary to switch to intensive technology with a yield of 32-34 hundredweight/ha, requiring other technical and technological support (timing of field work, nutrition and plant protection). The authors modeled the structure of the machine and tractor fleet based on the prediction method of the variants of annual field work complexes [2]. The technological support is based on the recommendations of the Institute of agriculture and chemization of the Siberian Federal scientific center for agrobiotechnologies of the Russian Academy of Sciences. The authors assessed the need for tractors and combines (table 2).

| Brands of equipment                | Need, units |
|------------------------------------|-------------|
| JohnDeere                          | 6           |
| NewHolland                         | 1           |
| MTZ -80 /82                        | 5           |
| John Deere seed complexes          | 6           |
| John Deere 4730 self-propelled sprayer | 1           |
| OP-2000 sprayer                    | 5           |
| Hardi Navigator 300 sprayer        | 1           |
| Amazone UX5200 sprayer             | 1           |

The cost of protective equipment amounted to 9063.83 rubles/ha, the remaining costs are shown in table 3.
Table 3. Operating costs for wheat cultivation using intensive technology with "No-till".

| Types of costs                        | Cost, thousand rubles |
|--------------------------------------|-----------------------|
| Fuels and lubricants                 | 7058.057              |
| Salary                               | 198.154               |
| Depreciation and maintenance         | 17647.587             |
| Purchase of protective equipment and fertilizers | 113225.728        |
| Buying seeds                         | 39679.017             |
| Total costs                          | 177808.500            |
| Cost per ha                          | 14.232                |
| Machine operators, people            | 12                    |

Sowing complexes worked on satellite navigation in two shifts and sowed 200 hectares per day, while K-744R3 with SZP-3.6 seeders sowed only 50 ha per shift. The transition to intensive technology with direct seeding (No-till) required an increase of 1.5 times in technical support and costs for mineral fertilizers and plant protection products: from 6 thousand rubles per 1 ha of wheat crops to 9 thousand rubles per 1 ha. In 2019, Novomayskoe farm received a wheat crop of 24 hundredweight/ha. At the same time, the transition to intensive technology with direct seeding allowed to reduce fuel consumption by 30 – 35% and reduce the need for machine operators by 1.7 – 2 times. The neighboring farm of Alexander Weiss followed the example of the farm "Novomayskoe", it was able to get a wheat yield of 34 hundredweight/ha using intensive technology with direct seeding (No-till).

Thus, intensive technologies ensure maximum crop yield and maximum gross harvest. The use of unsytematic technologies, the lack of calculations of the composition of the machine and tractor fleet leads to losses. For example, in 2017, farms in the Novosibirsk region lost 6 hundredweight of crop per hectare of wheat due to a lack of sprayers.

4. Conclusion
The most common technology of grain crops in the Novosibirsk region is extensive. Scientists come to the aid of agricultural producers and calculate the optimal structure of crops and machine and tractor fleet. Calculations for the Novomayskoe farm as a model were used in production and tested in practice. To achieve maximum productivity, it was necessary to increase technical support, costs for mineral fertilizers and plant protection products.

When switching from normal grain cultivation technology to intensive technology with "No-till", it is necessary to create a layer of straw and cover the field with it after harvesting the grain. When switching to intensive technology, the cost of chemical treatment was 9-10 thousand rubles per 1 ha of wheat crops, and the load on one tractor is 2 thousand hectares of wheat crops for a 10-day sowing period.

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