The role of an agricultural forecrop in increasing the yield of winter wheat

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Abstract. The article presents data on the study of the influence of an agricultural forecrop on the yield of winter wheat varieties Moskovskaya 40 and Nemchinovskaya 17. The experiments were carried out in Ryazan region, Russia, on dark gray forest soils of Malinki enterprise in Mikhailovsky district. The most effective forecrop in the experiment was vetch-oat mixture for variety Nemchinovskaya 17, with the following yield structure: grains per spike are 46.8 pieces, 1,000 seeds weight is 50.4 grams, with productive tillering of 1.80. On average, for two years, the maximum yield was observed in the variant with variety Nemchinovskaya 17 according to forecrop of vetch-oat mixture for green fodder (44.4 dt/ha) and in the variant with variety Moskovskaya 40 a forecrop was pea-oat mixture for green fodder (41.1 dt/ha). In studies, the maximum profitability was noted on the variant with forecrop of vetch-oat mixture in variety Nemchinovskaya 17 (153.1 %). In general, the profitability of the options was 109.5-153.1 %, that is highly profitable for agricultural crops in the region.

1. Introduction

Winter wheat grows on fertile soils, therefore it needs more mineral nutrition. With a balanced diet, the yield of winter grain is larger compared to spring grain. This is also influenced by the longer growing season. Winter varieties consume autumn-winter precipitation [1, 2]. The rapid growth of the crop contributes to the fight against weeds in the autumn, although modern technologies allow fighting in the fall with such malicious weeds as penny cress, bedstraw, field thistle, bindweed and others [3].

Since the beginning of 1991, about 40 million hectares of arable land and about 30 million hectares of meadows and pastures have been withdrawn from the crop rotation in Russia, that affected the gross grain harvest and deterioration in dual-purpose cattle. Wheat is capable of producing higher and more stable yields over the years compared to other crops [4, 5, 6]. The area of winter wheat in Russia varies from 8 to 12 million hectares from year to year. Ryazan region has about 450 thousand hectares.

The importance of increasing the grain yield of winter crops and improving the quality of products is currently of great importance in agricultural production. The solution to this problem is in the use of regional science-based innovative technologies for crops growing [7]. Winter and spring grain crops have still unstable yields in Ryazan region, largely due to insufficient use of soil and climatic conditions, as well as advanced experience and modern science.
Weather conditions of Ryazan region, especially the amount and time of precipitation, are very unstable both over the years and during the growing season. Therefore, in order to stabilize the gross harvest of food grain in the regional farms, the number of grain crops and the number of varieties for each of them should be increased. To obtain a high yield of high quality, it is necessary to observe the technology of growing crops [8, 9].

So, the arable area allotted for winter wheat in Ryazan region in 2019 was 312.4 thousand hectares and in 2020 it was 312.2 thousand hectares. At the same time, the average yield in the region was 34.4 dt/ha in 2019 and 47.2 dt/ha in 2020. The gross harvest of winter grains in the region in 2020 was 1,512.3 thousand tons, that was 419.1 thousand tons more than in 2019.

The measures used when growing winter wheat should be aimed, first of all, at improving these particular factors. This is achieved by the use of the best fore crops, differentiated tillage, the use of calculated levels of mineral nutrition, sowing at the optimum time [10]. The correct use of these elements in production technology will stimulate high yields of wheat.

The most important agrotechnical measures in obtaining high stable yields of winter crops are effective fore crops, correct soil cultivation, adherence to sowing dates, crop care, fertilization, etc.

The role of fore crops in the formation of grains with a high gluten content is clearly manifested. The best forecrop is black and well-fertilized fallow. Clover of the first year of use, peas for grain, early potatoes, corn for early silage are also often used as fore crops. The study of the role of the forecrop in the technology of growing winter wheat determined the direction of this research.

2. Materials and methods
The purpose of the research is to study the effectiveness of the choice of an agricultural forecrop and the effect on the yield of winter wheat in the technology of cultivation in the conditions of Ryazan region.

The studies were carried out in 2018-2020 on the fields of Malinki agricultural enterprise in Mikhailovsky district of Ryazan region.

The research included improving the technology of winter wheat cultivation adopted in the farm, developing agrotechnical measures and recommendations for increasing the yield and quality of winter wheat due to the most economically and agronomically effective choice of a forecrop.

Agrochemical properties of dark gray forest soil in the farm were as follows: humus - 3.9-4.1 %, higher than average values of phosphorus (165-174 mg/kg of soil) and potassium (132-141 mg/kg of soil), exchangeable acidity was 5.7.

Agrotechnical measures for growing winter wheat are generally accepted for the conditions of the region. The term for sowing winter wheat is the third decade of August - early September. The forecrop according to the scheme of the experiment is as follows: vetch-oat mixture, spring barley, peas-oat mixture, early potatoes, spring cereals.

The seeding rate is 5.1 million pcs. of germinating seeds/ha. The total area of the plot is 220 m², the accounting area is 180 m². The replication is fourfold.

The object of research is varieties Moskovskaya 40 and Nemchinovskaya 17.

In the genotype of varieties, Moskovskaya 40 and Nemchinovskaya 17, there is breeding material from Russia, Ukraine, Brazil, India, Italy, Poland, Japan, including the most common varieties such as Bezostaya 1 and Mironovskaya 808, which increases their adaptability.

The counts and observations during the growing season for winter wheat were carried out on the basis of generally accepted methods.

3. Results
The objective of the research was to improve the technology of cultivating winter wheat, adopted at the agricultural enterprise, to develop agrotechnical measures and recommendations for increasing the yield and quality of winter wheat. Despite significant shortcomings in the technology of growing winter wheat at the farm, there are reserves for increasing yields, but for this it is necessary to consider a number of features including accurate implementation of crop rotations developed at the farm. Winter
wheat is characterized as being selectively demanding on its fore crops. Data on the elements of the yield structure and the yield of winter wheat are presented in Tables 1, 2.

Table 1. Elements of the yield structure of winter wheat varieties depending on fore crops

| Variant                     | The number of grains per ear, pcs. | Weight of 1,000 grains, g | Productive tilling capacity |
|-----------------------------|------------------------------------|---------------------------|-----------------------------|
|                             | Moskovskaya 40                      | Nemchinovskaya 17         | Moskovskaya 40              | Nemchinovskaya 17          |
| Vetch-oats green forage     | 45.7                               | 46.8                      | 46.3                        | 50.4                        | 1.86                       | 1.80                       |
| Peas-oats green forage      | 45.6                               | 43.9                      | 48.0                        | 49.6                        | 1.70                       | 1.66                       |
| Barley                      | 42.9                               | 44.1                      | 45.5                        | 47.0                        | 1.51                       | 1.53                       |
| Early potatoes              | 43.0                               | 44.6                      | 45.3                        | 46.8                        | 1.53                       | 1.50                       |
|                             | 2019                               | 2020                      | 2019                        | 2020                        | 2019                       | 2020                       |
| LSD<sub>0.05</sub> by factor A | 0.19                              | 1.20                      | 0.33                        | 0.45                        | 1.12                       | 0.90                       |
| by factor B                 | 1.03                               | 1.34                      | 1.55                        | 0.96                        | 1.24                       | 1.05                       |
| AB interaction              | 1.77                               | 1.56                      | 1.63                        | 1.03                        | 1.36                       | 1.18                       |

According to the results of the field experiment carried out at plots of Malinki enterprise of Ryazan region in the years under study, the following fore crops were used: vetch-oats mixture, barley, peas-oats mixture, early potatoes, spring cereals.

Analyzing the tables, the most effective forecrop for wheat yield was legume-oats mixtures for green fodder. Legume-oats mixtures favorably influenced not only the studied crop, but also increased the yield of subsequent crops, reduced weeds in the fields, ensured the phytosanitary state of subsequent crops in the aftereffect.

The yield was mainly achieved due to an increase in such structural elements as the number of grains in an ear and productive tilling capacity of the crop, the maximum indicators of which were noted in the variant with vetch-oats mixture + variety Nemchinovskaya 17, having the following indicators: grains in an ear - 46.8 pieces, weight of 1,000 seeds - 50.4 grams, productive tilling capacity of 1.80.

Table 2. The influence of fore crops on the yield of winter wheat varieties, dt/ha

| Variant                     | Yield, dt/ha |
|-----------------------------|--------------|
|                             | 2019         | 2020         | Average     |
|                             | Moskovskaya 40 | Nemchinovskaya 17 | Moskovskaya 40 | Nemchinovskaya 17 | Moskovskaya 40 | Nemchinovskaya 17 |
| Vetch-oats green forage     | 33.6         | 39.2         | 45.1        | 49.6         | 39.3         | 44.4         |
| Peas-oats green forage      | 35.8         | 37.6         | 46.4        | 45.1         | 41.1         | 41.3         |
| Barley                      | 30.7         | 34.0         | 43.6        | 44.6         | 37.1         | 39.3         |
| Early potatoes              | 34.1         | 32.2         | 42.4        | 45.2         | 38.2         | 38.7         |
| LSD<sub>0.05</sub> by factor A | 3.29        | 2.99         | 3.29        | 2.99         | 3.29        | 2.99         |
| by factor B                 | 2.33         | 2.11         | 2.33        | 2.11         | 2.33        | 2.11         |
| AB interaction              | 4.65         | 4.23         | 4.65        | 4.23         | 4.65        | 4.23         |
On average, for two years, the maximum yield was observed on the variants with variety Nemchinovskaya 17 with forecrop vetch-oats mixture for green fodder (44.4 dt/ha) and Moskovskaya 40 variety with forecrop peas-oats mixture for green fodder (41.1 dt/ha).

Spring crops, including barley, are satisfactory forecrops and after barley wheat yields are low. As an improvement in the technology of winter wheat cultivation at the farm, complete and full fallows can be recommended as a forecrop. A promising technique for increasing the sustainability of agriculture is plowing green manure crops for fertilization. For green fertilizer, one can use plants of the legume family (lupine, sweet clover), as well as the cabbage family (rapeseed, white mustard, oil radish). The use of leguminous crops as embedding in the soil contributes to accumulation of biological nitrogen in the soil and provides an increase in the yield of the main crop and subsequent ones. Therefore, instead of black fallow (without manure), it is advisable to use green manure.

It is stated that the yield of the studied crop largely depended on the quality of the forecrop. It is recommended to harvest fallow crops a month before the generally accepted date for sowing winter wheat in Ryazan region, that is, from August 25 to September 15. Only if the timing of the harvesting of the forecrop is observed, a thorough tillage is achieved with the implementation of all the necessary agrotechnical methods of pre-sowing soil cultivation. In the case of barley, as a forecrop, the interval between harvesting and sowing winter wheat is less than a month.

4. Conclusion
Thus, the most effective variant in the experiment was a forecrop of vetch-oats mixture for variety Nemchinovskaya 17, with the following yield structure: grains per ear - 46.8 pieces, weight of 1,000 seeds - 50.4 grams, productive tilling capacity - 1.80.

On average, for two years, the maximum yield was observed on the variant with variety Nemchinovskaya 17 with a forecrop of vetch-oats mixture for green fodder (44.4 dt/ha) and variety Moskovskaya 40 with a forecrop of peas-oats mixture for green fodder (41.1 dt/ha).

Analyzing the economic efficiency, one can note that an increase in economic indicators occurs due to an increase in the yield. Studies have shown that the cultivation of winter wheat using improved technology is a more highly profitable production, having the maximum profitability with a forecrop of vetch-oats mixture for variety Nemchinovskaya 17 (153.1 %). In addition, the implementation of measures to increase yields at the farm, contributes to improving the quality of grain crops.

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