Influence of the main elements of winter wheat cultivation technologies on its productivity in the Kursk region

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Abstract. Wheat (Triticum aestivum L) is one of the most valuable and highly productive grain crops in Russia. Wheat bread is high in protein and carbohydrates. The climate and soil, as well as the cultivation technology, have a great influence on these indicators in grain. Winter wheat is the main and most productive grain crop in the Kursk region, which occupies 40-45% of the grain wedge area. Over the past 30 years, its yield has been higher than that of other cereals. However, the productivity of winter wheat largely depends on overwintering. The main purpose of winter wheat is to provide the population with bakery and confectionery products. The value of wheat bread is determined by the peculiar chemical composition of the grain. Among cereals, wheat grain is high in protein. Its presence in grain depends on the variety, cultivation conditions and can be at the level of 9-15%. Wheat grain contains a large amount of carbohydrates, including up to 70% starch, vitamins B1, B2, PP, E, as well as provitamins A, D, up to 2% ash minerals. Wheat proteins contain a complete amino acid composition, all essential amino acids that are well absorbed by the human body. The amount of proteins and starch in wheat grain is in a ratio of about 1: 6 - 7, which is most favorable for maintaining a normal body weight and working capacity. Wheat bread has a high calorie content - 1 kg of it contains 2000 - 2500 calories, which confirms its high nutritional value as an important source of energy. The bulk of wheat grain is carbohydrates. They are represented mainly by starch (48-63%). Carbohydrates are of great energy value in human nutrition. In addition to carbohydrates and starch, grain contains 2-7% sugars (mainly in the germ), as well as 2-3% fiber. Fiber does not dissolve in water and is not absorbed by the body. When making flour, it remains in the bran. Fat makes up an average of 2% in a grain of wheat and is found in the germ and aleurone layer.

The potential of winter wheat is far from being fully exploited. To realize the potential productivity of winter wheat, strict adherence to modern resource-saving environmentally friendly cultivation technologies is necessary, including the selection of winter-hardy, highly productive, lodging-resistant varieties, the placement of crops according to the best predecessors, compliance with the sowing time and soil cultivation techniques [1,2,8].

A comprehensive study of the requirements of cereals for life factors is the basis for the development of high-yielding resource-saving technologies.
Table 1. Soil density depending on the methods of basic tillage and the predecessor.

| Experience options        | Layer depth, cm | Pure fallow | Barley |
|---------------------------|----------------|-------------|--------|
|                           |                | Sowing      | Harvesting | Sowing | Harvesting |
| Plowing to a depth of 20-22 cm | 0-10          | 1.10        | 1.21    | 1.15   | 1.22        |
|                           | 10-20          | 1.14        | 1.23    | 1.17   | 1.24        |
| Flat cutting to a depth of 20-22 cm | 0-10          | 1.13        | 1.24    | 1.16   | 1.23        |
|                           | 10-20          | 1.15        | 1.26    | 1.17   | 1.25        |
| Disking to a depth of 14-16 cm | 0-10          | 1.10        | 1.22    | 1.16   | 1.23        |
|                           | 10-20          | 1.13        | 1.23    | 1.17   | 1.26        |

The physical properties of the soil are extremely important in the formation of the nutrient regime for plants. The ability to regulate these properties makes it possible to increase the yield of agricultural crops. Indicators such as density are of particular importance. On average, for 2 years of research during the growing season of winter wheat, the soil density was close to optimal for the growth and development of grain crops, in particular winter wheat (1.10-1.26 g/cm³) [4,5,9]. During the sowing period of winter wheat, the lowest soil density was observed in the option of plowing to a depth of 20-22 cm and amounted to 1.10 g/cm³ in the soil layer of 0-10 cm. The highest soil density was noted before harvesting in the option where the predecessor was barley and amounted to 1.26 g/cm³ [6,7,10]. All the treatments carried out in this experiment did not contribute to an increase in soil density above optimal values. Many researchers have found that the less the soil is loosened, the better its structure is preserved and restored. [3,11] With minimal treatments, the content of water-resistant aggregates in the topsoil increases. As a result of considering this issue, it should be concluded that changes in soil density in the studied variants were not observed significant changes [12]. In some periods, an increase in soil density was observed in the studied variants, but this increase was small and could not significantly affect the yield of winter wheat.

In conditions of unstable moisture, moisture is one of the main limiting factors for obtaining high and sustainable yields of all agricultural crops. As VR Williams pointed out [13], "water is one of the most important and necessary factors of plant life, and soil moisture is one of the indicators of its fertility." KA Timiryazev [14] and NM Tulaykov [15] emphasized that the level of crop yield is directly dependent on the moisture supply of plants, which is largely determined by meteorological conditions, soil cultivation methods, the characteristics of cultivated crops and other conditions. [sixteen]. Winter wheat makes better use of autumn and winter precipitation, consuming significantly more moisture than spring wheat. Consumption of moisture during the growing season is uneven and depends on age, intensity of growth and development, plant density, temperature, development of the root system and the presence of moisture in the soil [17].

In the phase of grain germination and emergence of seedlings, plants consume a relatively small amount of moisture. However, in order to get friendly and full-fledged shoots, it is necessary to have at least 10 mm of productive moisture in the upper soil layer (0-10 cm). For normal autumn tillering of winter wheat, it is necessary to have at least 30 mm of productive moisture in the soil layer 0-20 cm. Winter wheat spends the greatest amount of moisture from spring regrowth to earing (up to 70% of the total water demand for the growing season) and the least - from flowering to wax ripeness of grain (up to 20%). The critical period in relation to moisture in winter wheat is going out into the tube-mating. With a lack of moisture during this period, the growth of plants stops, the formation of leaf area, this leads to a violation of the differentiation of generative organs, which leads to a shortage of harvest. During flowering and grain filling, the lack of moisture reduces the grain content of the spike, the size and grain yield. To obtain high yields of winter wheat with good grain quality, soil moisture is most favorable (in the 0-60 cm layer) not lower than the capillary rupture moisture [18].
Black steam, regardless of the method of basic processing, allows accumulating a sufficient amount of productive moisture for sowing winter wheat. The method of basic tillage also did not significantly affect the dynamics of the water regime under the crops of the studied culture. The use of fertilizers contributes to the powerful development of plants, as a result of which, in the booting phase (in the most moisture-demanding period), the reserves of productive moisture significantly decrease in relation to plots without fertilizers.

In general, over the years of research, the conditions of moisture in critical periods with respect to moisture were not entirely favorable, its deficit was observed, which ultimately did not allow winter wheat plants to maximize their potential in productivity [19].

The study of the water regime of the soil in the field crop rotation showed that, on average, over the years of research, the content of productive moisture in a meter layer of soil under winter wheat when sowing after black fallow was at the level of 107.8-108.8 mm. This is due to the drying out of the soil in summer (July-August), which was facilitated by high air temperatures and insufficient precipitation. For the predecessors, the occupied fallow and sunflower, the value of this indicator was even lower - 66.2 and 57.3 mm, respectively, which is 39 and 47% less than for black fallow [20].

| Option                  | Layer depth, cm | Pure fallow | Barley |
|-------------------------|-----------------|-------------|--------|
|                         | Sowing | The beginning of the growing season | Harvesting | Sowing | The beginning of the growing season | Harvesting |
| Plowing to a depth of 20-22 cm | 0-20 | 24.3 | 11.3 | 17.3 | 14.7 | 8.3 | 16.2 |
|                         | 0-100 | 137.3 | 183.5 | 118.3 | 121.6 | 163.9 | 121.4 |
| Flat cutting to a depth of 20-22 cm | 0-20 | 21.6 | 11.7 | 18.1 | 13.9 | 9.7 | 15.3 |
|                         | 0-100 | 141.5 | 175.3 | 123.7 | 119.7 | 169.7 | 118.3 |
| Disking to a depth of 14-16 cm | 0-20 | 22.3 | 11.9 | 17.9 | 15.6 | 10.3 | 16.1 |
|                         | 0-100 | 144.3 | 165.1 | 114.5 | 121.5 | 163.2 | 111.3 |

Soil moisture is one of the main factors that determine the conditions for the existence of crops and tillage. [21] In our research, it was found that in the soil layer 0-20 cm in the period after sowing winter wheat on black fallow, the smallest reserve of assimilable moisture was during flat-cut plowing and amounted to in 2018-2019. this figure was 21.6 mm, in the variant with plowing and disk in 2018-2019 with plowing - 24.3 mm, disk - 22.3 mm. In the variant where the predecessor was barley in the soil layer 0-20 cm in 2018-2019 the version with flat-cut processing was 13.9 mm.

By cultivating the soil as a result of its loosening, wrapping, mixing, compaction, the necessary addition is created, determined by the density, on which its structure, water-air properties and biological activity depend. [22] Therefore, the choice of this or that method of soil cultivation will be determined by how natural, inherent in a given soil, the addition will correspond to the optimal one, which provides the best conditions for the growth of agricultural plants and the formation of the yield [23].

Revut I B [22] considers soil density as one of the important elements of its fertility. It has been established that plants react negatively to both overly loose and overly dense soil conditions. The optimum density of arable for grain crops is in the range of 1.1-1.3 g/cm³ [25], for row crops (corn, sugar beets, potatoes) 1.0-1.25 g/cm³ [24]. The upper and lower limits of the optimum density, according to some data [26], are in an even wider range - from 0.8 to 1.6 g/cm³. Of the factors affecting soil settlement, the variable in different zones of the inter-strip space is mainly moisture. Due to
waterlogging of the arable layer of soil, it can become more compacted in spring. An increase in soil density due to its better moisture content is also noted in open fields.

The change in the agrophysical properties of the soil in a direction positive for grain crops is traditionally associated with moldboard cultivation, the theoretical foundations of which in our country were laid by P A Kostychev [26], A G Doyarenko [27], V R Williams [28].

The harm of excessive compaction is manifested in an increased soil resistance to the penetration of growing roots, a decrease in non-capillary duty cycle and, in this regard, in a deterioration of the water, air and nutritional regimes. [29] Compacted soil poorly absorbs and filters moisture, and this, with heavy rainfall, contributes to increased surface runoff and erosion [30]. Scientists [31, 32, 33,] have established that when minimizing soil cultivation, crop yields of crop rotation do not decrease. Even in the absence of a reliable difference in yields between the options, minimizing soil cultivation is advisable, since it helps to reduce labor costs and fuel consumption, as well as soil compaction.

Table 3. Influence of the precursor and processing methods on the wet gluten content in winter wheat grain.

| Experience options | Gluten content %, 2018 | Gluten content %, 2019 |
|--------------------|------------------------|-----------------------|
| 1. Pure fallow + 20-22cm plowing | 21.5 | 28.6 |
| 2. Pure fallow + 20-22cm flat cutting | 21.2 | 28.4 |
| 3. Pure fallow + disking at 14-16cm | 21.3 | 28.5 |
| 4. Barley + 20-22cm plowing | 19.3 | 27.9 |
| 5. Barley flat-cut processing by 20-22cm | 19.0 | 27.7 |
| 6. Barley + disking 14-16cm | 19.1 | 27.7 |

In 2019, the highest gluten content was observed in the option with pure fallow and amounted to 28.6%, and in the option with barley - 27.9%. In 2018, the gluten content in winter wheat grain was noticeably lower and the maximum was 21.5% in the option with pure fallow, and 19.3% in the option with barley. It can be concluded that the conditions for the accumulation of protein substances in grain and, in particular, gluten have been studied quite fully, and now there are practical ways to increase the protein content in wheat by applying a certain system of agrotechnical measures, along with the selection of appropriate varieties.

Table 4. Average indicators of winter wheat yield depending on the predecessor and tillage methods.

| Experience options | Years of research | Average by options | Difference to control |
|--------------------|------------------|-------------------|----------------------|
|                    | 2018  | 2019  | ±100kg/ha | % |
| 1                  | 54.3   | 48.9   | 51.6 | - | - |
| 2                  | 52.1   | 48.3   | 50.2 | +1.4 | 2.7 |
| 3                  | 56.6   | 51.1   | 53.8 | +2.2 | 4.3 |
| 4                  | 51.2   | 48.4   | 49.8 | -1.8 | 3.5 |
| 5                  | 49.7   | 48.0   | 48.8 | -2.8 | 5.4 |
| 6                  | 53.4   | 48.5   | 50.9 | -0.7 | 1.3 |
| HCP0.5 AB           | 0.6    | 1.2    |         |     |     |
Over the period of research, a reliably large increase in yield can be noted in the variant with disking by 14-16 cm in pure fallow and amounted to +2.2 100kg/ha; in the variant with disking in barley, a slight decrease in yield was noted (table 9). Analyzing the data obtained, we can conclude that it is better to place winter wheat after clean steam and using disking at 14-16 cm.

**Table 5. Influence of the predecessor and processing methods on the efficiency of winter wheat production in 2018-2019 (calculated per 1 ha).**

| Indicators                          | Experience options |
|------------------------------------|--------------------|
| Grain yield, 100kg.                | 54.3 52.1 56.6 51.2 49.7 53.4 |
| Production cost, rub.              | 27150 26050 28300 25600 24850 26700 |
| Production costs, rub.             | 15750 15437 15590 13131 13049 12959 |
| Cost price 100 kg grain, rub.      | 290 296 275 237 242 224 |
| Net income, rub.                   | 11400 10613 12710 13469 12801 14741 |
| Profitability level,%              | 72.4 68.7 81.5 102.5 98.0 113.7 |

The lowest production costs were noted for the variant after disking barley and amounted to 12959 rubles per hectare, the level of profitability in the first option was 72.4%, the highest level of profitability was noted in the 6th option - 113.7%.

Over the period of research, a reliably large increase in yield can be noted in the variant with disking by 14-16 cm in pure fallow and amounted to +2.2 100 kg/ha; in the variant with disking in barley, a slight decrease in yield was noted. Analyzing the data obtained, it can be concluded that it is better to place winter wheat after clean steam and using disking at 14-16 cm. One of the main factors determining the conditions for the existence of crops and soil cultivation. In our research, it was found that in the soil layer of 0-20 cm in the period after sowing winter wheat on black fallow, the largest reserves, the smallest reserve of assimilable moisture were during flat-cut plowing and amounted to 5.6 mm in 2018-2019. This figure was 21.6 mm, on the variants with plowing and disking, in 2018-2019 - 8.3 and 6.3 mm, in 2018-2019 on the variant with flat-cut processing it was 13.9 mm. Differences in the amount of assimilated moisture in the studied variants varied depending on the prevailing weather conditions and, to a lesser extent, on the factors studied. The formation of soil density in the plowed layer was significantly influenced by weather conditions. The physical properties of the soil are extremely important in the formation of the nutrient regime for plants. The ability to regulate these properties makes it possible to increase the yield of agricultural crops. Indicators such as density are of particular importance. On average, for 2 years of research during the growing season of winter wheat, the soil density was close to optimal for the growth and development of grain crops, in particular winter wheat (1.10-1.26 g/cm³). During the sowing period of winter wheat, the lowest soil density was observed in the option of plowing to a depth of 20-22 cm and amounted to 1.10 g/cm³ in a soil layer of 0-10 cm. The highest soil density was noted before harvesting in the option where the predecessor was barley and amounted to 1.27 g/cm³.

All the treatments carried out in this experiment did not contribute to an increase in soil density above the optimal values. The number of productive stems in crops for pure fallow was maximum in the variant with disking. During the research period, a reliably large increase in yield can be noted in the variant with disking by 14-16 cm for pure fallow. and amounted to +2.2 100kg/ha, a slight decrease in yield was noted on the option with disking on barley. Analyzing the data obtained, we can conclude that it is better to place winter wheat after clean steam and using disking at 14-16 cm.
In 2019, the highest gluten content was observed in the option with pure steam and amounted to 28.6%, and in the option with barley - 27.9%. In 2018, the gluten content in winter wheat grain was noticeably lower, reaching a maximum of 21.5% in the case of pure fallow and 19.3% in the option with barley. This difference is related to different weather conditions. The lowest production costs were noted for variant after disking barley and amounted to 12959 rubles per hectare, the level of profitability in the first option was 72.4%, the highest level of profitability was noted in the 6th option - 113.7%.

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