Methodological fundamentals for obtaining high quality food grain and increasing the yield of winter wheat in crop rotations of Central Chernozem Region

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Abstract. The increase in the production and application of organic and mineral fertilizers, the cultivation of crops using intensive technology require the balance of the elements of productivity at the highest level. One of the leading places among them is occupied by plant nutrition. The intensive technology is characterized not only by a high level of fertilization, but also by the exact adherence to the rates, timing and methods of application. The ultimate goal of the intensive technology is not only to increase yields and improve the quality of winter wheat grain, but also to maintain or increase soil fertility. It was found that fertilizers improved the quality of wheat grain in all years of the study. Fractional application of nitrogen led to an increase in the content of protein and gluten in the grain in all the studied links of crop rotations. In increasing the yield of agricultural crops and the quality of grain, the development of scientifically substantiated crop rotations with correct alternation of crops in relation to specific soil and climatic conditions is by no means unimportant. Crop rotations also influence the elements of soil fertility. Changes in the structure of sown areas should be carried out taking into account the need to increase the area under high-yielding crops, both grain and row crops.

1. Introduction

The cultivation of winter grain crops in Kursk Region is an important and responsible task facing farmers. It is important because winter cereals, especially wheat, constitute a significant share in the small grain balance and provide the bulk of commodity grain.

Winter wheat is the main food grain crop for intensive farming. It is possible to get its maximum yields observing a proper technology and with safe overwintering. There are many examples from literary sources, and many examples in Kursk Region, when more than 5-6 tons of wheat grain are obtained from one hectare. The complexity of the cultivation of winter crops is explained, firstly, by their nature and a number of biological features inherent only in winter crops; secondly, by zonal features - frequent manifestations of unfavorable conditions during the growing season of plants. Due to a rather long period of growth, winter crops need autumn-winter and early-spring care for them. They have a more complex growing technology. There are special requirements, such as strict adherence to the entire agronomical complex, especially when there are harsh wintering conditions,
leading to thinning and death of winter crops. The instability of sown and harvesting areas manifests itself in years with dry summer-autumn periods, when due to the lack of rain it is difficult to obtain timely shoots of winter crops and their normal development in autumn. With good moisture and an average daily air temperature above 14°C, winter crops sprout in 5-6 days; with insufficient moisture or low temperatures - in fifteen to twenty days.

The increase in the supply of mineral fertilizers, chemical ameliorants to agriculture, as well as constant attention to organic matter, green manure crops, makes it necessary to study the effect of long-term systematic application of fertilizers on the yield and quality of products, winter wheatin particular. At the same time, it becomes possible to establish optimal rates and timing of fertilization, contributing to the maintenance of a positive balance of nutrients. In the system of ensuring an increase in yield, great importance is attached to crop rotations and predecessors, which significantly affect the yield of crops, and technological quality of the obtained food products [1–3].

2. Statement of the problem
To ensure the production of high-quality food grain yields, it is necessary to establish the best combinations of crop alternation in crop rotations and fertilizer application systems, taking into account the current trend of agricultural biologization. The study of the questions posed should be carried out in years with different combinations of meteorological elements.

3. Materials and methods
In our research, experiments were carried out in the fields of Synthetik winter wheat variety, following three predecessors: peas, corn, black fallow. The field management of the crop cultivation in the experiments is generally accepted for Central Chernozem Region (CChR). The trial establishment was carried out in the fields of stationary experiments. The tier is threefold. The placement of variants is systematic and sequential. The soil variant is typical medium-deep heavy loamy chernozem with humus content of 5.2–5.4% in the arable layer. The harvesting of the experimental plots was carried out by a continuous method, with a self-propelled harvester Sampo 500. Mathematical processing of the yield data was carried out by the method of variance analysis.

At the beginning of the growing season of winter wheat, soil samples were taken to determine the content of moisture and mobile nutrients.

4. Results
Systematic application of fertilizers undoubtedly leads to a change in some agrochemical indicators (Table 1).

| Experiment variants       | salt extract pH | Hydrolytic acidity | Sum of absorbed bases meq/100 g | Saturation with bases,% |
|---------------------------|-----------------|--------------------|---------------------------------|-------------------------|
| Control (N30 PPN)         | 5.8             | 3.4                | 34.7                            | 91.1                    |
| Control (N30 PPN)         | 5.3             | 5.1                | 34.7                            | 87.1                    |
| N120P120K120 + N30        | 5.2             | 5.8                | 34.1                            | 85.5                    |
| Green manurecrops         | 5.5             | 5.0                | 35.0                            | 87.5                    |

In most variants with fertilization, a higher content of nitrates in the soil was observed compared to the control. Over the years of research, with the application of nitrogen fertilizers alone in top dressing, the degree of soil saturation with bases decreased from 91.1 to 87.1%. With the application of triple fertilization this figure was 85.5, and application of green manure crops - 87.5%.
A decrease in the degree of saturation of soils with bases occurs due to an increase in hydrolytic acidity from 3.4 meq/100 g of soil up to 5.0–5.8 meq/100 g. This is due to the systematic application of fertilizers, a significant increase in yield, and, consequently, with an increase in the removal of bases and an increase in exchangeable acidity from 5.8 to 5.2.

The yield of winter wheat is greatly influenced by the predecessors of the crop. Thus, on average for three years (Table 2) without fertilization, the grain yield of winter wheat grown after black fallow was 10 metric center per hectare (c/ha) higher than that for the predecessors of peas and corn. Moreover, precipitation did not have a significant effect on the yield increase after black fallow. For example, in 2016, with a precipitation level of 759 mm per year, the increase from fertilizers was up to 8.4 c/ha, in 2018 with a precipitation of 390 mm - about 10 c/ha. It should be noted that the general level of yield for Synthetic wheat variety in these years varied, respectively, from 50 to 35 c/ha. More significant differences were from fertilizers after other predecessors. For example, for peas, the increase was 18 and 7 c/ha, respectively.

Table 2. Efficiency of fertilizer application for Synthetic winter wheat variety during its cultivation after various predecessors (average for 2016-2019 yrs.)

| Experiment variants | Yield, c/ha | Yield increase, c/ha | Protein,% | Gluten,% |
|---------------------|-------------|---------------------|-----------|---------|
| Control             | 37.4        | 35.8                | 36.8      | -       |
| P60K60              | 37.5        | 35.6                | 34.8      | 0.1     |
| N60P60K60           | 43.4        | 41.9                | 41.5      | 6.0     |
| N60P60K60 in autumn + N30 in spring | 46.2 | 44.4                | 35.8      | 8.8     |

Research data allow us to conclude that even when sowing winter wheat after black fallow without green manure, in order to obtain high, stable yields, it is necessary to apply complete mineral fertilization. Similar results were obtained by other researchers [4, 5].

Fractional application of nitrogen leads to an increase in yield only for the predecessors that retain more mineral nitrogen in the soil (black fallow, peas). The application of nitrogen fertilizers (Table 3) at a rate of N30 in the form of top dressing in early spring and during the earing phase of cereals against the background of N60P60K60 turned out to be significant, but ineffective.

Table 3. Efficiency of mineral fertilizers applied for Synthetic winter wheat variety

| Experiment variants | Yield, c/ha | The average, 2016-2019 | Increase in yield c/ha |
|---------------------|-------------|------------------------|------------------------|
| Control             | 37.4        | 36.4                   | -                      |
| P60K60              | 37.5        | 36.3                   | 2.5                    |
| N60P60K60           | 43.4        | 43.5                   | 5.0                    |
| N60P60K60 in autumn + N30 in spring | 46.2 | 45.5                   | 6.4                    |
Complete mineral fertilization also contributes to an increase in product quality in comparison with phosphate-potassium fertilizers alone. It should be noted that fractional nitrogen application promoted an increase in the protein and gluten content in the grain for all predecessors [6, 7, 8].

Fertilizers improve the quality of wheat grain in all years of research. The effect of fertilizers is reflected both in natural weight and in the vitreousness, protein and gluten content of the grain. The positive effect of fertilizers is also noted in the chemical composition of the grain (Table 4). These data provide information that, in the fertilized variants not only the protein content of the grain increased, but also other important indicators of grain quality, from which it follows that a correct fertilization system and crop rotation is the most important condition for increasing the yield and improving the indicators of the technological quality of grain used for food and processing.

### Table 4. Influence of fertilizers on chemical composition of grain, % in dry matter (average for 2016-2019)

| Experiment variants | Starch | Cellulose | Sugars | Lipid | Ash |
|---------------------|--------|-----------|--------|-------|-----|
| Control             | 64.46  | 2.15      | 4.45   | 2.15  | 1.89|
| P\_60K\_60          | 62.35  | 2.08      | 4.29   | 2.17  | 1.84|
| N\_60P\_60K\_60     | 61.54  | 2.06      | 4.26   | 2.10  | 1.77|
| N\_60P\_60K\_60 in autumn + N\_30 in spring | 60.79  | 2.03      | 4.13   | 2.06  | 1.76|

* The data are given on an average for the years of research.

### 5. Conclusion

The yield of crops is the main factor that determines the volume of crop production [9]. This indicator is given priority attention. Research methodology is an important section of scientific work, which reveals the theoretical basis of research. The fact is that in modern science there is no actual opportunity to develop new knowledge without relying on what is already known. This is the meaning of determining the theoretical and practical methodological fundamentals. It follows from the above that the generally accepted application of high rates of mineral fertilizers or moderate, introduced green manure fields fails to maintain the constancy of indicators, although the yield of winter wheat grain increases.

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