Assessment of winter wheat yield depending on agrotechnical techniques and fertility of typical chernozem

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Abstract. The article considered the issues of increasing the yield of winter wheat grain, depending on the method of basic tillage, application of manure and mineral fertilizers. A correlation and regression analysis of the yield of winter wheat grain from the applied agrotechnical techniques, indicators of the fertility of typical chernozem were carried out. It was found that the greatest increase in yield in the grain-grass crop rotation was due to shaft-free tillage for maximum fertilization, and in the grain-tillage with the same doses of fertilizers - with the use of minimal tillage. Linear regression equations have been calculated to predict the yield of winter wheat grain from agrotechnical techniques.

1. Introduction

The state of the grain economy has a decisive influence on the development of all branches of the agro-industrial complex and the improvement of national economic well-being. The level of grain production depends on the satisfaction of the population's needs for raw materials, as well as the creation of the necessary state resources. In addition, highly developed grain farming plays an important role in the rise of meat and dairy cattle breeding, pig breeding and poultry farming [1-3].

The country's grain needs are not met at the expense of its own production. According to the grain balance of Russia, the level of self-sufficiency of the country with grain does not exceed 75%, whereas in the countries of the European Union over the same period it amounted to 110-115%, in the USA - 145-150%. The main attention in Russia is paid to the production of food grain: it accounts for more than 60% of the gross harvest, while in the European Union 50-56%, and in the USA no more than 30%. The need for food grains, accepted at the level of 165 kg per capita, is generally being met. There is only a shortage of hard and strong wheat grain, the share of which in the total volume of purchases does not exceed 8% in recent years. World and domestic experience shows that as the consumption of livestock products by the population increases, the main problem becomes ensuring the need for feed grain [4-6].

2. Materials and methods

Studies on the influence of methods of basic tillage, doses of mineral and organic fertilizers on the yield of winter wheat grain were carried out on the basis of the Laboratory of soil fertility and monitoring in the stationary field experiment of the Belgorod Scientific Research Center of the Russian Academy of Sciences.

Precursors of winter wheat: grain-grass crop rotation (hereinafter GGCP) - esparcet 2 years of use, grain-tillage crop rotation (hereinafter GTCP) - peas.
The soil of the experimental site is a typical medium-sized low-humus heavy loam on loess-like loam.

Three methods of basic tillage were studied in the experiment:
- dump plowing plow PLN-5-35 to a depth of 20-22 cm, which is preceded by disc peeling to a depth of 6-8 and 8-10 cm;
- shaft-free tillage with a “Paraplawn” type plow to a depth of 20-22 cm;
- minimum tillage with a disc harrow BDT-7 to a depth of 10-12 cm.

Mineral fertilizers were applied at a dose of N\textsubscript{84}P\textsubscript{124}K\textsubscript{124} and N\textsubscript{120}P\textsubscript{124}K\textsubscript{124}, manure at a dose of 16 tons per 1 ha of crop rotation area. Manure was applied once per rotation of the crop rotation for sugar beet.

The dependence of winter wheat yield on agrotechnical techniques and fertility indicators of typical chernozem was assessed by correlation and regression analysis. Multivariate correlation and regression analysis was performed using the Excel program from the MS Office package. Mathematical models were constructed reflecting the relationship between the yield of winter wheat and agrotechnical techniques, indicators of fertility of typical chernozem.

### 3. Results and discussion

One of the most important tasks facing agricultural production is to ensure the country's food security. To do this, it is necessary to use mineral fertilizers in increased doses, otherwise soil fertility and crop yields decrease [7-13].

For this purpose, on the basis of the Belgorod FASC RAS in 1987, field experience was laid to study the influence of methods of basic tillage, doses of organic and mineral fertilizers on the yield of winter wheat grain.

Photos of field studies are shown in Figure 1-2.

Table 1 shows the yield of winter wheat grain depending on fertilizers, methods of basic tillage and precursors.
**Table 1. Winter wheat grain yield depending on agrotechnical techniques, t/ha**

| Saturation of 1 ha of crop rotation area | Doses of NPK for winter wheat (factor B) | Crop rotation | GGCP predecessors (factor A) | GTCP predecessors (factor A) |
|----------------------------------------|------------------------------------------|--------------|-----------------------------|-----------------------------|
| Manure *                               | Mineral fertilizers                         | Crop rotation | esparcet 2 2 years of use | peas                         |
| 0                                      | 0                                        | 2.98         | -                           | -                           |
| NPK                                    | N\textsubscript{180}P\textsubscript{120}K\textsubscript{120} | 4.30         | 0.32                        | 44.3                        |
| 16                                     | 0                                        | 3.68         | 0.70                        | 23.5                        |
| NPK                                    | N\textsubscript{180}P\textsubscript{120}K\textsubscript{120} | 4.70         | 1.72                        | 57.7                        |
| Shaft-free tillage                     |                                          | 2.98         | -                           | 3.09                        |
| 0                                      | 0                                        | 4.15         | 1.17                        | 39.3                        |
| NPK                                    | N\textsubscript{180}P\textsubscript{120}K\textsubscript{120} | 3.53         | 0.55                        | 18.5                        |
| 16                                     | 0                                        | 4.82         | 1.84                        | 61.7                        |
| Minimum tillage                        |                                          | 3.23         | -                           | 3.05                        |
| 0                                      | 0                                        | 4.44         | 1.21                        | 37.5                        |
| NPK                                    | N\textsubscript{180}P\textsubscript{120}K\textsubscript{120} | 4.10         | 0.87                        | 26.9                        |
| 16                                     | 0                                        | 4.96         | 1.73                        | 53.6                        |

SSD\(0\) (the smallest significant difference)

\(A=0.56, B=0.49, C=0.40, AB=0.98, AC=0.80, BC \text{ and } ABC =0.70\)

Note: * the dose of NPK application per 1 ha of crop rotation area: GGCP – N\textsubscript{45}P\textsubscript{120}K\textsubscript{124}, GTCP – N\textsubscript{120}P\textsubscript{124}K\textsubscript{124}, ** - factor C

The greatest increase in yield from the combination of the use of mineral fertilizers and the aftereffect of manure - 1.92 t/ha (65.5%) was observed in the grain crop rotation for plowing, compared with 1.64 t/ha (53.1%) for shaft-free tillage and 1.88 t/ha (61.6%) for minimal tillage. In the grain-grass crop rotation, the highest increase from the combination of mineral fertilizers and the aftereffect of manure was noted for non-tillage tillage - 1.84 t/ha (61.7%), compared with 1.72 t/ha (57.7%) for plowing and 1.73 t/ha (53.6%) for minimal tillage.

Table 2 shows the correlation and regression analysis of the yield of winter wheat grain from agrotechnical techniques.

**Table 2. Dependence of winter wheat grain yield on agrotechnical techniques**

| Indicators                                      | Crop rotation | GGCP     | GTCP     |
|------------------------------------------------|---------------|----------|----------|
| Basic processing method                        | y = 4.4865-0.0282x\(_1\)  
  \(r = 0.1931\)                  | y = 4.2891-0.0138x\(_1\)  
  \(r = 0.0947\)                  |
| Application of manure                          | y = 3.7214+0.0074x\(_2\)  
  \(r = 0.3487\)                  | y = 3.7396+0.0080x\(_2\)  
  \(r = 0.3781\)                  |
| Application of mineral fertilizers             | y = 3.5033-0.01430x\(_3\)  
  \(r = 0.6370\)                  | y = 3.5225+0.1496x\(_3\)  
  \(r = 0.6671\)                  |
| A set of agrotechnical techniques              | y = 3.679-0.028x\(_1\)+0.007x\(_2\)+0.143x\(_3\)  
  \(r = 0.7514\)                  | y = 3.434-0.014x\(_1\)+0.008x\(_2\)+0.150x\(_3\)  
  \(r = 0.7726\)                  |

Note: * \(x\(_1\)\) – the depth of the treated layer, cm; \(x\(_2\)\) - the dose of manure, t/ha; \(x\(_3\)\) - the dose of mineral fertilizers in the main application, kg/ha

As a result of the correlation and regression analysis, it was found that when determining the
relationship between the yield of winter wheat grain and individual agrotechnical techniques, the dependence is weak on the method of basic tillage, and in the GGCP and GTCP - \( r = 0.1931 \) and \( r = 0.0947 \), respectively. The dependence on the application of both manure and mineral fertilizers is average and was in the range of 0.3487-0.6671. Only the joint use of these techniques determined a strong dependence of the yield of winter wheat grain on them, the correlation coefficient in this case was 0.7514-0.7726.

Table 3 shows the data of correlation and regression analysis of the yield of winter wheat grain from the content of different forms of nitrogen, humus and density in the soil. Linear regression equations are also established.

Table 3. Dependence of winter wheat grain yield on different forms of nitrogen, humus content and soil density

| Indicators                      | Soil layers, cm | 0-20 | 20-50 | 50-100 |
|--------------------------------|-----------------|------|-------|--------|
| Total nitrogen content         | y=2.24+6.34x    | y=2.63+5.10x | -     |
|                                | r = 0.4299      | r = 0.2270 | -     |
| Content of hydrolyzable nitrogen | y=-3.54+0.05x   | y=-1.09+0.04x | -     |
|                                | r = 0.7005      | r = 0.7007 | -     |
| Nitrification capacity         | y=2.59+0.03x    | y=2.51+0.05x | -     |
|                                | r = 0.5276      | r = 0.6631 | -     |
| Nitrate nitrogen content       | y=3.27+0.05x    | y=3.05+0.10x | y=3.47+0.09x |
|                                | r = 0.5497      | r = 0.7124 | r = 0.4105 |
| Humus content                  | y=-11.03+2.70x  | y=-4.51+1.68x | -     |
|                                | r = 0.5316      | r = 0.5968 | -     |
| Soil density                   | y=12.75-7.24x   | y=12.23-6.63x | -     |
|                                | r = -0.4593     | r = -0.4280 | -     |

The dependence of winter wheat grain yield on the total nitrogen content in the soil is average in the layer 0-20 cm - \( r = 0.4299 \), in the soil layer 20-50 cm - \( r = 0.2270 \), which is due to the fact that the main reserves of organic nitrogen are located in the arable layer. The content of hydrolyzable nitrogen strongly correlates with the yield of winter wheat grain, both in the arable and sub-arable layers.

According to our calculations, we observed the level of average dependence of winter wheat grain yield on the nitrification capacity of typical chernozem, humus content and soil density. This is due to the fact that these indicators are usually determined by the method of tillage, and this indicator has a weak correlation with yield.

The content of nitrate nitrogen affects the yield of winter wheat grain differently, so in the 0-20 and 50-100 cm layer, the correlation coefficient was \( r = 0.5497 \) and \( r = 0.4105 \), respectively. In layer 20-50 cm, a strong relationship is seen - \( r = 0.7124 \). This is due to the mobility of nitrate forms of nitrogen and their migration along the soil profile.

4. Conclusion

Thus, as a result of the conducted studies, it was found that the application of mineral fertilizers individually has a stronger effect on the yield of winter wheat grain. However, the combined use of the studied techniques gave a synergistic effect, which is confirmed by the volume of grain collection, the increase from the complex combination was higher than 50% of the control. There is also a high degree of correlation between the yield of winter wheat grain and mobile forms of nitrogen.

The obtained linear regression equations allow you to adjust the doses of fertilizers depending on the planned yield, which will allow you to farm more efficiently.
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