Yield of barley grain and returns of fertilizers when applying different doses in the Vologda region

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Abstract. The article presents studies conducted in 2015 - 2018. in the field of stationary long-term experience. It was found that the studied fertilization systems made it possible to increase the yield of spring barley grain from 90 to 120% in comparison with the control, nitrogen removal of 1 ton of grain with the corresponding amount of straw - by 4-6 kg. The payment for the applied fertilizer systems was the highest in the variant where 44 kg of a.i. / ha were applied. An increase in fertilizer doses up to 210-230 and more kg a.i. / ha showed a tendency towards a decrease in the payment for fertilizers by the crop.

1. Introduction

Ensuring the country's food security is an urgent task for all agricultural producers in the Russian Federation, including the Vologda Oblast, which is one of the largest in terms of area. It is well known that without the use of optimal doses of fertilizers it is impossible to solve the problem of food security [1-2]. At the same time, in modern conditions, the principles of resource conservation in agricultural production are relevant. According to which, it is necessary to optimize the needs for the resources used, including various fertilizers, by rationalizing their use in accordance with modern requirements for the environmental safety of agricultural production.

The main types of soils in the Nonchernozem zone of the Russian Federation are characterized by low natural fertility, which manifests itself in the acidic reaction of the soil solution, low content of organic matter, and so on. Therefore, for these conditions, decisive importance is assigned to liming, the use of various types of organic fertilizers, the introduction of scientifically grounded doses of mineral fertilizers. Thus, in the Vologda Oblast, it is possible to provide from 30 to 60% of the potential harvest due to fertilizers [3-10].

In the Vologda Oblast, barley is cultivated mainly not for brewing and cereals, but for grain fodder purposes, and is used in cattle rations as the main fodder. The grain of this grain contains the necessary set of essential amino acids. Productivity and quality of barley grain, incl. the content of essential amino acids largely depends on the balanced fertilization of the crop. It is important to clarify the optimal system of barley fertilization in crop rotation in the Vologda Oblast in order to obtain high crop yields with good product quality indicators. Therefore, the purpose of this work is to develop calculation systems of fertilization to obtain the planned level of grain yield of spring barley - 3.5 t / ha on sod-podzolic medium loamy soil.
2. Materials and methods
Research years - 2015-2018; place of research - field stationary long-term experience with established coordinates, according to the certificate of experience, number 164, included in the State Register, four-field field crop rotation. Crop rotation scheme:

- The steam is busy - vetch-oat mixture,
- Winter rye,
- Potatoes,
- Spring barley

We studied varieties Mikhailovsky (2015, 2016) and Sonnet (2017, 2018), which are included in the State Register of the Russian Federation [9].

The studied doses of fertilizers were determined according to the results of generally accepted calculations, the method of which is given in previously published works. The level of the planned yield of spring barley grain is 3.5 t / ha, taking into account the agro-climatic potential of the territory. When sowing, nitrogen-phosphorus-potassium fertilizer was applied (on option 2 only when sowing). For the cultivation of spring barley, a system of measures was used that was characteristic of the generally accepted technology of cultivation of crops for the conditions of the Vologda region. The research technique was discussed in detail in previously published works [3; 5-8; 10]. The repetition rate is fourfold, the location of the plots is complicated systematic, the plot area is 140 m², and the counting area is about 24 m². The yield of the culture was taken into account by the continuous method, N, P, K were determined according to standard methods. Mathematical processing of the data according to B.A. Dospekhov (1985) [1].

The main agrochemical indicators of the arable layer have been established: pH_KCl 4.9, P₂O₅ - 132 and K₂O - 55 mg / kg of soil, humus - 2.56%.

3. Results
During the main growing season of barley (June - July), the hydrothermal coefficient (HC) in 2015, 2016 and in June 2018 was below the multiyear value (figure 1).

![Figure 1. SCC by months 2015 - 2018 research in comparison with smd.](image-url)
A high GTC was observed in 2017, which exceeded the long-term values in June and July by more than 2 times. Such an excess amount of incoming moisture caused a decrease in the yield of barley grain (table 1).

Table 1. Productivity by variants of the experience of spring barley grain for 2015 - 2018, t / ha.

| Years of Research / Experience Options | 1. Control (without the use of fertilizers) | 2. N_{12}P_{16}K_{16} | 3. N_{80}P_{40}K_{90} | 4. N_{80}P_{40}K_{110}+aftereffect 40 t / ha bp | 5. N_{30}P_{10}K_{30}+aftereffect 40 t / ha bp | HCP<sub>0.05</sub> |
|---------------------------------------|-------------------------------------------|----------------------|----------------------|---------------------------------------|--------------------------------------|------------------|
| 2015                                  | 2.7                                       | 3.2                  | 4.2                  | 5.2                                   | 4.7                                  | 0.8              |
| 2016                                  | 1.7                                       | 2.8                  | 4.4                  | 4.9                                   | 4.7                                  | 0.7              |
| 2017                                  | 1.1                                       | 1.5                  | 2.4                  | 2.8                                   | 2.4                                  | 0.6              |
| 2018                                  | 2.4                                       | 3.5                  | 4.4                  | 4.5                                   | 4.4                                  | 0.8              |

For 2015 research, the yield of barley was 3.2 - 4.7 t / ha. Fertilizers applied only during sowing (option 2) provided an increase of 0.5 t / ha or 18% to the control, and calculated fertilization systems (option 3-5) provided 120 - 148% of the programmed yield value.

In 2016, the highest yield of barley grain was provided by the 4th option - 4.9, which is 3.2 t / ha more than the control, which means a significant difference. The same high yield was recorded on the 5th variant, where the organic-mineral fertilizer system was studied, by 3.0 t / ha more than the control. Variants 2 and 3 also provided a significant increase in yield in the control, exceeding it.

During the growing season 2017 the yield reached a value of 1.1 - 2.8 t / ha.

For 2018 grain yield amounted to 4.4-4.5 t / ha, exceeding the target by 20%.

For 2015-2018 fertilizers increased the yield of barley by 40-120% compared to the control, and the studied calculation systems of fertilization by 90-120% (figure 2).

![Figure 2. Grain yield of spring barley (average) and increase in grain yield in 2015-2018.](image)

4. Discussion
On average, over the years of research, the value of 108-126% of the planned level of barley yield has been achieved.

It is necessary to note the tendency of increasing nitrogen consumption for the creation of 10 centners of barley grain, respectively, by 1-6 kg, and the calculated systems of barley fertilization
increased the carry-over by 4-6 kg. The removal of phosphorus per unit of barley production did not change with the use of fertilizers. The removal of potassium increased with the use of fertilizers by 4-6 kg and changed weakly with an increase in the applied doses of fertilizers from 44 kg a.i. up to 210-230 kg a.i. / ha, for 1-2 kg (figure 3). If we compare the values of the removal of nutrients with the planned ones, then they were 3-5 kg higher in nitrogen, 2 kg lower in phosphorus, and almost corresponded to this value in potassium (figure 3).

In the studies carried out, it was shown that due to the calculated fertilization systems, the grain yield increases by 90-120% compared to the control option and the nitrogen removal of one ton of grain with the corresponding amount of straw increases by 4-6 kg.

The largest payment for fertilizers was received when 44 kg of ai / ha were applied. With an increase in fertilizer doses up to 210-230 kg a.i. / ha, the payment decreased by 1.7-2.1 times, amounted to 8.57-10.43 kg / kg a.i. / ha (figure 4).
5. Conclusion
Thus, the calculated fertilization systems increase the grain yield of spring barley by 90-120% compared to the control, the removal of nitrogen in 1 ton of grain with the corresponding amount of straw - by 4-6 kg.

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