The assessment of the bioecological method use for spring barley cultivation in the Krasnoyarsk territory forest-steppe zone

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Abstract. The article presents the results of the field experiment aimed at determining the effective modes of microwave heating and their impact on sowing quality, field germination, infection reduction, spread and development of diseases during the growing season, quality and yield of products. In the process of results interpretation, the data on the barley yield were obtained which showed that the increase, relative to the control option, can be obtained at all power levels from 180 to 900 W and exposure equal to 30 seconds. But the most effective is the option at \( P = 540 \) W and \( \tau = \) from 30 to 60 s which gave the greatest biological effect, relying on the statistical processing. As a result, the method of microwave heating in the field conditions has a positive effect on the formation of the yield structure main elements, the significant reduction in infection and the increased grain germination.

1. Introduction

Despite the contrast of natural and climatic conditions in Siberia, barley is a reliable crop that can maximize the bioclimatic potential for sustainable yield. In spite of this, barley suffers to some extent from root rot in all grain areas of Siberia. As a result, the yield of this crop in some years may be reduced to 70 % [6].

The damage from root rot increases annually in the Krasnoyarsk territory; in recent years, along with traditional pathogens of this disease (species of r. r. Fusarium and Bipolaris), the share of r. Alternaria fungi in the phytopathogenic complex has increased [4]. Local outbreaks of Alternaria-Fusarium infection lead to contamination of the spring barley grain and products of its processing with phytotoxins which are dangerous for human and animal health and life [8].

It follows from the above-mentioned that the grain does not meet the restrictive and basic requirements on technological, phytosanitary and biological properties. As a result of the current situation, on the one hand economic, on the other – phytosanitary, the main role is given to pre-sowing preparation of seeds for sowing [7].

The analysis of the existing methods of barley grain disinfection showed a number of shortcomings, because they are environmentally unsafe, lead to the significant and undesirable change in the physical-chemical and biological properties of the processed objects, they are very power-intensive and have a restrictive field of application.

Considering the fact that a large part of the Krasnoyarsk territory is in the conditions of the soil weak self-purification capacity, there exists the obvious importance of choosing the method which is...
able to meet the requirements of high efficiency and bioecological security. Such functions can be performed by the microwave method of the seed sanitary improvement [2, 10, 11].

The purpose of research is to determine the biological efficiency of the studied modes for field germination, development and spread of diseases, yield and quality of products in the conditions of field experience.

Methodology of research. Federal state budget educational institution of higher education “Krasnoyarsk state agrarian university” has been conducting research on the use of bioecological method for the grain crop cultivation for several years. One of the bioecological methods is the method of microwave heating. In the course of laboratory and field studies, the influence of microwave heating on the phytosanitary condition, sowing and yielding qualities of grain crops were studied.

The field experiment was conducted to determine the effect of microwave heating modes on the technological quality of spring barley seeds, as well as the contamination by phyto-pathogenic microflora.

The equalizing sowing of oats was carried out on the experimental site. The scheme of the experiment consisted of 14 variants, the repetition was fourfold, the area of the experimental plot was 10 m², the location of the plots in the experiment was randomized, the number of plots was 72. The sowing was done with the sowing machine SFK – 17. The seeding rate was determined on the basis of the sowing validity of seeds. The variety was “Krasnoyarsk-80”.

Three specific power levels, three treatment times (exposures) and three doses of the biological preparation were assessed in the three-factor experiment. First, the seeds were processed in the laboratory, with pre-moistening. The method of active planning was used to process the results [9].

2. Research results and discussions

During the experiment, field germination, development and spread of diseases were taken into account, as well as the contamination by phyto-pathogenic microflora.

With active planning of field experience, the input parameters varied at three levels: minimum (–1), average (0), maximum (+1). The dependence of the output parameters on the input is expressed by the equation:

\[
Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_{11}X_1^2 + B_{22}X_2^2 + B_{33}X_3^2 + B_{12}X_1X_2 + B_{13}X_1X_3 + B_{23}X_2X_3.
\]  

(1)

Where: \(B_n\) – coefficient of regression equation,

\(X_1\) – exposure (τ, sec),

\(X_2\) – processing power (P, W),

\(X_3\) – biological preparation (trichodermin, g.).

Since the experiment requires a plan with a minimum number of tests, plan \(B_3\) was chosen. This is one of the best plans with a small number of variables. The results of experimental observations are recorded in the matrix for dispersion and then regression analysis [1].

As a result of these equations tabulation in the Excel software on personal computers, the graphical dependencies were constructed. The research results on the effect of different modes of microwave heating are shown in figures 1 – 9.

- The data analysis showed that the increase in productive tillering under the influence of microwave heating (figure 1) was about 25% relative to the control option. This indicator cannot be taken as the basis, because according to the literature, the most effective value that productive tillering can take is 2. But in our case, this figure is of great importance for the characteristics of the yield.

- There is a change in plant height (figure 2), depending on the microwave heating parameters. Here one can observe both the lowering of indices in the range of 4% and the increase up to 3 %.
Figure 1. The dependence of the plant productive tillering capacity on the microwave heating parameters.

Figure 2. The dependence of plant height on the microwave heating parameters.

Figure 3. The dependence of the flag leaf length on the microwave heating parameters.

Figure 4. The dependence of the plant roots weight on the microwave heating parameters.

Figure 5. The dependence of the plant ear length on the microwave heating parameters.

Figure 6. The dependence of the cones number in the plant ear on the microwave heating parameters.
Figure 7. The dependence of grain number in the ear on the microwave heating parameters.

Figure 8. The dependence of 1000 grains weight on the microwave heating parameters.

Figure 9. The dependence of the malting barley yield on the microwave heating parameters.

- Large values of the flag leaf length (figure 3) are present in variants at power $P = 180$ W and exposure $\tau = 30 - 90$ seconds. All other variants have smaller values and lie in the same plane.
- The roots weight does not have a significant impact on the formation of grain yield, but in this case (figure 4) no regularities were established.
- As it is shown in figure 5, the ear length does not vary widely. Here, too, there is a decrease both in biological efficiency within 10.7 %, and its increase (by 16.7 %), while there is a direct dependence of this indicator on the power and exposure of microwave heating. If, at $P = 180$ W and $\tau = 30$ s, and $P = 900$ W and $\tau = 30$ there is no change, then there is a change in performance with the load increasing.
- The number of cones in the ear (figure 6), according to the obtained data analysis, depends on the length of the ear, while there is almost a direct relationship: the longer the ear, the more cones it has.
- The number of grains in the ear does not have special dependence on the previous indicator; it lies in one plane and does not change significantly (figure 7).
- The weight of 1000 grains is one of the main indicators in assessing the spring barley quality (figure 8). From the presented data, we see that at low processing power $= 180$ W and exposure from 30 to 90 seconds, there is a slight increase, and in the future – a decrease in this indicator. At other power levels and the same exposure limits, the weight of 1000 grains increases up to 44.2 g, while the biological efficiency in this variant was 7.3 %.
- Also, in the process of results interpretation, the data on the barley yield was obtained, which showed that the increase, relative to the control option, can be received at all power levels from 180 to 900 W and exposure equal to 30 seconds. But the most effective option, which
gave the greatest biological effect, relying on statistical processing, is an option at $P = 540$ W and $\tau = \text{from } 30 \text{ to } 60 \text{ seconds}.$

3. Conclusion
As a result of the assessment of the bioecological method use in the field conditions of the Krasnoyarsk forest-steppe, the positive impact on the basic elements formation of the spring barley yield structure, the significant reduction in infection and increase in the seed germination were revealed. Moreover, this method is the safest for the environment. The method of microwave heating along with low energy consumption has high productivity and efficiency and, most importantly, makes it possible to obtain environmentally friendly grain crop products.

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