The effectiveness of the modes of the super-high frequency electromagnetic field on the viability and infection of the second generation barley seeds

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Abstract. This article presents the results of experimental studies, the assessment of barley seeds contamination obtained from effective variants of exposure by the electromagnetic field of super-high frequency, tested in laboratory and field conditions, pathogens genera Bipolaris, Fusarium and Alternaria. The positive effect of the super-high frequency electromagnetic field is manifested not only in barley seeds treated immediately before sowing, but also persists in the second generation, i.e. after harvesting. At the same time, there is a significant decrease in the infection rate of samples for both external and internal infection.

1. Introduction

Barley is an annual forage, food and technical plant, it belongs to the bluegrass family (Poaceae).

Currently, barley occupies the second place in the area of sowing after wheat. All cultivated barley species make up one combined species – barley (Hordeum sativum) [1].

Barley is a valuable food crop. Its grain is widely used for the preparation of cereals (barley and pearl barley), barley coffee, as well as to obtain Maltzekstrakt – a product needed in baking, confectionery, pharmaceutical, paint, textile and leather industries. Barley grain is the main raw material for brewing [1, 2].

The critical situation, in which the contamination of seeds with pathogens repeatedly exceeds the thresholds of harmfulness, destabilizes the agro-industrial complex of the region. Barley is the most affected crop due to its biological characteristics.

As a result, crop losses from a complex of harmful objects, taking into account the contamination and intoxication of grain, in normal years reach 25-27%, and in the conditions of outbreaks and epiphytosis increase up to 35-50% or more [1].

In particular, damage from root rot is increasing annually in the region; in recent years, along with traditional pathogens of this disease (species of p.p. Bipolaris and Fusarium) [3, 4, 5], the share of participation of p. Alternaria fungi has increased in the pathogenic complex [6].

A serious threat, even against the background of the modern protectants use, is also an increase in the development intensity and frequency of outbreaks of all forms of fusariosis on barley [3].

In the zones of the region, the infection of ear and grain with alternariosis on average for the last three years varies from 15 to 50, with fusariosis – from 25 to 52 and helminthosporiosis (species of p. Bipolaris) – from 10 to 35 % [6].
Local epiphytosis of Fusarium-Alternaria infection leads to contamination of barley grain and products of its processing with phyto-toxins dangerous for human and animal life and health [4, 5, 7]. As a result, the grain of barley varieties zoned in the region, in most years, does not meet the basic and restrictive conditions for phytosanitary, technological and biological properties. In solving the existing problem, on the one hand phytosanitary, on the other – economic, the main role is given to pre-sowing treatment of seeds for sowing [8]. Given that most of the Krasnoyarsk territory is in conditions of the poor self-cleaning ability of soil and surface layers of the atmosphere, the importance of choosing from among the existing methods of the one that will be able to meet the requirements of both high efficiency and bioecological safety becomes obvious [8]. Such functions are performed by an electromagnetic field of super-high frequency. In the conditions of high seeds contamination in the region, the developed technology of disinfection in the electromagnetic field of super-high frequency of barley seeds due to its efficiency and environmental friendliness is relevant [8]. At the same time, attention should be given to the study of the healing aftereffect in the grain grown from seeds exposed to the electromagnetic field of super-high frequency (memory effect) before sowing. The purpose of the research is to establish the manifestation possibility, the degree and the nature of the healing effect of the electromagnetic field of super-high frequency (memory effect) in barley seeds of the new crop.

2. Research methods
Research on the subject was carried out in the scientific laboratory of the Krasnoyarsk state agrarian university. The laboratory technical installation based on the Samsung microwave oven with an operating frequency of 2450 MHz was chosen for the experiment. Private methods were used to assess the EMFSHF impact on the object [8].

The object of the study is barley seeds taken one month after harvesting. Sampling for analysis was carried out according to State standard 10968-88 [9], the mode effect on phyto-pathogenic microorganisms was carried out according to the results of phyto-expertise, using the biological method according to State standard 12044-93 [10], and the germination energy and laboratory germination (viability) – according to State standard 10968-88 [9].

3. Research results
The research was conducted in the laboratory in order to establish the healing effect of the electromagnetic field of super-high frequency (memory effect) in barley seeds of the new crop.

Using the biological method of determining disease contamination (State standard 12044-93), it was found that this method of treatment has a disinfecting effect on seeds infected with fungal phyto-pathogenic microflora, not only after direct exposure to pathogens, but also manifests itself in the aftereffect in the next generation of seeds obtained in the field experiment with the most effective modes of exposure (heating rate = 0.6 °C/s; exposure = 60 and 90 seconds).

The indicators of infection with the above-mentioned pathogens and seeds laboratory germination were determined. External (epiphytic) and internal (endophytic) infections were considered separately. The results of the studies are presented in tables 1 and 2.

According to the analysis of the obtained results (table 1) it is established that in the mode with parameters \( V_t = 0.6 \) °C/c and exposure of 90 seconds a significant increase in laboratory germination was obtained (95% relative to 89% in control).

Based on this experiment data on the influence of the aftereffect of electromagnetic fields of super-high frequency on the germination of barley seeds it was determined that the increase in germination in the first case was 6%, second 2% relative to the control. The result of the experiment indicates to a favorable effect of the electromagnetic field on the germination of barley seeds in the aftereffect.
Table 2 presents the results of seeds phyto-expertise, according to which there is a decrease in infection of both external and internal infection (24-82 and 22-57 %, respectively).

**Table 1.** The influence of super-high frequency electromagnetic field on the laboratory germination of second generation seeds.

| Variant                  | Germination % | Average value | Increase of germination in relation to control, % |
|--------------------------|---------------|---------------|-----------------------------------------------|
|                          | Repeatability |               |                                               |
|                          | 1  2  3  4    |               |                                               |
| $V_t = 0.6 \, ^{0}\text{C}/\text{c}$ and $T=90 \, \text{c}$ | 92 96 96 96   | 95             | 6                                             |
| $V_t = 0.6 \, ^{0}\text{C}/\text{c}$ and $T=60 \, \text{c}$ | 92 92 90 90   | 91             | 2                                             |
| Control                  | 96 80 92 88   | 89             | -                                             |

The highest rates of infection reduction in the aftereffect are noted in p. Alternaria, smaller in p. Fusarium. The results of the experiment are presented in figures 1, 2 and 3 for each genus of pathogens.

**Table 2.** Influence of super-high frequency electromagnetic field on infection of second generation seeds.

| Variant                  | External infection | Internal infection |
|--------------------------|--------------------|--------------------|
|                          | Bipolaris          | Alternaria         | Fusarium |
|                          | Bipolaris          | Alternaria         | Fusarium |
| $V_t = 0.6 \, ^{0}\text{C}/\text{c}$ and $T=90 \, \text{c}$ | 13 48 3 50 2 82   | 14 44 3 57 5 22  |
| $V_t = 0.6 \, ^{0}\text{C}/\text{c}$ and $T=60 \, \text{c}$ | 19 24 2 66 4 64  | 12 52 2 71 8 14  |
| Control                  | 25 - 6 - 11 -     | 25 - 7 - 8 -      |

**Figure 1.** Influence of microwave heating modes on barley seeds contamination by fungi of Bipolaris genus.
Figure 2. Influence of microwave heating modes on barley seeds contamination by fungi of Alternaria genus.

Figure 3. Influence of microwave heating modes on barley seeds contamination by fungi of Fusarium genus.

The aftereffect of the super-high frequency electromagnetic field on the contamination of barley grain with fusariosis was observed in respect of external infection (64 – 82%), as well as internal (14 – 22%). Infection with pathogens p. Bipolaris decreased on the surface of the grain by 24-48%, internal by 44-52%.

Infection with p. Alternaria fungi in the variants was lower than in the control group by more than two times, both in external and internal infections.

4. Conclusion
Thus, according to the processing and analysis of the obtained results, the positive effect of the super-high frequency electromagnetic field is manifested not only in barley seeds treated immediately before sowing, but also persists in the second generation, i.e. after harvesting. At the same time, there is a significant decrease in the infection rate of samples (from 14 to 82 %) for both external and internal infection, with a simultaneous increase in laboratory germination from 2 to 6 percent relative to the control.
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