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The development of the environmentally safe method for disinfection and biostimulation of spring wheat seeds using electro-magnetic field of super-high frequency

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Abstract. The article presents the laboratory experiment results aimed at determining the effective modes of electro-magnetic field of super-high frequency (EMFSHF) and their impact on the laboratory germination of spring wheat seeds, reducing the infection by the most harmful microorganisms. In the conditions of high seeds contamination in the Krasnoyarsk territory, the developed technology of microwave disinfection of spring wheat seeds is relevant due to its efficiency and environmental friendliness. The analysis of the results shows that the effective mode of the microwave field in which the infection of wheat grain with phytopathogenic microflora in the established thresholds of harmfulness, along with the simultaneous preservation of sowing qualities, is the variant with $P_{sp} = 650 \text{ W/dm}^3$ and $\tau = 90 - 60$ seconds.

1. Introduction

In the agricultural sector of Russia, in the conditions of material and technical resources shortage for most producers, there is an extremely low level of agriculture and critical phytosanitary condition of agroecosystems. On many agricultural lands, which are currently not used, stable complexes of harmful organisms have been formed. A number of specialized pests and pathogens cause biogenic emergencies annually, destabilizing the agro-industrial complex [5]. In the Krasnoyarsk territory the phytosanitary situation is similar to the all-Russian. In many grain-producing districts the territory of sowing areas affected by septoria spot, brown rust, powdery mildew has increased. Root rot, Fusarium infection of ear and in recent years Alternaria have acquired the status of epiphytotics.

Local epiphytotics of Fusarium-Alternaria infection lead to infection of grain and products of its processing with phyto-toxins dangerous to life and health of humans and animals. As a result, the grain does not meet the basic and restrictive requirements for phytosanitary, technological and biological properties. In solving the situation, on the one hand phytosanitary, on the other economic, the main role is understandably given to pre-sowing preparation of seeds for sowing.

Given that most of the territory of the region is in a weak self-cleaning ability of the soil and the atmosphere surface layers, the importance of choosing from among the existing such methods that can meet the requirements of both high efficiency and bioecological safety becomes obvious. Such functions are able to be performed by the method of seed sanitary improvement in the electro-magnetic field of super-high frequency (EMFSHF).



2. Materials and methods

The aim of the research was to develop environmentally safe disinfection and biostimulation of spring wheat seeds using EMFSHF. On the basis of the FSBEI of HE “Krasnoyarsk state agrarian university” laboratory studies were conducted on the topic, including – active planning methodology, the main task of which is to choose the plan that allows to get the most comprehensive information with a minimum number of experiments. Based on the conditions of the analysis of two factors (exposure τ seconds, specific power P_{sp} , W/dm³) affecting the process of exposure, a two-factor experimental plan Kono 2^{n-1} was chosen. The main output parameters of wheat seeds disinfection in the laboratory experiment were the heating temperature, the infection of grain with pathogenic microflora, as well as the sowing quality of seeds (germination). In order to conduct the experiment, the laboratory technical installation based on the Samsung microwave oven with an operating frequency of 2450 MHz was used [2]. To evaluate the impact of EMFSHF on the object, the private techniques were used:

- selection of samples for analysis – according to State Standard 12037-66;
- influence of modes on the phyto-pathogenic microorganisms according to phyto-expertise, with the help of biological method – according to State Standard 12044-93 [4];
- germination energy and laboratory germination (vital capacity) – according to State Standard 10968-88 [3].

3. Research results

The research aimed at developing effective modes of microwave fields for decontamination and biostimulation of wheat was conducted in the laboratory conditions. The influence on the phyto-pathogenic microorganisms was established according to the results of phyto-expertise on natural infectious background. The most important indicator of seeds sowing qualities is their germination capacity. The results of the EMFSHF parameters influence on the germination of wheat seeds are presented in table 1.

Table 1. The influence of EMFSHF on laboratory wheat seeds germination.

Variant	Modes of EMFSHF		Average temperature of seeds after treatment	Average laboratory germination
	Exposure	Specific power		
	sec	W/dm ³	°C	%
1	90	1550	95	20
2	60	1550	82	90
3	30	1550	66	98
4	90	1100	85	26
5	60	1100	76	94
6	30	1100	48	92
7	90	650	52	94
8	60	650	41	96
9	30	650	35	88
10	Control		-	94

The surface of the response of wheat seeds laboratory germination is constructed and shown in figure 1.

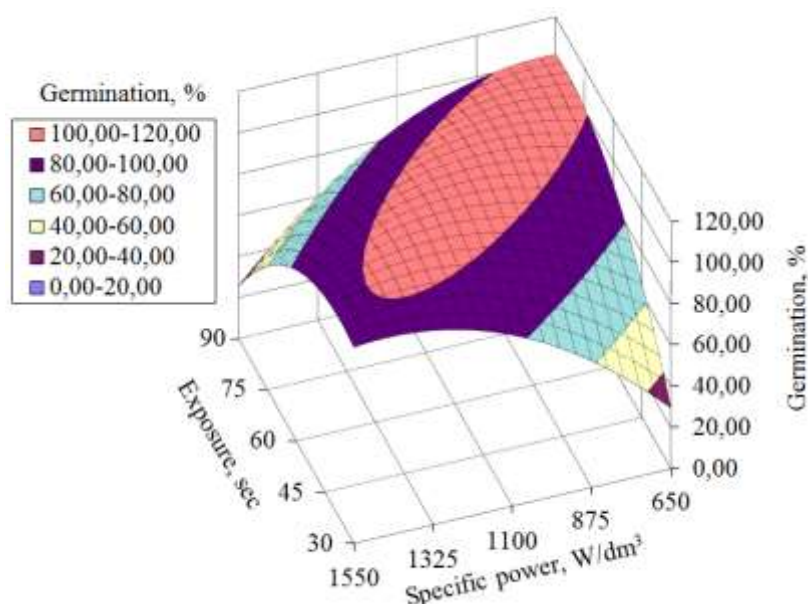


Figure 1. Laboratory germination of wheat seeds depending on the modes of EMFSHF.

It was found that the indicators of laboratory seeds germination vary in a fairly wide range and have a direct dependence on the parameters of EMFSHF and, accordingly, the heating temperature. It was established that at higher specific power and exposure (1550 W/dm³ and 90 seconds) there is a significant decrease in laboratory germination (74%) relative to control. This is due to the high temperature of the seeds after processing (95 °C), in which the processes of the grain vital activity are disturbed. A similar trend is observed at 1100 W/dm³ and 90 seconds with a temperature of 85 °C. In the rest of the modal parameters of EMFSHF influence, the germination capacity remains at the level of control and does not change significantly.

According to many authors' research, the effect of growth process stimulation, as the seeds reaction to the EMFSHF influence, is explained by the conformational changes and activation of the enzyme seed cell composition, as well as by increase of the their membrane permeability, the implementation of free radical energy; all these changes contribute to the "re-preservation" of nutrients in the cell and their transformation into simple digestible compounds. This occurs as a result of heat exposure [2]. The response reaction of seeds is characterized by an increase in the intensity of respiration and cell division. The increase in germination is explained by the favorable conditions created during processing by effective modes, and the activation of growth processes in the grain due to optimal temperature and humidity.

The results of the influence of SHF-field parameters on the wheat seed infestation by *Fusarium* fungi.

Mycelial fungi of genus *Fusarium* affect wheat grain in different periods of ripeness, as well as in swaths [1, 7, 8]. The lengthening of harvesting time leads to an increase in the degree of grain damage by these pathogens. The grain crop cultivation in the high humidity conditions (more than 70 %), entails an increase in the grain infection by representatives of genus *Fusarium*, the value of which can reach 10-18 %. At the humidity less than 15 %, natural grain recovery is possible due to the mycelium gradual death. In this regard, if the processed wheat grain had no residual moisture (14.5 - 15.5 %), then it should be moistened additionally during the pretreatment before germination.

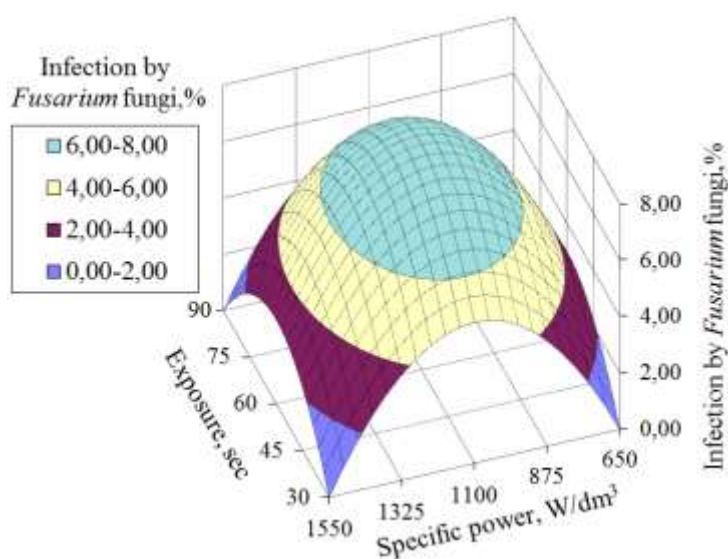
Fungi of genus *Fusarium* are considered to be resistant to known disinfecting techniques; however, the impact of EMFSHF is fatal for them.

The research data on the infection and the effect of EMFSHF on *Fusarium* fungi is presented in table 2.

Table 2. The influence of EMFSHF on the infection of wheat seeds by *Fusarium* fungi.

Variant	Modes of SHF-field		Infection of wheat seeds	Biological effectiveness
	Exposure	Specific power		
	sec	W/dm ³		
1	90	1550	0	100
2	60	1550	0	100
3	30	1550	0	100
4	90	1100	0	100
5	60	1100	4	-
6	30	1100	6	-
7	90	650	4	-
8	60	650	2	50
9	30	650	8	-
10	Control		4	-

The graphic dependences of wheat seeds infection by *Fusarium* fungi are constructed.

**Figure 2.** Infection of wheat seeds by *Fusarium* fungi depending on the modes of EMFSHF.

The infection of wheat grain by *Fusarium* fungi is manifested in the frail nature, whitish color or in the form of pinkish or orange pustules (sporulation of the fungus on the grain surface) [1, 7, 8]. In the control variant infection by *Fusarium* fungi was 4 %. This wheat grain is not allowed to be used for processing (its rate should not exceed 1%).

As can be seen from figure 2, the infection of wheat grain by *Fusarium* fungi is inversely proportional to the parameters of the SHF-field, i.e. it decreases with the increase of specific power and exposure. Thus, pathogens are completely destroyed in all modes with a specific power of 1550 W/dm³, as well as in the mode with a specific power of 1100 W/dm³ and an exposure of 90 seconds. In other cases, the infection is not reduced, but remains at the control level, except for modes with field parameters of 1100 W/dm³ – 30 seconds and 650 W/dm³ – 30 seconds. It is explained by the fact that under these operating parameters, the seed temperature does not reach the level necessary for the

destruction of Fusarium infection. The power ratio of 1100 and 650 W/dm³ with low exposure (30 seconds) can even stimulate the development of infection [6].

The results of the influence of SHF-field parameters on the wheat seed infestation by *Alternaria* fungi. Data on the effect of SHF-field on *Alternaria* fungi is presented in table 3.

Table 3. The influence of EMFSHF on the infection of wheat seeds by *Alternaria* fungi.

Variant	Modes of EMFSHF		Infection	Biological effectiveness
	Exposure	Specific power		
	sec	W/dm ³	%	%
1	90	1550	1	96,7
2	60	1550	5	83,4
3	30	1550	14	53,4
4	90	1100	1	96,7
5	60	1100	6	80,1
6	30	1100	19	36,7
7	90	650	12	60,0
8	60	650	10	66,7
9	30	650	14	53,4
10	Control		30	-

The graphic dependences of the wheat seeds infection by *Alternaria* fungi are constructed.

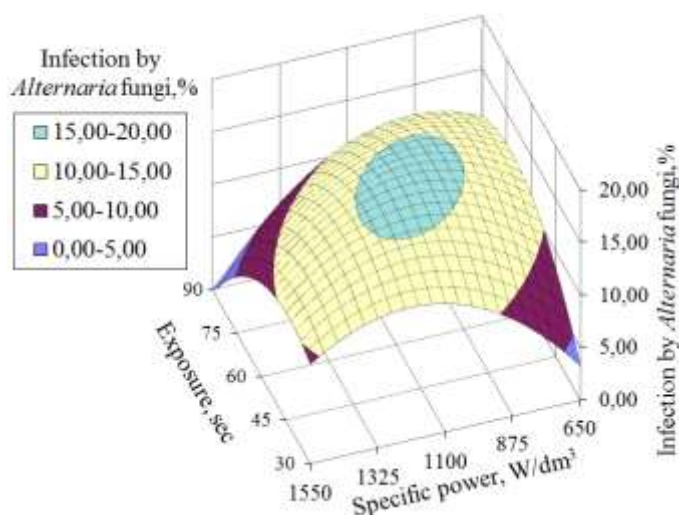


Figure 3. Infection of wheat seeds by *Alternaria* fungi depending on the modes of EMFSHF.

Having analyzed the data on the infection of wheat seeds by *Alternaria* fungi, we can draw the conclusion that the infection in all variants is much lower than in the control variant, the decrease varies from 11 to 29%. At the same time, the biological efficiency of some modes reaches 96.7%. Judging from the results of the response surface and the regression equation, the level of wheat seeds infection by *Alternaria* fungi is more dependent on the exposure. For example, with a specific power of 1550 W/dm³ and exposure change from 90 to 60 seconds, the disinfection efficiency is reduced by 13.7%, and when changing from 60 to 30 seconds – by 35.9%. A similar situation is observed at other specific power levels.

4. Conclusions

As a result of laboratory studies it was revealed that the increase in specific power and exposure differently affects the phyto-pathogenic complex, but in almost all modes there is a significant decrease of infection.

The presented phyto-pathogenic complex consisting of pathogens of *Fusarium* and *Alternaria* genera is concentrated both on the surface and in the endosperm of wheat grain. It was established that low-load of EMFSHF does not have destructive effects on fungi, as the temperature in these modes is not high enough to destroy them. The most effective mode of EMFSHF which reduces the infection of wheat grain by pathogens to the established thresholds of harmfulness, along with the simultaneous preservation of sowing qualities, is the variant with $P_{sp} = 650 \text{ W/dm}^3$ and $\tau = 90 - 60$ seconds.

Analyzing the above-mentioned material, it can be concluded that the treatment of wheat seeds with EMFSHF has not only the stimulating but also the disinfecting effect which is higher compared to the control option.

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