The use of electroactivated solutions for plants phytosanitary optimization in a forest-agricultural landscape

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Abstract. Electrochemically activated liquid systems stimulate biological processes of plant life, at the same time, these funds are ecologically safe and budgetary [9]. This paper presents the results of evaluating the electrochemically activated solutions use effectiveness in a forest-agricultural landscape. Pre-sowing seed treatment with the use of biologically active systems has a pronounced positive influence on the growth and development of plants. This contributes to the increase in their resistance to harmful organisms, while the reactions of harmful biota are individual: the decrease in the crops density by pests (by 20.0-78.1%) and diseases (by 76.2-92.0%) are lower in comparison with untreated ones. The combination of pre-sowing seed treatment with the treatment of vegetative plants provides a better result.

1. Introduction
The use of agents variety and their combinations alternative to chemical pesticides (microbiological preparations, entomophages, biologically active substances, etc.) [1, 2, 4, 10, 13, 14, 17-19] is the priority direction of agroecosystems phytosanitary optimization based on the agrotechnical method of plant protection.

The use of biologically active substances of a non-biocidal nature that stimulate the protective functions of plants in relation to economically dangerous pests species and infectious diseases pathogens is very promising [3-5, 9, 13-19]. Electrochemically activated (ECA) water and electrolytically nanostructured solution based on bischofite (ENRB) [3-6, 8] are among the environmentally friendly means. Seed treatment with such means improves the growth and development of plants, contributes to a significant increase in plant resistance to harmful organisms [1-6, 8, 13, 16, 17].

Therefore, it seems appropriate to evaluate the effectiveness of the biologically active electroactivated liquid systems use during seeds pre-sowing treatment and crops foliar treatment in the region of unstable moisture conditions.
2. Materials and methods
The work was carried out in the forest reclamation developed agricultural landscapes of the Volgograd region on the land use of the FSC of Agroecology RAS (formerly All-Russian Research Institute of Agroforestry) [12]. Sampling, counting the number of insects, the spread and development of diseases were carried out according to the methods adopted for these organisms study [7, 11]. The effect of electroactivated solutions on biota was determined during seeds pre-sowing treatment and vegetative plants foliar treatment, taking into account the economic thresholds of harmful organisms’ harmfulness [7, 11].

3. The study of the structure of the modified lead-tin-base bronze
The main condition for obtaining high yields is the use of healthy seeds, free from pathogenic infection. The phytosanitary state of crops also largely depends on the quality of the seed. In recent decades, the cereals infection with pathogens of fusarium and helminthosporium root rot, septoria, spotting, etc. has increased. The main reason for this is the high level of seed infection with fungal pathogens.

Pre-sowing seed treatment with disinfectants existing on the market allows getting healthy shoots of plants. These funds destroy superficial and internal infections, protect seedlings from mold and soil pathogens in the early period of their development, and improve the overwintering of winter grain crops. However, disinfectants are among the expensive means, their use is accompanied by the decrease in seed germination by 2 ... 4% and they have a negative influence on the environment.

In the course of research work, we analyzed the possibility of infectious diseases suppressing pathogens through the use of biologically active electroactivated liquid systems. At the first stage of plant development, the effect of biologically active solutions of activation varying degrees on seeds was evaluated in laboratory conditions. We used anolyte (ORP + 400 ... + 700), catholyte (ORP -300 ... -700) and ENRB (10%). The standard was bischofite aqueous solution, 10%.

The obtained results showed that the seed treatment with biologically active agents contributed not only to the activation of plant growth, but also caused a decrease in the seed diseases development by 76.2 ... 92.0% (Figure 1).

The efficiency of ECA of water was in direct proportion to the value of the redox potential. Higher results were recorded for variants with anolyte (+ 500mV), ENRB (10%) and catholyte (-300mV). According to the results of the experiment, it can be concluded that the seeds treatment with electroactivated solutions has an inhibitory effect on seed infection, and, consequently, allows an increase in the number of germinated seeds and accelerate the growth of seedlings.

The high result of the electroactivated liquid systems action is due to the biological processes course activation in the seed due to the receipt of additional energy and nutrients during the processing. The acceleration of plant growth and development is the consequence of this.
The data obtained were the basis for studying the possibility of using these funds to regulate the phytosanitary state of grain agrocenoses in the field. Their use was evaluated for pre-sowing treatment of winter wheat seeds Triticale at the rate of 8 l/t. The impact of aqueous solutions was carried out by changing the quantitative abundance of vegetative plants when spraying crops during the "tillering-booting" period at the consumption rate of 400 l/ha and by combining these methods.

Field data correlate with laboratory test results. The growing season of agricultural crops (from germination to physiological maturity) in the experimental variants proceeded faster, since electrochemical substances activate the growth of plants, resistance to pathogens contributes to the increase in the activity of the enzyme and the full course of biochemical processes in plant cells.

The seeds treatment before sowing with electrochemically structured means reduces the development of the most important plants infectious diseases (Table 1). The greatest effect was shown by ENRB and anolyte: the development of powdery mildew, rust and bacteriosis of the ear was inhibited 2.3 ... 3.6 times, root rot - 3.0 ... 4.0 times. The use of catholyte provided a much lower result - 1.6 ... 2.5 times and 2.4 times, respectively.

The analysis of the biologically active solutions influence on the dynamics of pathogenic microflora on the Triticale crops revealed the change in the diseases development by phenophases of this culture. Plant infection with phytopathogens begins in the last decade of April. In the tillering phase, signs of damage to plants by powdery mildew are clearly visible; its pathogens are virulent throughout the growing season - from the emergence of seedlings to the grain waxy ripeness. This is facilitated by the change in the distribution of conidia of the fungus under conditions of its optimum temperature. In the control period, the peak of the pathogen harmfulness during the research period happen to the earing phase, after which the level of infection development falls. This was especially pronounced when the air temperature reached 30 °C and above.

The use of electroactivated solutions for seed treatment suppresses phytopathogens starting from the earing phase. Anolyte and ENRB increases the plants immunity and resistance to powdery mildew in a greater degree. These agents against bacteriosis showed a similar result, and anolyte turned out to be more effective against this disease.

A similar seasonal rhythm is characteristic for leaf rust. The action of the disease causative agents is manifested already in the early spring period, despite the low air temperatures. The seeds pre-sowing treatment with anolyte and catholyte provides the increase in plant resistance to this disease almost equally.

The use of biologically active liquid agents for seed treatment leads to the suppression of root rot pathogens. Largely, the resistance of plants to root rot is increased by anolyte. Already starting from the flowering phase on the variant with the use of this agent, the intensity of root system diseases development here decreased.
Table 1. The electrochemical agents influence on the development of Triticale winter wheat diseases with different methods of application, %.

| Variants                  | Powdery mildew | Rust | Bacteriosis | Root rot |
|---------------------------|----------------|------|-------------|----------|
| **Pre-sowing seed treatment** |                |      |             |          |
| Control                   | 19.9           | 15.8 | 11.2        | 1.2      |
| Bischofite, 10% – standard| 16.5           | 7.7  | 6.0         | 0.3      |
| Anolyte, + 500 mV         | 7.0            | 4.6  | 4.3         | 0.3      |
| Catholyte, - 300 mV       | 12.4           | 6.4  | 5.9         | 0.5      |
| ENRB, 10%                 | 8.1            | 4.4  | 4.8         | 0.3      |
| **Spraying of crops**     |                |      |             |          |
| Bischofite, 2% – standard | 13.6           | 11.0 | 10.3        | 1.3      |
| Anolyte, + 500 mV         | 12.1           | 9.3  | 8.1         | 0.8      |
| Catholyte, - 300 mV       | 16.4           | 14.7 | 7.4         | 0.7      |
| ENRB, 2%                  | 12.7           | 9.9  | 9.2         | 1.0      |
| **Pre-sowing seed treatment + Spraying of crops** | | | | |
| Bischofite, 10% + Bischofite, 2% | 12.9 | 10.5 | 5.0 | 0.4 |
| Anolyte, (+ 500 mV) + Anolyte, (+ 500 mV) | 5.2 | 3.9 | 4.1 | 0.3 |
| Catholyte,(- 300 mV) + Catholyte, (- 300 mV) | 11.5 | 6.2 | 5.6 | 0.4 |
| ENRB, 10% + ENRB, 2%      | 7.5            | 4.0  | 4.2         | 0.3      |

Spraying of crops with activated solutions had a positive influence on the phytosanitary state of plants. At the same time, in terms of fungicidal properties with respect to the pathogenic complex, electrochemical agents were practically at the same level.

With the combination of pre-sowing seed treatment with spraying of vegetative plants, a pronounced protective effect was observed in the variants with the use of anolyte and ENRB. If in the control, the assimilation apparatus diseases development fluctuated at the level of 11.2 ... 19.9%, and in the variants with the use of these means it was 3.9 ... 5.2% and 4.0 ... 7.3%, respectively. The efficiency of the catholyte was significantly lower than 5.6 ... 11.5%.

Of all the pests inhabiting crops, the biocenotic bonds of plants with such a pest as wheat thrips are exposed to the greatest negative impact when using electroactivated liquid systems. This is reflected in a sharp reduction in the density of the pest in the experimental variants - 77.8 ... 86.7%. The number of flea beetles in the early spring period decreased by 29.3… 62.5%. In summer, the decrease in the density of the Eurygaster integriceps by 21.8 ... 54.0% and Meromyza by 69.9 ... 73.0% was noted.

Pre-sowing treatment of Triticale seeds with test solutions helps to optimize the entomological situation on crops during the entire growing season. The observations showed that the effect of these funds is manifested in different ways on certain types of pests. Anolyte (+ 500mV) increases plant resistance to pests to a greater extent (Table 2). In this variant, their number decreases by 62.4% on average. The effectiveness of using catholyte (- 300 mV) was almost 17% lower.

Table 2. Triticale winter wheat seeds pre-sowing treatment by ECA water influence on the number of pests

| Pests                      | Control, PCS. / unit accounting | Bischofite, 10% | Anolyte, + 500 mV | Catholyte, - 300 mV | ENRB, 10% |
|----------------------------|---------------------------------|-----------------|-------------------|---------------------|-----------|
| *Eurygaster integriceps* (Putton, 1881) | 16.4                           | 39.5            | 54.0              | 21.8                | 36.3      |
| *Anisoplia austriaca* (Herbst, 1783) | 4.0                            | 33.7            | 40.0              | 25.0                | 37.9      |
| Chrysomelidae: Chaetocnema, Phyllotreta | 78.3                           | 23.1            | 62.5              | 29.3                | 48.9      |
| *Haplothrips tritici* (Kurdjumov, 1912) | 192.0                           | 78.1            | 86.7              | 81.3                | 77.8      |
| *Meromyza nigriventris* (Macquart, 1835) | 11.5                           | 63.3            | 72.8              | 69.9                | 73.0      |
Anolyte (+500 mV) has a significant inhibitory effect on pests when spraying of vegetative plants. Its application into the agrocenosis during the tillering-booting period reduces the number of Eurygaster integriceps by 9.6…33.4%. There was also a 55.1% decrease in the abundance of leafhoppers. At the same time, flea beetles practically do not react to the application of ECA water into the plant stand.

Anolyte solutions with a redox potential from +800 mV to +900 mV have an entomocidal effect on wheat thrips when spraying of crops. The crops treatment by them provides the decrease in the number of pest larvae by almost three times relative to control. The number of adult insects remains practically unchanged.

The influence of ECA water on the grain crops resistance to harmful insects is associated, in our opinion, with the following factors: changes in the structural-morphological, anatomical-biochemical (mechanical) barriers caused by the structure of integumentary and internal tissues; mismatch in the phenology of plants and harmful insects. The reliability of barriers in plants is determined by the acceleration of the growth cone differentiation process, the tightness of the leaf sheaths and glumas, the increased content of fiber - a mechanical barrier for the colonization of plants by harmful insects, their nutrition, oviposition, etc.

In the course of observations, activated agents positive influence on the abundance of useful biota was noted. The accumulation and preservation of entomophages in the agrocoenosis are more vividly manifested in the first stages of plant vegetation, when the number of pests in the phytocoenosis is maximum.

4. Conclusion

The use of electroactivated liquid systems for pre-sowing seed treatment and the combination of this technique with spraying of crops is an effective, environmentally friendly and resource-saving method that successfully competes with the use of plant protection chemicals in the fight against economically dangerous pests and diseases. The use of such agents in the forest-agricultural landscape is accompanied by the formation of a qualitatively new ecological environment and the creation of favorable conditions for self-regulation in biocoenoses.

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