Prospects for using sapropel deposits to increase the resistance of plants to stress factors

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Abstract. Root rot is a disease of plants, which have weak plant resistance to pathogens (from seed or soil inoculum) and environmental factors. Depending on the cultivation zone, the degree of saturation with one crop, agricultural technologies and varieties, the species, racial, strain composition of pathogens is constantly changing. The manifestations of root rot at an early stage of plant development are especially harmful. Healthy seed is a contribution to successful production, but stressful factors often attack plants with infectious pathoplora in the soil. The article discusses the use of combined soil mixtures as a stimulating factor in increasing the stress resistance of plants with the further production of healthy plants and seed material, which is a necessary reality of modern scientific technologies.

Key words: wheat, stress, soil mixtures, root rot, sapropel deposits, root system, Bipolaris, Fusarium.

The real ecological situation in the world helps to identify priority areas in the study. Researchers project the problem of interest in different ways, comparing and excluding concomitant conditions. In practical agricultural science, along with field experiments, laboratory studies are carried out according to a given projection. These experiments very often simulate more severe conditions for the tested culture (nutrient medium, humidity, temperature and light conditions, etc.), but it is these conditions that show a greater reliability of the crop response.

Objects of research: winter wheat (Triticum), the causative agent causing fusarium lesions of grain crops: Fusarium culmorum (W.G.Sm.).

The studies used the roll method (Benken et al., 1977) and/or inoculation of seeds and two-day-old seedlings with a spore suspension (5 ml/25 pieces at a concentration of 100-120 x 10^-6 spore load) (Ovsyankina, 1998, Glinushkin, 2012).
Figure 1. Carrying out experimental work to identify the growth characteristics of the root system of winter wheat.

The assessment of the pathogenicity of the strains was carried out on the 5th day according to the length of the primary root and sprout, the number of secondary roots. The intensity of plant damage by fungi was assessed by the modified M.F. Grigoriev (1976) scale. For each variant, at least 100 germinating seeds of the same variety were used. The experimental results were processed statistically. Seedlings planted for germination and development in water and clean, calcined sand served as control.

The causative agents of the disease are fungi from the genera: *Fusarium*, *Bipolaris*, *Alternaria*, *Pythium*, *Gaemonnomyces*, *Cercosporella*, *Typhula*, *Rhizoctonia*, *Aureobasidium* living in soil, on seeds and plant debris. In terms of frequency of occurrence and harmfulness, the priority belongs to fungi of the genus *Fusarium*, *Bipolaris* and *Alternaria*. Root rot fungi possess a wide range of different enzymes, with the help of which they destroy the tissues of the feeding plant and cause its death. The disease externally manifests itself in the form of brownish roots, underground internodes, base of the stem and sheath of the lower leaves. When infected with root rot pathogens, the underground internode and tillering nodes lose their strength, become loose, fragile and break off when the plants are pulled out of the soil. In agrobiocenoses, root rot pathogens are a mixed infection, which is more often localized in the rhizosphere of plant roots.

Sapropel deposits of the Volga-Akhtuba flood plain have the necessary nutritional components for the full-fledged initial growth of wheat plants. The use of sapropel deposits will allow maintaining the immunity of wheat from severe damage by pathogenic fungi (possibly with a necessary set of mineral nutrients) at the earliest stages of wheat development during the growing season. In general, the use of sapropel deposits in the design of soils allows reducing the infectious load on agrobiocenoses and crops.

Sapropel deposits of the Volga-Akhtuba floodplain also act as a recultivation component capable of activating soil processes to improve the properties of soil fertility. Expanded reproduction of soil fertility is possible only under the condition of regulating the circulation of substances and energy flows in agroecosystems, including when optimizing their humus state. Report that soil humus is formed in an oxidizing environment during aerobic decomposition and humification of terrestrial vegetation, and humic substances of sapropels - in hydromorphic conditions at the bottom of reservoirs from the products of partial decay of plankton and aquatic vegetation. In addition, some water bodies are brought in from the surrounding territories. These differences in the conditions of humification and in the quality of the starting material are undoubtedly reflected in the molecular structure of humic substances in soil and sapropel.
The healthy and fertile soil is a unique environment-forming, production and bioresource ecosystem of the biosphere, the main natural resource for food production of the Earth's population [4]. Scientists systematically prove that any human impact on a bioresource ecosystem leads to changes that can only be compared with the intensity of the impact. The development of conceptual justifications aimed at preserving the uniqueness of the biosphere can be found in the works of M.S. Sokolov, Yu.Ya. Spiridonov, A.P. Glinushkin. [8, 11].

Such conditions with the chosen priority direction were modeled in our research, where the main goal was to consider the influence of sapropel deposits on the growth processes of wheat at the early stages of ontogenesis. The object under consideration was winter wheat, i.e. a set of indicators of one plant.

Laboratory studies with prepared artificial conditions were regulated according to the conditions for recording the obtained data. The registration of the root system was carried out according to the three main formed roots, in averaged indicators. It was important to consider the effect of various soil mixtures with a moisture content of 100%. the lowest moisture capacity on growth characteristics with a background load of artificial infection with the fungus *Fusarium culmorum*.

In literary sources, soil is interpreted as an organic substance, based on a humus-containing component with added mineral impurities. Soil - any fertile soil that does not have a constant composition. The filling depends on the material and on the method of its production (place, time, method of extraction and the process of artificial processing). There is no classification according to the types of soil, as well as the proportions of the contents of the components. Varying different components and the difference in dosage allows you to get an infinite number of types of fertile soil with special characteristics, where micro- and macroelements are in a form accessible to plants [3].

The seed of winter wheat «Moskovskaya-39» was used as a test culture.

Prepared soil mixtures consisted of two composite components:
- light chestnut soil (production-and-training centre «Gornaya Polyana» Volgograd agricultural university Volgograd region).
The chemical constituents of this soil base are presented in Table 1.

**Table 1. Methodical Guidelines for comprehensive monitoring of soil fertility, agricultural land**

| Controlled indicators                      | Units of measure | Actual value | Reference documentation under test |
|--------------------------------------------|------------------|--------------|-----------------------------------|
| Alkaline hydrolysable nitrogen             | mg/kg            | 29,4         | MG M 85                           |
| Mass fraction of mobile phosphorus compounds | mg/kg            | 32,1         | all-Union State Standard 26205-91 |
| Mass fraction of mobile potassium compounds | mg/kg            | 337,0        | all-Union State Standard 26205-91 |
| Water extraction:                          |                  |              |                                    |
| Dense residue                              | %                | 0,047        | all-Union State Standard 26423-85 |
| Carbonate ion (aqueous extract) Bicarbonate ion | mmol/kg          | 0,72         | all-Union State Standard 26424-85 |
| Calcium                                    | mmol/eq          | 0,48         | all-Union State Standard 26428-85 |
| Magnesium                                  | mmol/eq          | 0,32         | all-Union State Standard 26428-85 |
| Sodium                                     | mmol/eq          | 0,20         | all-Union State Standard 26427-85 |
| Chloride ion                               | mmol/eq          | 0,14         | all-Union State Standard 26425-85 |
| Sulfate ion                                | mmol/eq          | 0,02         | all-Union State Standard 26426-85 |

- sapropel deposits of the «Osinka» erik of the Volga-Akhtubinskaya floodplain of the Volgograd region.

Chemical data presented in table 2.

The parameters of this chemical study of sapropel deposits show them as high-ash with a favorable pH environment, which, in combination with a weakly acidic soil (during the reaction of a soil solution), will bring the soil mixture closer to neutral.

**Table 2. Tests for the actual content of gross forms of NPK sapropel**

| Controlled indicators                      | Units of measure | Actual value | Reference documentation under test |
|--------------------------------------------|------------------|--------------|-----------------------------------|
| pH                                         | units g.          | 6,71         | all-Union State Standard 27979-88 |
| Carbonates (CO₂)                           | %                | doesn’t boil | MG M-85                          |
| Fur. Composition (physical clay, particles <0.01 mm) | %                | 41,80        | MG M-1977                        |
| Organic matter                             | %                | 8,85         | all-Union State Standard 27980-88 |
| Ash content                                | %                | 82,3         | all-Union State Standard 11306-83 |
| Macronutrients (gross forms)               |                  |              |                                    |
| Nitrogen                                   | %                | 0,64         | all-Union State Standard 26261-84 |
| Phosphorus                                 | %                | 0,41         | all-Union State Standard 26261-84 |
| Potassium                                  | %                | 2,12         | all-Union State Standard 26261-84 |
| Calcium                                    | %                | 5,04         | MG M-2000                        |
| Iron                                       | %                | 2,12         | MG M-2000                        |
| Trace elements (movable forms)             |                  |              |                                    |
The analysis of the initial data was viewed in two time periods: 7- and 14-day. The results of the study to identify the effect of the compiled soil mixtures on the root system are presented in Tables 3 and 4.

**Table 3.** Initial data for options, with the definition of the multiplicity between backgrounds (a - without a background load; b - with a background load of artificial infection with the fungus *Fusarium culmorum*)

| No | Variant | 7-day period | 14-day period | Multiplicity | Control deviations, ± | Multiplicity | Control deviations, ± |
|----|---------|--------------|--------------|--------------|-----------------------|--------------|-----------------------|
|    |         | a            | b            | Between backgrounds | a            | b            | Between backgrounds | a            | b            |
| 1  | C (control) | 9.96         | 9.99         | 1.00         | -                      | 9.22         | 7.29         | 1.27         | -                      |
| 2  | D        | 10.73        | 8.80         | 1.22         | -                      | 13.13        | 8.23         | 1.59         | + 0.32         |
| 3  | Dd₁      | 11.17        | 9.88         | 1.22         | + 0.13                 | 14.96        | 8.78         | 1.7          | + 0.5         |
| 4  | Dd₂      | 11.35        | 11.09        | 1.02         | -                      | 13.61        | 10.29        | 1.32         | + 0.05         |
| 5  | Dd₃      | 10.5         | 11.13        | 1.06         | -                      | 11.35        | 8.49         | 1.34         | + 0.07         |
| 6  | Dd₄      | 11.91        | 10.5         | 1.13         | -                      | 13.49        | 9.05         | 1.49         | + 0.22         |
| 7  | E        | 11.12        | 6.78         | 1.64         | + 0.64                 | 10.05        | 8.57         | 1.17         | - 0.1          |

**Table 4.** Initial data for options, with the definition of the frequency between time periods.

| No | Variant | Background without fungi | 7-day period | 14-day period | Multiplicity | Control deviations, ± | Background with fungi | 7-day period | 14-day period | Multiplicity | Control deviations, ± |
|----|---------|---------------------------|--------------|--------------|--------------|-----------------------|-----------------------|--------------|--------------|--------------|-----------------------|
|    |         |                           | Interperiodic| Control      | Interperiodic| Control      | Interperiodic| Control      | Interperiodic| Control      |
| 1  | C (control) | 9.96                      | 9.22         | 1.08         | -             | 9.99        | 7.29         | 1.37         | -             |
| 2  | D        | 10.73                     | 13.13        | 1.22         | + 0.14       | 8.80        | 8.23         | 1.07         | - 1.3        |
| 3  | Dd₁      | 11.17                     | 14.96        | 1.34         | + 0.26       | 9.88        | 8.78         | 1.13         | - 0.24       |
| 4  | Dd₂      | 11.35                     | 13.61        | 1.20         | + 0.12       | 11.09       | 10.29        | 0.93         | - 0.44       |
| 5  | Dd₃      | 10.5                      | 11.35        | 1.08         | 0             | 11.13       | 8.49         | 1.31         | - 0.06       |
| 6  | Dd₄      | 11.91                     | 13.49        | 1.13         | + 0.05       | 10.5        | 9.05         | 1.16         | - 0.21       |
| 7  | E        | 11.12                     | 10.05        | 1.11         | + 0.03       | 6.78        | 8.57         | 1.26         | - 0.11       |

According to the results of the studies presented in Tables 3 and 4, it can be concluded that for all options, soil mixtures with the use of sapropel deposits show positive dynamics in the development of...
the wheat root system. Differences are observed in the dosage of the applied sapropel deposit, which is clearly distinguished with the background load of artificial infection with the fungus *Fusarium culmorum*. In a 7-day period, seed infested with *Fusarium culmorum* does not stand out much from the background without additional stress, although some indicators give better results. But when looking at the 14-day indicators, we see a distinct suppression of the growth of the wheat root system.

To compile the volumetric characteristics of the study, it is necessary to consider the % survival rate of winter wheat. Comparative characteristics of the study are well traced in the graphs.

**Figure 4.** Graph of survival rates with the background load of artificial infection with the fungus *Fusarium culmorum*, 7-day period

**Figure 5.** Graph of survival rates with the background load of artificial infection with the fungus *Fusarium culmorum*, 14-day period
Legend:
- D - sapropel deposits;
- d1, d2, d3, d4 - sapropel + light chestnut soil, differences in doses;
- E - light chestnut soil.

Baseline data clearly show the beneficial effect of sapropel deposits on wheat survival under stress conditions. The mineralized composition of these soil mixtures stimulates the immune potential of the plant, thereby increasing resistance to the environment, in our case the presence of *Fusarium culmorum*.

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