The efficiency of using complex micronutrient fertilizers, humates and biological preparations in the technology of growing fiber flax

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Abstract. The article evaluates the effectiveness of the use of Aquarin, sodium humate, Epin and Zircon in the production of flax products. The use of these preparations was studied for topdressing of plants during the growing season and in the process of retted stalks maturation. Topdressing of crops was carried out in the phase of "rapid growth". The processing of the fiber flax ribbon was carried out on the fifth day after pulling. The greatest efficiency in spraying fiber flax crops and processing retted stalks was shown by the combined use of Aquarin and Humate "Fertility". The combined treatment of crops with Aquarin and a humic preparation provided an increase in all production indicators: straw yield increased by 11.6 %, seeds by 24.8 %, retted stalks and fibers by 4.6-6.2 %, and scabbard fiber by 44 %. The treatment of flax ribbon with micronutrient fertilizer Aquarin together with Humate "Fertility" led to an increase in the fiber yield by 5.1 %, the long fiber yield by 2.4 %, and the fiber strength by 0.35 Dan. The data obtained make it possible to recommend the use of preparations both during the growing season and in the process of retted stalks maturing to increase the efficiency of fiber flax production.

1. Introduction
Fiber flax is the most important and oldest technical crop in Russia. The cultivation of flax and the production of flax products have been at the forefront of the Russian economy for centuries.

Modern agriculture should be aimed at obtaining high and stable yields of high-quality flax products, regardless of weather conditions. In this situation, obtaining competitive products is possible only on the basis of widespread introduction of new agro-technological methods into the technology of flax cultivation, one of which is the use of various growth-activating substances: growth regulators, mineral complexes with microelements, bacterial preparations, etc. [1-3].

Among such substances, complex micronutrient fertilizers, humic preparations and stimulating biological preparations have been widely used recently. Their effectiveness has been proven by numerous studies on various agricultural crops, including the production of flax [4-13].

The problem of obtaining competitive flax products poses a task for manufacturers to improve agro-technological methods from the moment of germination to the moment of receiving the fiber flax retted stalks. A possible way out of this situation is the use of substances that make it possible to adjust
the process of crop formation and its quality in accordance with agrotechnical conditions, both at the stage of cultivation and at the stage of dew-retting.

2. Materials and methods

The purpose of the work is to study the effectiveness of the application of complex micronutrient fertilizers, humates and stimulating biological products at the stages of cultivation of fiber flax and preparation of retted stalks.

The studies were carried out for two years in field and production experiments on the experimental field of Kostroma Research Institute of Agriculture being a branch of "FIC of Potato Named after A.G. Lorkh" in Kostroma region. The soils of the experimental site were sod-podzolic with a humus content of 1.6 %, mobile phosphorus was 272.0 mg/kg soil, exchangeable potassium was 47.9 mg/kg of soil. In spring, complex mineral fertilizers (N₁₃P₁₉K₁₉) were applied under cultivation at a dose of 2 dt/ha. In field experiments, the effectiveness topdressing of fiber flax crops was investigated with the following preparations: mineral complex Aquarin (3 kg/ha), Humate "Fertility" (1.5 l/ha), biological preparations Epin (50 ml/ha) and Zircon (25 ml/ha). The characteristics of the preparations are presented in Table 1.

| Indicator                              | Characteristics of the indicator for the preparation |
|----------------------------------------|-----------------------------------------------------|
| The nature of the preparation          | Complex water-soluble mineral fertilizer (N - 3 %, P - 11 %, K - 35 %, MgO - 9 %) with microelements in a chelate form. |
| and the active ingredient             | Sodium salts of humic acids with a concentration of 20 g/l obtained from lake sapropel |
| Mechanism of action                   | Favourably affects the soil, promotes a more complete use of the nutrition elements by the plant from soil |
| Preparative form                      | Crystalline powder Liquid suspension Solution Solution |

The effectiveness of treating fiber flax ribbon with preparation Aquarin and humate "Fertility" on technological indicators of flax fiber was studied in production experiments. The treatment of fiber flax ribbon with these preparations was carried out on the fifth day after pulling according to the following scheme: 1) Control, 2) Aquarin (3 kg/ha), 3) Aquarin (3 kg/ha) + Humate "Fertility" (1 l/ha).

Weather conditions during the growing season of plants in the years under study differed both in average monthly air temperature and in precipitation.

The moisture supply conditions in the first year of research did not meet the requirements of the crop: the amount of precipitation in May-July was 101 mm lower than the average long-term values, the hydrothermal coefficient was 0.7, which led to a decrease in the yield of flax products in that year. The growing season of the second year of research was generally very favorable for the growth and development of flax: the sum of effective temperatures for May-July exceeded the average long-term data by 81° C with a sufficient amount of precipitation (HTI = 1.5), which ensured the formation of fairly high yields of flax products.

All studies and observations were carried out in accordance with the recommendations of the All-
Russian Research Institute of Flax (Guidelines for conducting field experiments with fiber flax. Torzhok, Rzhevsk printing house, 1978). Experimental data were processed by statistical methods using Excel program.

3. Results and Discussion

Studies have shown that the use of topdressing of fiber flax crops with growth-activating substances has a positive effect on the formation of economically useful products. The effectiveness of various preparations can be analyzed in terms of the increase in the yield of flax products in relation to the control (Fig. 1).

![Figure 1](image)

**Figure 1.** Effects of increments of production parameters of fiber flax to the control when using plant topdressing with various growth-activating preparations on average over 2 years of research, %.

It was found that the use of biological preparation Zircon was manifested mainly in an increase in the biomass and seed productivity of plants, while large elementary fibers with a thin cell wall of low quality were formed, which negatively affected the yield of flax [7, 14].

As can be seen from Figure 1, the yield of seeds in the variant with Zircon was 27 % higher than the control indicators, while the yield of retted stalks and flax fiber was lower than the control by 3-7 %. The effect of complex fertilizer Aquarin, on the contrary, was reflected mainly in the formation of the fibrous part of the product. The yield of retted stalks in comparison with the control increased by 41.7 % and that of flax fiber by 46-48 %. At the same time, the seed yield was 8.3 % lower than the control. The combined treatment of flax crops with Aquarin and a humic preparation provided an increase in production indicators: the yield of straw increased by 11.6 %, that of seeds by 24.8 %, that of retted stalks and fibers by 4.6-6.2 % and pulled fiber by 44 %. Thus, the most effective variants of the studied ones are the treatment of plants with biological preparation Epin and the complex treatment of crops with Aquarin and the humic preparation. These agrotechnical methods had a positive effect on all economically valuable indicators of flax.

In modern conditions, it is important not only to obtain a high yield of flax products, but also to preserve it at the stage of dew-retting. The dew-retting process is highly dependent on weather conditions and is a part of risk that often negates all crop cultivation efforts.

Studies of many authors have established that the instability of weather conditions at the stage of dew-retting disrupts the course of microbiological processes as a result of changes in the ratio between bacterial and fungal microflora, and this is primarily reflected in the formation of the quality of flax products. It is possible to change the development of bacterial and fungal microflora by using various biologically active preparations in the technology for the preparation of retted stalks, which can have a stimulating or inhibitory effect on the development of pectin-decomposing microorganisms [15, 16].
To treat the fiber flax ribbon complex fertilizer Aquarin and humate "Fertility" were used, which showed the greatest efficiency in the formation of the fibrous part of the product. Based on the research, it was found that the method of treating the flax ribbon with Aquarin solution had a positive effect on the main technological indicators of flax fiber (Table 2).

Table 2. The influence of mineral complex Aquarin and humate "Fertility"
on technological indicators of flax fiber, on average for 2 years.

| Variant of treatment | Fiber separability, units | Fiber yield, % | Long fiber yield, % | Breaking load, Dan |
|----------------------|--------------------------|----------------|--------------------|-------------------|
| Control              | 4.4                      | 34.8           | 23.7               | 8.84              |
| Aquarin              | 5.1                      | 36.6           | 27.3               | 8.99              |
| Aquarin + humate “Fertility” | 5.6                  | 39.9           | 28.1               | 9.19              |
| HCP05                | 0.20                     | 1.68           | 1.65               | 0.21              |

The components included in Aquarin contributed to activation of the maceration process, as evidenced by the fiber separability indicator, the value of which was 0.7 units higher than the control. Significant increases were also noted in the yield of total and long fibers by 1.8 % and 3.6 %, respectively. At the same time, there was no significant increase in fiber strength.

Joint spraying of the flax ribbon with Aquarin and the humic preparation made it possible to improve all the studied technological parameters. The fiber separability index in this variant was 5.6 units, the fiber yield was 39.9, the long fiber yield was 28.1 % and the breaking load was 9.19 Dan.

The use of mineral complex Aquarin allows to enhance the nutrition of pectin-decomposing microorganisms, and the action of the humic preparation stimulates the formation of pigments and enzymatic activity. Thus, the combined action of the preparations increases the rate of decomposition of pectin substances and shortens the maturation time of the retted stalks, which in turn ensures the production of higher quality products.

4. Conclusion
The studies have proved the positive effect of using complex micronutrient fertilizers, humates and biological preparations in the technology of growing fiber flax. The greatest efficiency both when spraying crops of fiber flax and when processing retted stalks was shown by the combined use of Aquarin and humate "Fertility". The joint spraying of flax crops with Aquarin and the humic preparation provided an increase in all production indicators: straw yield increased by 11.6 %, that of seeds by 24.8 %, retted stalks and fibers by 4.6-6.2 %, pulled fiber by 44 %. The use of this agricultural technique at the stage of dew-retting led to an increase in the total fiber yield by 5.1 %, the long fiber yield by 2.4 % and the fiber strength by 0.35 Dan. The data allow to recommend the use of preparations both during the growing season and in the process of retted stalks maturing to increase the efficiency of fiber flax production.

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