Ways to increase the biologyzation of crop production

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Abstract. Promoting better root growth and soil fertility through biofertilizers is proving to be an effective means of increasing yields. Methods of pretreatment of agricultural waste - cavitation delignification, electric pulse and ultrasound contribute to the transformation of complex molecular structures into simpler monomers and the development of new value-added bio-products such as biofertilizers. It was found that the use of these methods does not destroy the fibrillar structure of cellulose, but causes the re-localization and partial removal of lignin. Pretreatment of samples increases the yield of dry substances by an average of 3.4 times when using ultrasound and 5.6 times when using hydrodynamic cavitation. At the same time, the amount of reducing sugars increases by 2.3 and 5.8 times, respectively. The obtained extracts after fermentation of Bacillus have a growth-stimulating effect, increase the germination energy of wheat seeds by 29.4% to control and by 34.2% germination.

1 Introduction

In improving agricultural technologies, the concept of biologization is promising, which includes the maximum number of factors providing for the introduction of beneficial microorganisms into the soil and the use of their exometabolites as growth stimulants, which ensures an increase in the activity of the rhizosphere and the philosopher. An additional positive point is the sanitation of the soil, while lysis of hyphae of micromycetes occurs [11,12,13]. The involvement of biological factors in the intensification process has not only an ecological, but also an economic priority [1,3,8].

Biologization of agriculture includes techniques for restoring and maintaining soil fertility. Promoting better root growth and increasing soil fertility with the help of organic materials – biofertilizers, biologics, plant destructors and others, turns out to be an effective means of increasing the yield of many agricultural plants using less moisture, fertilizers, seeds, agrochemicals and greater resistance to changing climatic conditions [2,4,6,9].

Plant waste is rich in bioactive compounds with antioxidant and antimicrobial properties, which expands the scope of application. For example, the crop residues of buckwheat straw are suitable for bioconversion by microorganisms after extraction of BAS (bioflavonoids), which are used in the pharmaceutical, food industry, in the creation of NWR [5,7,10].

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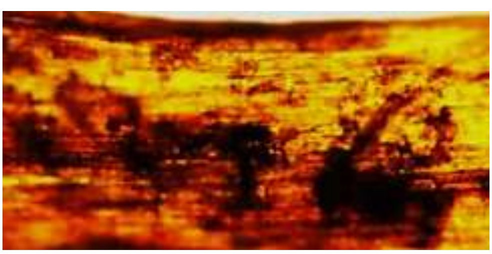
2 Research methodology

Methods of pretreatment of agricultural waste for the conversion of complex molecular structures into simpler monomers and the development of new ones: Physical methods of pretreatment (grinding, ultrasound, heat treatment, microwave, pyrolysis, irradiation), Chemical methods of pretreatment (acid hydrolysis, alkaline hydrolysis, ozonolysis, organosolvent, wet oxidation), Biological methods of pretreatment (enzymes, bacteria, fungi), "green" solvents (ionic liquids, deep eutectic solvents, natural, deep eutectic solvents).

The use of these techniques will avoid the harmful effects of plowing crop residues and straw, because when plowing in the same year when sowing is carried out, straw acts depressingly on the crop into which it was introduced as fertilizer. In addition, toxic compounds of phenol derivatives have been found in straw and its decomposition products. Such compounds inhibit plant growth. Especially many different compounds accumulate in the soil due to the anaerobic decomposition of straw. In this regard, the development of technologies for the production of biofertilizers using highly effective strains of microorganisms is relevant. The objects of the study were buckwheat straw treated with various physical methods: hydrodynamic cavitation, ultrasound, electromagnetic action in a 10:36 hydromodule. Destructive changes in straw were assessed by microscopy.

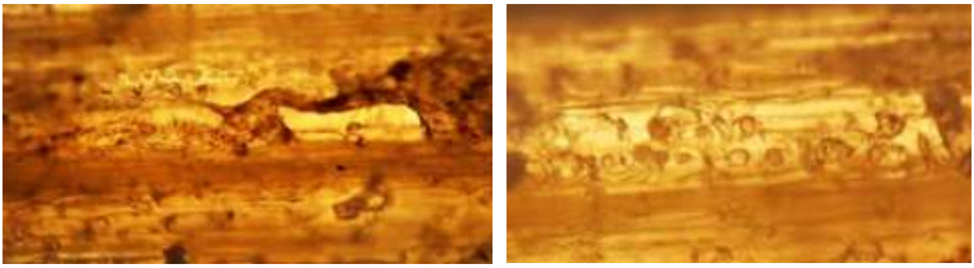
The results of the study. The delignification of buckwheat straw opens up wide possibilities for its processing. The pretreatment methods used have high performance properties, an inexpensive and acceptable source of energy in the processes. To increase the effectiveness of the traditional approach to separation, loosening of fibers and delignification of polysaccharide components, cavitation delignification, electric pulse and ultrasound were used. The effectiveness of the methods was evaluated by the yield and properties of the insulated fibers compared to traditional heat treatment. Figure 1 shows the initial microstructure of buckwheat straw.


a)


b)

Fig. 1. Native microstructure of buckwheat straw: a) from the outside; b) from the inside.

The original buckwheat straw is characterized by rigidly bonded fibers. The breaking length reaches 10,500 m, the absolute tear resistance is 320 mN, which is 2 times stronger than other types of straw – rice, oats. This strength of the straw is achieved by tightly fitting fibers coated with a shell containing lignin, fats and waxes, which form a protective coating. On the inside, the straw consists of loose, randomly scattered cells (parenchyma). Heat treatment makes it possible to obtain a straw structure with longitudinal and transverse breaks, as well as isolated cellulose fibers (Fig.2). Schematically, the destruction process is shown in Figure 4. Pretreatment of buckwheat straw, regardless of the method, physical, thermal or chemical, leads to the destruction of the lignin layer, multiple ruptures of hemicellulose and the release of cellulose.



a) b)

Fig. 2. Microstructure of buckwheat straw after heat treatment: a) t= 1000C, 1.5 h; b) t=1200C, 0.25 h.

The fragment of crushed buckwheat straw shown in Figure 3 demonstrates a disordering of the structure and an increase in the specific surface area, which on the one hand makes the substrate accessible to enzyme molecules, and on the other hand there is a danger of oxidation and hydrolysis of biologically active substances, and also under such conditions condensation and oxidation of lignin is possible.

Fig. 3. Microstructure of crushed buckwheat straw.

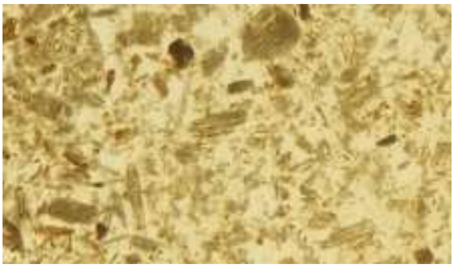


Fig. 4. Microstructure of buckwheat straw under cavitation.

When cavitation is applied using a set of devices for generating low and high intensity cavitation, the lignin layer is thinned, bonds in hemicellulose are broken and soluble monomers are formed (Fig.4). It was found that the use of hydrodynamic cavitation does not destroy the fibrillar structure of cellulose, but causes re-localization and partial removal of lignin. It is important to note that the mechanism of straw delignification through the process of hydrodynamic cavitation is hydrolytic. Figure 6 shows the destruction of buckwheat straw under ultrasonic exposure. There is a violation of the spatial orientation of the fibers, minor longitudinal breaks are visible, single cellulose fibers are obtained.

Fig. 5. Microstructure of straw under ultrasonic exposure.

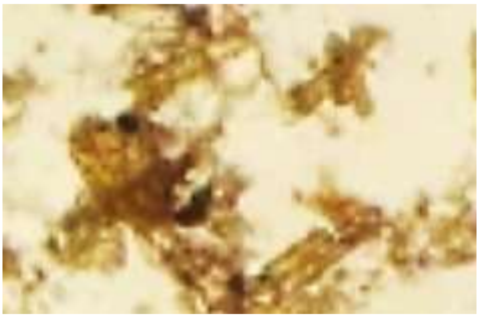


Fig. 6. Straw microstructure after electromagnetic exposure.

In the photo of Figure 6, partial removal of hemicellulose and lignin is noticeable, the cellulose structure is not damaged.

3 Discussion of the results

The results obtained predetermine the further use of substrates as the basis of nutrient media for microorganisms that destroy straw. Pretreatment of samples, in addition to loosening the fibers, increases the yield of solids in the studied samples by an average of 3.4 times when using ultrasound and 5.6 times when using hydrodynamic cavitation. At the same time, the amount of reducing sugars increases by 2.3 and 5.8 times, respectively. After the work of microorganisms of the genus Bacillus, extracts of light yellow color, pH 6.5, with a stimulating effect were obtained. When sprayed with a working solution in a concentration of 10-7, together with tank mixtures, they increase soil fertility and strengthen immunity of cultivated plants. Soaking the seeds of agricultural plants leads to an increase in germination energy and germination (Fig.7).

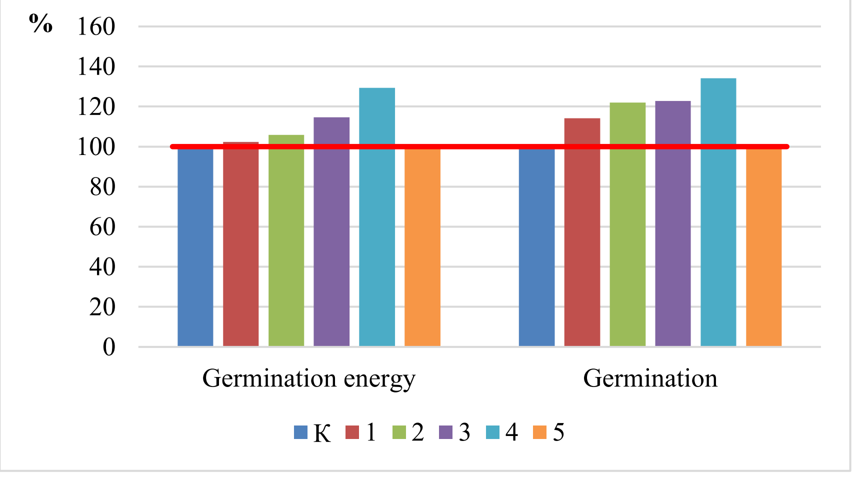


Fig. 7. Efficiency of treatment with Triada wheat seed extract in concentration: K – control (0%); 1– 10^{-2}; 2– 10^{-3}; 3– 10^{-5}; 4– 10^{-7}; 5– 10^{-9}

The maximum effect was found when processing Triada wheat seeds at a concentration of 10-7%, which is +29.4% of the control in germination energy and +34.2% in germination. Conclusion. The considered methods are effective as a pretreatment of lignocellulose biomass for further use. Partial removal of hemicellulose and removal of lignin are important factors in increasing the digestibility of buckwheat straw by microorganisms, perhaps more important than breaking the structure of skeletal cell walls and modifying the crystallinity of cellulose. The experimental data obtained on the biological activity of extracts after microbial exposure to prepared straw as biofertilizers showed a growth-stimulating effect on wheat seedlings, which is determinant in obtaining high yields.

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