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from energy production. In particular, there was a 33% reduction in the grain content and an 18.4% reduction in the vegetative mass of winter wheat. Under the influence of the military factor, the use of the proposed *Haupsyn BT* resulted in a 24% reduction in Zn content in the grain and 32% in the vegetative mass of the test crop.

Conclusions. The results of the approval of the method established: (1) the bioremediation effect of the biological preparation in the contaminated soil-plant system by intensifying the bioremediation processes and restoring the plant productivity according to the indicators of the increase in the yield of the test crop and on the reduction of the accumulation of HM by the test plants in comparison with the control; (2) the restoration of the quality of the chemically contaminated soil-plant system while minimising the impact of the chemical pollution and the military factor; (3) the reduction of resource consumption by reducing the doses of the drug to achieve a bioremediation effect; (4) the suitability of the method on black soils of disturbed land plots as a result of shelling from "Grad" installations, field and self-propelled howitzers; calibre 120 mm, mortars with 82 mm fragmentation projectiles and high-explosive fragmentation mines, calibre 82 mm, for the detected diameters of 1-4 m pits.

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NANO SELENIUM SYNTHESIZED USING (*BACILLUS SUBTILIS* IMB B-7392 AND IMB B-7393) AND *LACTOBACILUS PLANTARUM* IMB B-7679

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Introduction. The involvement of probiotic microorganisms in the synthesis of selenium nanoparticles (Nano-Se), makes it possible to obtain selenium-enriched probiotics and Nano-Se, which can be used as an alternative and effective way of obtaining nanoparticles (NPs).

The aim of the research is to study the processes of biogenic synthesis of selenium nanoparticles by probiotic strains of *Bacillus subtilis* and *Lactobacillus plantarum* and their prospects for practical application.

Materials and methods. Bacterial strains *B. subtilis* IMB B-7392, *B. subtilis* IMB B-7393 and probiotic *L. plantarum* IMB B-7679 to be used in the biogenic production of

SeNPs. During the study, *B. subtilis* bacteria were grown in MPB medium and Man-Rogosa-Sharpe (MRS) broth was used for the growth of *L. plantarum*. The selenium-dependent growth of the probiotic bacteria was evaluated in the appropriate medium under aerobic and static conditions. The probiotic bacteria were cultured aerobically in a shaking incubator at 220 rpm and in static conditions at 30°C. The mechanism of Se(Ⅳ) tolerance of *L. plantarum* IMB B-7679, *B. subtilis* IMB B-7392 and IMB B-7393 and the biotransformation of selenium by probiotic bacteria were investigated to characterise their biomass under Se(Ⅳ) stress. In order to obtain the biogenic Nano-Se with the help of probiotic microorganisms, the nutrient medium was enriched with sodium selenite at different concentrations ranging from 1 to 30 ppm for Se and cultivated under aerobic conditions using a shaker and compared with the corresponding samples cultivated under static conditions. Bacterial growth was assessed by viable cell count, and the formation of Nano-Se was detected by the change and intensity of the red colour, then confirmed by transmission (TEM) microscopy.

An equal 5% (v/w) inoculum of each strain (*B. subtilis* and *L. plantarum*) was inoculated into the appropriate medium. The number of viable bacterial cells in 1 ml of suspension (colony forming units, CFU) was determined by the limiting dilution method by enumeration (ICS, 1998). The reduction of $(SeO_3)^{2-}$ to SeO was determined by changing the colour of the medium to different shades of pink.

The microbial biomass was collected after 48 h of growth and centrifuged at 6,000 rpm for 20 min. The pellets were washed 3 times with 0.15 M NaCl. The washed cell sediments were examined visually and the formation of Nano-Se was observed by TEM.

Results and discussion. It was found that the number of viable *L. plantarum* IMB B-7679 during cultivation in the presence of 30 ppm Se in the composition of Na_2SeO_3 decreased to 5.17 ± 0.09 log CFU/cm^3 compared to the control 7.65 ± 0.08 log CFU/cm^3 and the appearance pink colours of the culture environment were observed. Visualised by TEM, Nano-Se synthesised by *L. plantarum* IMB B-7679 had a spherical shape and their size ranged from 150-180 nm.

It is possible that the significant resistance of strains *B. subtilis* IMB B-7392 and IMB B-7393 to high concentrations of selenite is due to the extracellular formation of Nano-Se, which was confirmed by TEM. The TEM analysis revealed the presence of extracellular electron-dense Nano-Se particles with an average size of 120 ± 20 nm and the formation of nanoagglomerates under the conditions of enrichment of the culture medium with 30 ppm Se (IV) and aerobic cultivation of *B. subtilis* IMB B-7392 for 72 h. It is possible that the significant resistance of strains *B. subtilis* IMB B-7392 and IMB B-7393 to high concentrations of selenite is due to the extracellular formation of Nano-Se, which was confirmed by TEM. The TEM analysis revealed the presence of extracellular electron-dense Nano-Se particles with an average size of 120 ± 20 nm and the formation of nanoagglomerates under the conditions of enrichment of the culture medium with 30 ppm Se (IV) and aerobic cultivation of *B. subtilis* IMB B-7392 for 72 h.

It appears that the extracellular synthesis of NPs involves the capture of metal ions or metalloids on the surface of cells and the reduction of the ions in the presence of enzymes [1, 2]. Thus, during the extracellular process, $(SeO_3)^{2-}$ ions are reduced by proteins, enzymes and organic molecules in the environment or components of the cell wall of *B. subtilis*. Unlike *B. subtilis*, the probiotic culture *L. plantarum* IMB B-7679 is able to reduce Se(IV) with the formation of monodisperse spherical Nano-Se localised intracellularly. The capacity for intracellular Nano-Se production requires the maintenance of intracellular redox homeostasis to protect cells from oxidative damage. Glutathione is thought to be involved in the reduction of selenite in certain strains of *Lactobacillus* [3, 4, 5].

Meanwhile, *Bacillus subtilis* is a probiotic bacterium that has a different aerobic extracellular mechanism to reduce Se(IV) to Nano-Se. It is known that cultures of *B. subtilis* do not have the enzyme glutathione, but they do have bacillithiol [6]. In addition, the reduction of selenite to biogenic Nano-Se by *B. subtilis* occurs with the participation of thioredoxin reductase and reduced thiols, which are present in microbial cells and can catalyse the reduction of selenite [4, 7, 8]. The extracellular production of Nano-Se by *B. subtilis* gives a higher yield, while the intracellular production of Nano-Se by *L. plantarum* IMB B-7679 gives spherical, monodisperse, constant size Nano-Se. However, the increase in the intensity of the red colour of the medium culture of *B. subtilis* IMB B-7393 under aerobic conditions allows to predict the involvement of additional enzymes to explain the biological reduction of $(SeO_3)^{2-}$.

Conclusions. Thus, aeration is an essential parameter for the growth of *B. subtilis* and *L. plantarum* cultures, selenium is involved in biotransformation processes under aerobic conditions, but the localisation of Nano-Se are different, which may be related to different ways of its biotransformation. The use of probiotic strains *L. plantarum* IMB-7679 and *B. subtilis* IMB-7392 and IMB-7393 in the biosynthesis of Nano-Se is an inexpensive and ecological method that can be an alternative to chemical and physical methods for obtaining Nano-Se.

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MAIZE CULTIVATION TECHNOLOGY OPTIMIZATION IN THE IRRIGATED CONDITIONS OF THE SOUTH OF UKRAINE

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Introduction. Cultivation of modern maize hybrids of different maturity groups in combination with different sowing dates and plant densities is one of the main factors in the formation of crop productivity and depends on the soil and climatic conditions of the zone, agricultural cultivation techniques, and morphological and biological characteristics of the plants.

A key aspect of the use of new maize hybrids of different maturity groups in agricultural production is the identification and application of optimal agronomic parameters. The development and implementation of new methods of varietal agrotechnology of maize hybrids contributes to the full use of their genetic potential and is of practical interest for modern agriculture. In the irrigated conditions of the southern region of Ukraine, it is necessary to carefully select the sowing period and plant density, which are one of the main factors influencing the yield of maize.

Materials and methods. In order to optimise the elements of maize cultivation technology in the conditions of southern Ukraine, research was conducted in 2020-2021 at the experimental field of the Institute of Irrigated Agriculture of the National Academy of Agrarian Sciences (currently the Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences).