Reduction of heavy metal phytotoxicity using *Rhodococcus*-biosurfactants

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Key message. The influence of heavy metals on the germination of crop seeds (*Vicia sativa* L., *Sinapis alba* L., and *Avena sativa* L.) in the presence of *Rhodococcus*-biosurfactants was studied.

Keywords: *Rhodococcus*, biosurfactants, heavy metals, phytotoxicity

The environmental pollution increasing by industrial waste negatively affects natural and man-made ecosystems. The application of biosurfactants into soils contaminated with heavy metals (HMs) helps to increase their bioavailability and facilitates the accumulation of metals by microbial cells. The action of biosurfactants reduces the negative effect of HMs due to their binding with the subsequent formation of stable "biosurfactant-metal" complexes [1,2].

The aim of this study was evaluation of the effect of *Rhodococcus*-biosurfactants on seed germination in the presence of HMs. In comparative studies, the effect of different concentrations of *Rhodococcus*-biosurfactants (2.0, 4.0 and 8.0 g/L) on the phytotoxicity of cadmium, chromium, copper, lead, molybdenum, nickel and zinc to the germination of oat (*Avena sativa* L.), white mustard (*Sinapis alba* L.) and common vetch (*Vicia sativa* L.) were examined. The phytotoxicity level was determined in accordance with Standard Methodological Recommendations (Phytotest). HMs were added in concentrations multiple of 1, 10, 50, 100 and 200 maximum permissible concentrations (MPC), taking into account the Clark background in terms of pure metal. The actinobacterial strain *Rhodococcus ruber* IEGM 231 is active producer of biosurfactants (Regional specialised collection of alkanotrophic microorganisms, official acronym IEGM, www.iegmc.ru, large-scale research facilities number 73559) in a liquid mineral medium containing *n*-dodecane (C₁₂) or *n*-hexadecane (C₁₆) [3].

In terms of the degree of resistance to HMs, the plants tested could be presented in a row: *Avena sativa* L. > *Sinapis alba* L. > *Vicia sativa* L., where the seeds of oats were the most resistant to HMs. Preliminary seed treatment with *Rhodococcus*-biosurfactants contributed to an increase (up to 4.9 times) in the intensity of seed germination of roots and seedlings compared to seed germination in the presence of HMs without the addition of biosurfactants. The germination rate of crop seeds varied from 10 to 92% depending on the concentrations of HMs ions. After preliminary treatment of seeds with biosurfactants, the energy of their germination and viability increased up to 15 times, while the resistance of plants to HMs increased up to 22 times. It should be noted that seed germination in the presence of biosurfactants obtained on a medium with C₁₆ was most effective (3 times) than using those obtained on a medium with C₁₂. By the degree of phytotoxicity, HMs were presented in a row: Cu²⁺ > Zn²⁺ > MoO₄²⁻ > Ni²⁺ > CrO₄²⁻ > Pb²⁺ > Cd²⁺, in which copper ions were the most toxic and cadmium ions were the least toxic. In the presence of CrO₄²⁻, Pb²⁺, Zn²⁺ ions, the growth of roots and shoots was inhibited. Seed treatment with *Rhodococcus*-biosurfactants removed the inhibitory effect of these HMs on seedlings. The data obtained indicate the feasibility of preliminary treatment of seeds with biosurfactants in order to reduce the toxic effect of HMs on the growth of plant crops, as well as improve the conditioning properties of seeds.

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1. Litvinenko L.V., Tishchenko A.V., Ivshina I.B. Reduction of copper ion phytotoxicity using *Rhodococcus*-biosurfactants // Biology Bulletin. 2019. 46 (10): 135–140.
2. Tishchenko A.V., Litvinenko L.V., Shumikhin S.A. Effects of *Rhodococcus*-biosurfactants on the molybdenum ion phytotoxicity // IOP Conference Series: Materials Science and Engineering. 2019. 487: 012021.
3. Ivshina I.B., Kuyukina M.S., Philp J.C., Christofi N. Oil desorption from mineral and organic materials using biosurfactant complexes produced by *Rhodococcus* species // World Journal of Microbiology and Biotechnology. 1998. 14: 711–717.