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BIOLOGY

NANOPARTICLES SiO_2 PHYTOSTIMULATIVE EFFECT ON THE DEVELOPMENT OF SEEDLINGS ARABIDOPSIS THALIANA

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ABSTRACT

The article is devoted to the study of the influence of nanoparticles SiO_2 (NPs) on the growth of the roots of Arabidopsis thaliana, which serves as a model of bivalve plants. The method of photonic correlation spectroscopy showed that in an aqueous colloidal solution contains SiO_2 particles in the size from 33 to 80 nm. Most of the particles (46%) have a size of 58 nm. The solution of NPs increased the growth of roots by 1.7 times after 24-hour treatment, 1.6 times after 48 hours of treatment, 1.5 times after 72 hours. Also, on-the-cloud increased the number of primordial lateral roots by 1.4 times. Microscopy of different areas of the root allows to assert that at the concentration of NPs 0.07% toxic effect was not detected. The investigated drug can be used to stimulate the growth and rooting of cultivated plants.

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Introduction.

At the beginning of the 21st century, humanity faced problems of soil erosion, environmental pollution, global climate change, energy shortages, and the loss of quality of agricultural products. Solving these problems requires the widespread adoption of new, environmentally friendly and yet highly effective agricultural practices. One of the reasons for the degradation of agricultural land and the decline in the quality of agricultural products is unbalanced mineral nutrition in plants [1].

A promising method for soil restoration may be the use of silicon based fertilizers. World experience proves the efficiency of the use of silicon fertilizers in modern agriculture [2]. Silicon plays an important role in the life of plants, especially in stressful conditions [3]. Some authors state an analogy between the values of silicon and secondary organic metabolites that perform protective functions in plants [4].

It is proved that optimal doses silicon promotes a better exchange of nitrogen and phosphorus in tissues, increases consumption of boron and other elements, provides reduction of toxicity of heavy metals. Optimizing the silicon nutrition of plants leads to an increase in leaf area and creates favorable conditions for the biosynthesis of plastidic pigments. In such conditions, more solid cell walls are formed in the plants, which reduces the risk of shedding of crops, as well as damage to their bacterial diseases and pests [5].

One of the important functions of active forms of silicon is the stimulation of the development of the root system [6, 7]. Studies on cereals, citrus fruits, vegetable crops and fodder grasses have shown that silicon nutrition of plants increases the number of secondary and tertiary roots by 20-100% [3].

Progress in nanophysics allowed to create nanoprticles SiO_2 (NPs). NPs is a new type of modern fertilizers. The study of the NPs effect on sunflower seeds, rice, corn, couch grass and pumpkin allowed to constants that it's effect are depends on its concentration and exposure time. Several authors the mechanism of NPs effect are associated with the expression of certain genes [8]. It is also believed that the NPs materials give them new functions, changing their influence on the cell and tissue levels [9].

In research we used the drug NPs, which was made by the Scientific Production Association "International Medical Center". The drug was tested for toxicity according to protocol [10], LD_{50} is 125 mg / kg. According to Dorovsky A.V. the drug normalizes the metabolism at the cellular level and serves as a catalyst for oxidative-reduction reactions [11].

The object of the study was *A. thaliana* (L.) Heynh. (Col-0), which acts as a classic model of dicotyledonous aphid plant.

Purpose of the study: NPs affects the growth and development of the *A. thaliana* root.

Material and methods. The object of the study was *A. thaliana* (L.) Heynh. (Col-0), which acts as a classic model of dicotyledonous aphid plant. Four-day-old seedlings treated by NPs.

Time-lapse images of growing *A. thaliana* seedling were captured by a Canon Power Shot G6 digital camera (Canon, Taiwan) in the macro mode. The increase in root length was measured with Image J software (version 1.38 d), which is freely available on the website http://rsb.info.nih.gov/ij/). Effects of on roots growth were determined as the percentage ratio between roots length (in mm) at the beginning of the experiments (0 h) to the roots length (in mm) after chemicals treatment for 24, 48, and 72 h. Root growth rates (D) were calculated using the following equation: $(L_{ev}–L0/L0) * 100\%$, where L_0 - initial root length (no treatment); Lev - root length after the treatment [12]. Data represent means ± standard error (SE) (n=10 of at least three independent experiments). To estimate the statistical significance between means, the data were analyzed by Student's t-test.

Changes in the morphology of the primary *A. thaliana* roots after 24-, 48- and 72 h treatments by 0,07% NPs studied using microscope Axioskop 40 (Carl Zeiss, Germany) with Plan-Neofluar 10x/0.30, 20x/0.5 и 40x/1.30 Oil DIC lenses.

Research results. The method of photonic correlation spectroscopy evaluates the distribution of the number of nanoparticles SiO_2 in an aqueous medium (Fig.1)

It was shown that in an aqueous colloidal solution SiO_2 particles are contained in the range of sizes from 33 to 80 nm, with a significant proportion of nano-particles with a diameter of 58 nm, which is 46% in the medium.

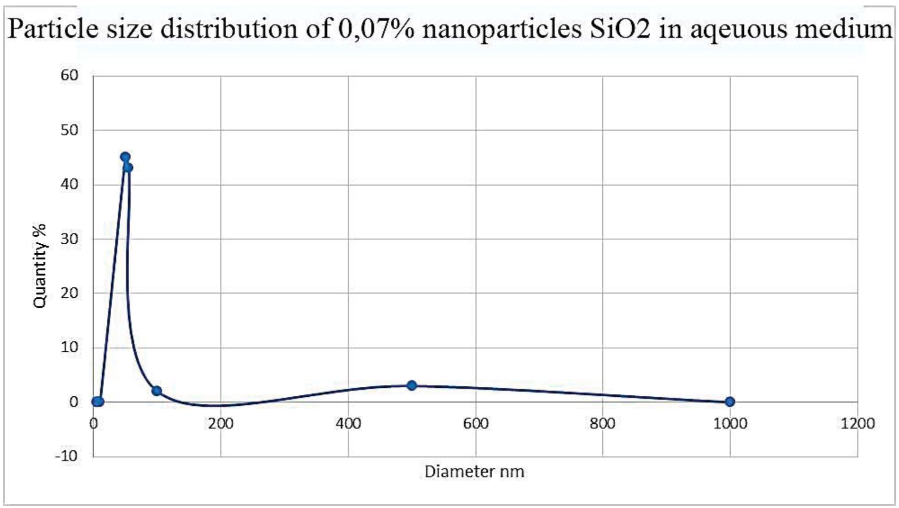

Fig. 1 The size and amount of particles in the aqueous medium is 0.07% nanoparticles SiO_2

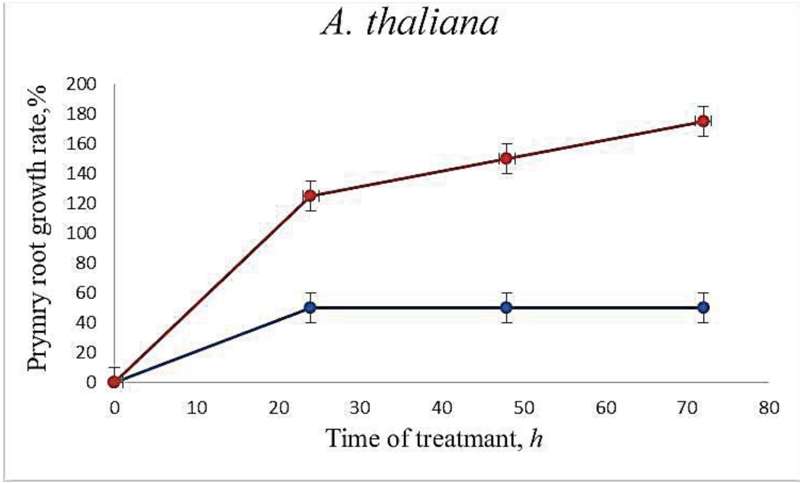

Fig. 2. Influence of silicon nanoparticles on growth of primary roots Arabidopsis thaliana.

According to the results of the study, 0.07% solution of silicon nanoparticles increased the growth of roots by 1.7 times after 24-hour treatment, 1.6 times after 48 hours of treatment and 1.5 times after 72 hours of treatment. At the same time, the greatest stimulant effect manifested itself on the first day of the experiment. In our opinion, the NPs in the aforementioned concentration increase the permeability of the cells of the rhizoids of the root and may activate the mitotic division of the apical meristematic cells.

The prymary root of *A. thaliana* plants belonging to the Dicotyledones class distinguish the following growth or functional zones: meristematic, transition and elongation zones of *Arabidopsis* roots [13]. The cells of the cylindrical shape on the surface of the root form an epidermal layer that borders on the stocking layer of measles cells. The latter in its structure contain a large number of intercellular and intercellular contacts (plasmodesm). There are centripetal epidermal cells with subsurinized Caspara belts. The root apex includes a meristematic zone covered by a root cap [13]. Transition zone cells gradually extend as far as distances from isodiatic cells of the meristematic and approaching the elongated cells of the tensile zone. In the cell differentiation area, rhizoids give rise to root hairs.

Investigation of roots is due to the fact that it is this plant organ first contacted with a biologically active NPs.

In addition, the selected model object is characterized by the presence of a significant variety of plant cells: they have undifferentiated cells of the apical meristem, as well as highly specialized root cork cells, tensile zones, differentiation and root hairs.

During the experiment, we observed numerous changes in the morphology of the prymary roots of *A. thalaiana* under the influence of the above concentration of silicon nanoparticles. In particular, we have shown that there was an increase in the number of rudiments of the lateral roots under the influence of 0.07% solution of nanosilicon. When treated with nanosilicon, an 1.4 times increase in the number of primordial lateral roots was observed (Fig. 3).

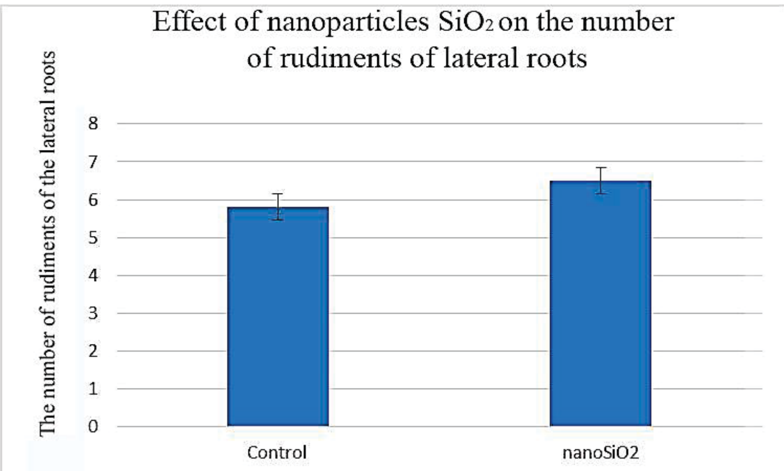

Fig. 3. Effect of NPs on the number of rudiments of lateral roots

We also observed an increase in the length of root hairs. In particular, 0.07% nanosilicon increased the length of root hairs by 2.2 times (Fig. 4).

Such changes contribute to the additional growth of the main root and the plant as a whole, as the total area of the absorption zone increases, and hence the ingestion of nutrients, mineral salts and water in the middle of the plant.

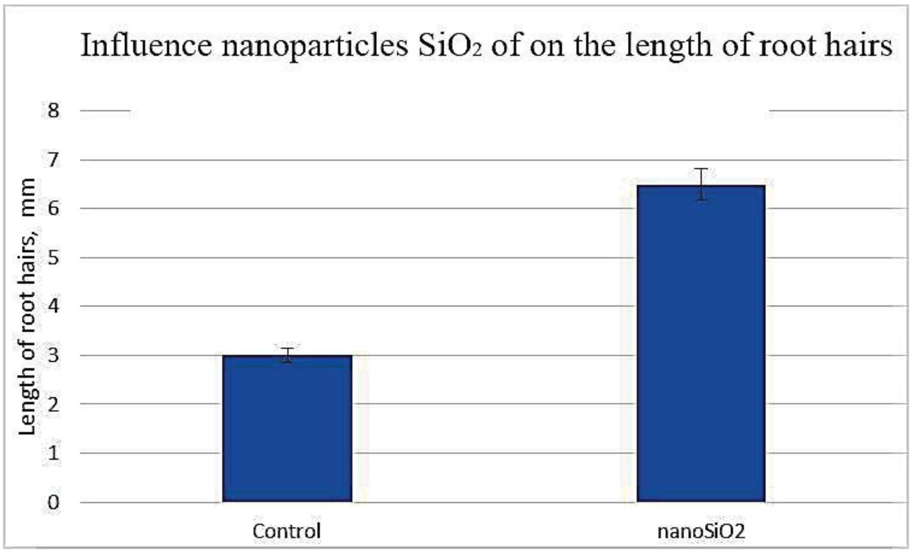

Fig. 4. Influence of NPs on the length of root hairs.

In general, the anatomy of the root of *A. thaliana* was not disturbed when processing 0.07% nanosilicon, which gives grounds for the absence of cytotoxicity and genotoxicity, and therefore the safety of the use of this preparation at the indicated concentration for bivalve plants (Fig. 5).

In addition, the absence of anisotropic enlargement of the cells of the tensile zone confirms our assumption regarding the mitogenic activity of the drug, since growth stimulation due to local tension of the cells of the tensile zone has not occurred, that is, in this case, only the cells of the apical meristem are involved, which was also demonstrated at the germs of the lateral roots.

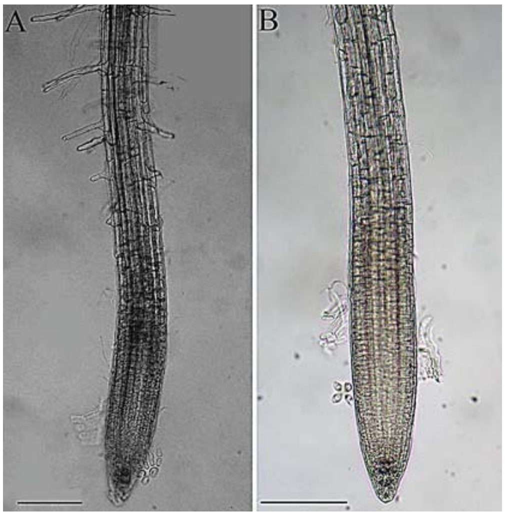

Fig. 5. Morphology of A. thaliana primary roots after 48 h of treatment:
(a) control; (b) 0,07% NPs. Bar: 400 nm.

Conclusions.

1. Summing up all the above, it can be argued that the use of NPs is accompanied by a stimulating effect on growth and morphogenesis of the roots of bivalve plants. In this case, the microscopy of different zones of the root can confirm that at a concentration of 0.07% NPs did not show a toxic effect.

2. The cells of all areas of the main root remained similar to control.

3. A potential target for the influence of NPs is the apical meristemtic, both the prymary root and the rudiments of the lateral roots.

4. Thus, the study drug NPs can be used to stimulate the growth and rooting of cultivated and wild plants.

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