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Assessment of phytotoxicity of Nb-containing nano-composites on the basis of saponites with the use of cress-salad (Lepidium sativum L.)

M. Savchuk,
National University of Bioresources and nature use of Ukraine

The purpose. To study phytotoxicity of Nb-containing nano-composites on the basis of saponites on an instance of test-crop cress-salad *(Lepidium sativum* L.*).* **Methods.** Method of the scanned electronic microscopy, method of study of phytotoxicity on test-plants, statistical. **Results.** Safety is shown of use of Nbcontaining nano-composites, unlike to nano-particles Nb2O5 on an instance of test-culture *Lepidium sativum* L. **Conclusions.** Sparing action on germinative energy, germination and growth indexes of test-culture *Lepidium sativum* L. at use of nano-composites on the basis of saponite was not revealed. That testifies to safety of these nano-matters. Biotesting of Nb-containing nano-particles has shown inhibition of growth indexes of test-culture.

Key words: *nano-composites, cress-salad, germination, biotest, saponite.*

Nanotechnology is a relatively young branch of science, which has rapidly entered our lives and is developing very rapidly. Nanomaterials have received considerable attention due to the complex of their special properties, including taking into account the large specific surface area and high reactivity [3, 4, 5]. Nowadays nanomaterials and nanotechnologies are used in almost all branches of agriculture. According to scientists, the use of nanomaterials in agriculture will allow improving crop yields, growth rates, crop yields. [9] Creation of nano-fertilizers and nano-pesticides with scientifically grounded use is an actual direction of research. However, the specific physicochemical properties of nanomaterials, as compared to conventional microparticles, can carry unexpected risks to the ecosystem [8]. Therefore, research on newly created nanomaterials is currently a very urgent task.

Materials and methods. The effect of Nb-containing nanocompositions based saponit, in particular Saponite (H); Nb-Saponite (Cl) and Nb-Saponite (Et) and Nb_2O_5 nanoparticles, for phytotoxicity with respect to the *Lepidium sativum* L cress salad, which served as a biotech. The newly created nanomaterials were provided under the NATO Project No. NUKR.SFP 984481 by the Research Institute of Molecular Technologies in Milan, Italy. [1, 2]

Microstructure of nanocomposites was studied by scanning electron microscopy (CEM) using Leo 1550 Gemini SEM, for voltage from 10 to 20 kV and standard aperture value of 30 microns.

Saponite (H) samples had a triangular shape that reflects the tetragonal structure of their structure. Under dissolution conditions, they agglomerated into larger spatial formations, but remained porous, with a pore size at 100 nm, indicating a significant area of their active surface. The samples of Nb-Saponite (Et) of triangular shape were 20-30 nm in thickness. Nanocomposites of Nb-Saponite (Cl) have sizes greater than 30 nm, but similar to the previous ones, they were agglomerated with the formation of individual scales. Nb_2O_5 nanoparticles are spherical, multifaceted particles with an average grain size of 20-30 nm.

The phytotoxic test is based on the ability of germination of salad seeds to various concentrations of nanoparticles. For research on filter paper, 40 seeds of cress salad were placed in a Petri dish. The filter paper was moistened in a controlled manner with distilled water, and in experimental samples, aqueous solutions of nanomaterials in concentrations ranging from 150 to 600 mg / l. The incubation, which lasted for 7 days, was carried out in controlled conditions with respect to light and temperature. After completing

the experiment, the percentage of sprouted seeds and length of seedlings were counted. The results were processed by statistical analysis. [6, 7, 10].

Results and discussion. The study of the influence of nanomaterials on the energy of germination and the similarity of cress salad seeds showed that the newly synthesized nanocomposites did not show an inhibitory effect on the germination energy and similarity of the seeds, but rather improved these parameters. Solutions of nanoparticles Nb_2O_5 starting from the concentration of 300 mg / l showed a phytotoxic effect. With the use of a solution of nanoparticles at concentrations of 300, 450 and 600 mg / l compared with the control, the germination energy decreased by 3%, 5% and 4% respectively, while the similarity was 2%, 10% and 4%, respectively (Fig.1.).

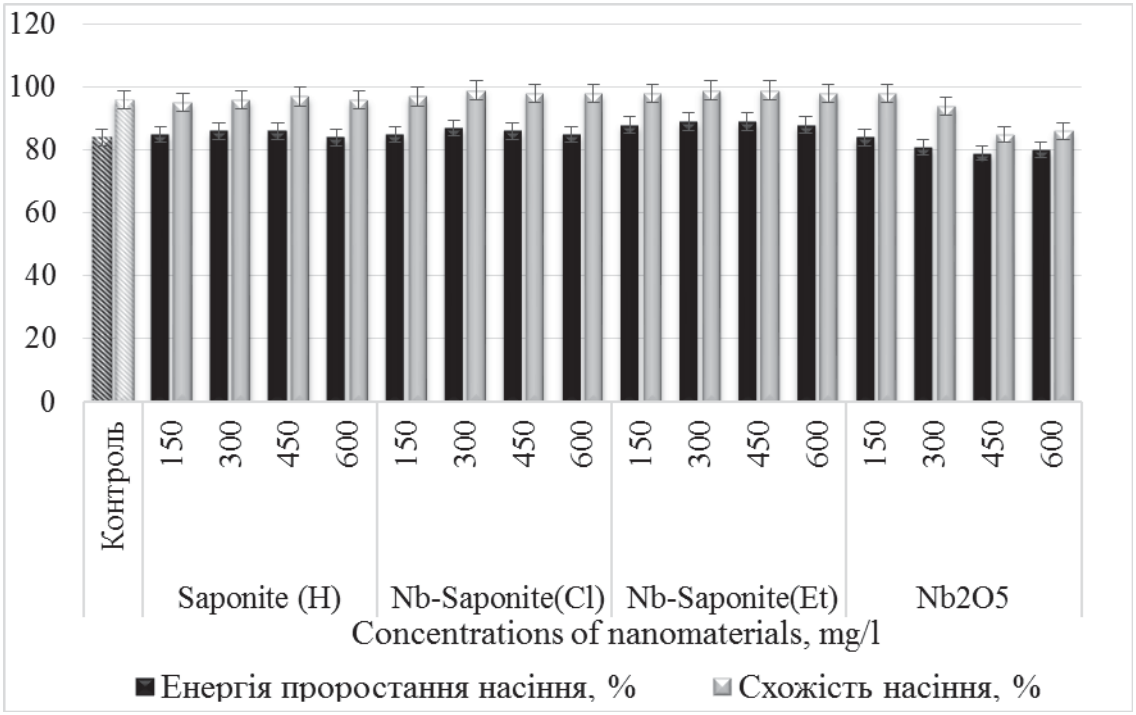

Fig.1 Influence of nanomaterials on the energy of germination and the similarity of cress salad seeds

As in the previous experiment, the results of the influence of nanomaterials on the morphometric indices of the cress salad (Lepidium sativum L.) also demonstrated that during their action at concentrations of 150 to 600 mg / l no adverse effects were observed, but, on the contrary, improvement of the aforementioned indicators. At the same time, when studying the influence of nano-particles of niobium oxide, the inhibition of the development of the root and stems of cress-salad was recorded. The maximum depressant effect was noted when using a solution of nanoparticles in a concentration of 450 mg / l. Compared to control, root and stem length indices decreased by 8.6% and 19.23% respectively (Table 1).

Table 1. Influence of nanomaterials on the growth processes of cress salad

Variant	**Concentration in aqueous medium, mg / l**	**The length of the root, sm (7 days)**	**The length of the stem, sm (7 days)**
Control	-	2,9±0,16	2,6±0,08
Saponite(H)	150	3,2±0,08	3,0±0,03
	300	3,3±0,21	3,0±0,06
	450	3,2±0,13	2,9±0,12
	600	3,2±0,32	2,7±0,06

Nb-Saponite(Cl)	150	2,8±0,15	3,2±0,12
	300	3,5±0,13	2,7±0,03
	450	3,0±0,23	2,8±0,05
	600	3,4±0,16	2,9±0,11
Nb-Saponite(Et)	150	3,1±0,09	3,8±0,15
	300	3,8±0,17	3,3±0,23
	450	3,6±0,23	3,5±0,05
	600	3,4±0,14	3,8±0,06
Nb_2O_5	150	2,7±0,09	2,3±0,04
	300	2,87±0,21	2,3±0,11
	450	2,65±0,16	2,1±0,09
	600	2,66±0,23	2,1±0,21

Biotesting on cress salad seeds showed that all investigated aqueous solutions of nanocomposites did not exhibit phytotoxic effects. But, individually tested, nano-particles of niobium oxide, which are part of the nanocomposite, have inhibitory ability. This can be explained by the fact that metal oxide nanoparticles have very small sizes and specific physico-chemical properties; they can penetrate into plant cells and inhibit biochemical processes, thus phytotoxic effect is observed. Nb-content nanocomposites, in contrast to nanoparticles, have larger sizes and additional nutrients that are part of a saponite, namely ions Si^{2+}, Mg^{2+}, Al^{3+}. All these factors allowed to facilitate the penetration and movement of elements to the plant organism without harming it, and as a result, the growth parameters and seed quality of seeds were stimulated.

Conclusions

• Under the influence of saponite-based nanocomposites on germination energy, similarity and growth rates of the *Latuca sativa* L. culture, depressant action was not found, which indicates the safety of these nanomaterials.

• Biotesting of Nb-content nanoparticles showed suppression of growth test-culture indices. The maximum depressant effect was noted when using a solution of nanoparticles in a concentration of 450 mg / l. Compared to control, root and stem length indices decreased by 8.6% and 19.23% respectively. The energy of germination and the similarity of seeds in concentrations of 300, 450 and 600 mg / l in comparison with the counter. Olm decreased by 3%, 5% and 4% respectively, while the similarity was 2%, 10% and 4%, respectively.

• With these results, the safety of the use of Nb-content nanocomposites is confirmed, unlike Nb2O5 nanoparticles. Thus, nanocomposites require further study and development of precise technologies for their application.

References

1. *Carniato F.* Nb(V)-Containing Saponite Clay: a Catalyst for the Oxidative Abatement of Blistering Chemical Warfare Agents / F. Carniato, C. Bisio, R. Psaro, L. Marchese, A. Katsev, M.V. Taran, N. F. Starodub, M. Guidotti. // Selective Oxidation and Functionalization: Classical and Alternative Routes and Sources DGMK Conference October 13 — 15, 2014, Berlin, Germany.

2. *Guidotti M*. An efficient ring opening reaction of methyl epoxystearate promoted by synthetic acid saponite clays / Guidotti M., Psaro R., Ravasio N., Sgobba M., Carniato F., Bisio C., Gatti G., Marchese L. // Green Chem., 2009, 11, P.1173—1178.

3. *L. Yan.* Chemistry and physics of a single atomic layer: Strategies and challenges for functionalization of graphene and graphene-based materials / Yan L., Zheng Y.B., Zhao F., Li S., Gao X., Xu B., Weiss P.S., Zhao Y. // *Chem. Soc. Rev.* 2012, № *41*, P.97—114.

4. *M. Amelia.* Electrochemical properties of CdSe and CdTe quantum dots / Amelia M., Lincheneau C., Silvi S., Credi A. // *Chem. Soc. Rev.* 2012,№ *41*, P. 5728—5743.

5. *S. Laurent.* Magnetic iron oxide nanoparticles: synthesis, stabilization, vectorization, physicochemical characterizations, and biological applications /Laurent S., Forge D., Port M., Roch A., Robic C., van der Elst L., Muller R.N. // *Chem. Rev.* 2008, № *108*, P. 2064—2110.

6. *Біотестування* нанопрепаратів з врахуванням особливостей їх впливу на нецільові обєкти природних екосистем (науково-методичні рекомендації)/ Н.А. Макаренко, В.І. Бондарь та ін., за ред. д. с.-г. н., проф. Макаренко Н.А. — К.: НУБіП України, 2015. —26 с.

7. *Зейферт Д.В.* Оценка фитотоксичности глюконатов и хлоридов ряда d-элементов с использованием кресс-салата (*Lepidium sativum*) / Д.В. Зейферт, Ф.Р. Опарина, Н.Р. Тукумбетова, О.А. Князева, А.И. Уразаева, И.Г. Конкина // Башкирский химический журнал — 2012, - Т.19 - №4. — С. 20-23.

8. *Макаренко Н. А*., Рудніцька Л. В. Екотоксикологічна оцінка наноагрохімікатів за впливом на біоту ґрунтової та водної екосистем / Н.А. Макаренко, Л.В. Рудніцька // Таврійський науковий вісник. 2015. Вип. 94. С. 133—138.

9. *Таран Н.Ю.* Вплив неіонного колоїдного розчину наночасток біогенних металів на вміст елементів металів у рослинних тканинах / Н.Ю. Таран Н.Ю., Л.М. Бацманова Л.М., К.Г. Лопатько К.Г., А.О. Мелешко А.О., Є.О. Конотоп // Фізика живого, Т. 19, No 2, 2011. С. 9-11.

10. *Якість* ґрунту. Визначення мінералізації впливу забрудників на флору ґрунту. Спостережний дослід на проростання насіння салату (Latuca sativa L.) (ISO 17126:2005, IDT): ДСТУ ISO 17126:2007. — [Чинний від 2009—07—01]. — К.: Держспоживстандарт України, 2012. — 6 с. — (Національний стандарт України).