Thematic Section: Biochemical Research. **Full Paper**
Subsection: Physiology and Biochemistry of Plants. *Reference Object Identifier* – ROI: jbc-01/17-51-7-137
The Digital Object Identifier – DOI: 10.37952/ROI-jbc-01/17-51-7-137
Submitted on Jule 26, 2017.

The features of the influence of heavy metal compounds on germinated barley *Hordeum vulgare* L. in the presence of ammonium and nitrate nitrogen

© **Ekaterina S. Petukhova**,[1] and **Tamara Ya. Ashihmina**[1,2]*[+]

[1] *Department of Fundamental Chemistry and Methods of Teaching Chemistry. Vyatka State University. Moskovskaya St., 36. Kirov, 610000. Russia. Phone: +7 (8332) 37-02-77. E-mail: ecolab2@gmail.com*
[2] *Institute of Biology of the Komi Science Centre of the Ural Division RAS. Kommunisticheskaya St., 28. Syktyvkar, 167982. Russia.*

*Supervising author; [+]Corresponding author

Keywords: pollutants, single, double, triple and quadruple systems, separate and combined influence, stimulating and inhibiting effect, antagonism.

Abstract

The article analyzes the cumulative effect and toxic influence of pollutants on germinated barley *Hordeum vulgare* L. in the model experiment at different concentrations by the example of heavy metal ions Cd^{2+}, Cu^{2+}, Pb^{2+} and Zn^{2+} in the presence of ammonium and nitrate nitrogen in the form of single and multicomponent systems. The experiment enables to make a multivariate analysis of the effect of heavy metal compounds on germinated barley *Hordeum vulgare* L. in the presence of nitrate nitrogen and to draw a conclusion about the presence or absence of a summation or potentiating effect of various combinations of pollutants under study. Based on the multifactorial analysis of the influence of pollutants on barley caryopses in the presence of nitrogen-bearing compounds, inhibition and stimulation series are ascertained for single, double, triple and quadruple systems of pollutants being studied.

It has been established, that the strongest toxicants of components being analyzed for roots of barley *Hordeum vulgare* L. are copper compounds, both in the separate presence and together with zinc, ammonium and nitrate nitrogen, then for shoots they are cadmium compounds. This research has also indicated that the compounds of ammonium nitrogen heighten the inhibiting effect of copper, zinc, lead and cadmium on root system and shoot development. But the pollutants under study should be more toxic in the presence of ammonium ions, compared to the nitrite ion. The antagonistic effect of heavy metal on the impact of the root system and barley shoots *Hordeum vulgare* L. is more significant than the synergetic one and it would intensify by increasing the concentration of pollutants. The multivariate analysis of the effect of copper, lead, zinc, cadmium and ammonium nitrogen on the root system and barley shoots *Hordeum vulgare* L. in single and multicomponent systems has made it possible to determine the series of inhibition and stimulation of pollutants under examination. For the root system of barley the combined presence of copper and zinc at the concentration of 100 μm is the most toxic (the root length makes up 3.6 cm, in comparison with the separate influence of zinc with 9.1 cm, and copper – with 4.7 cm). Then copper and cadmium ions in the combined presence have the most inhibiting effect on shoots (the coleoptile length is 2.9 cm, compared to the separate influence of copper with 4.3 cm, and cadmium – with 3.8 cm).

References

[1] T.I. Matveenko. Fundamentals of toxicology. Course of lectures. *Khabarovsk: TOGU.* **2006**. 142p. (russian)
[2] F. Villiers, C. Ducruix, V. Hugouvieux et al. Investigating the plant response to cadmium exposure by proteomic and metabolomic approaches. *Proteomics.* **2011**. Vol.11. P.1650-1663.
[3] D.I. Bashmakov, A.S. Lukatkina. Ecological and physiological aspects of accumulation and distribution of heavy metals in higher plants. *Saransk: Izd-vo Mordov. un-ta.* **2009**. 236p. (russian)
[4] B.V. Ilyin. Heavy metals in the system soil-plant. *Novosibirsk: Nauka.* **1991**. 150p. (russian)
[5] A.F. Titov, N.M. Kaznina, V.V. Talanova. Heavy metals and plants. *Petrozavodsk: Karelskij nauchnyj tsentr RAN.* **2014**. 194p. (russian)
[6] U. Krämer, I.N. Talke, M. Hanikenne. Transition metal transport. *FEBS Lett.* **2007**. Vol.581. P.2263-2272.

[7] S. Husted, D.P. Persson, K.H. Laursen et al. Review: The role of atomic spectrometry in plant science. *J. Anal. At. Spectrom.* **2011**. Vol.26. P.52-79.
[8] C.A. Blindauer, R. Schmid. Cytosolic metal handling in plants: determinants for zinc specificity in metal transporters and metallothioneins. *Metallomics.* **2010**. Vol.2. P.510-529.
[9] R. Hänsch, R.R. Mendel. Physiological functions of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B, Cl). *Curr. Opin. Plant Biol.* **2009**. Vol.12. P.259-266.
[10] V.P. Kovrigo, I.S. Kaurichev, L.M. Burlakova. Soil science with basics of geology. *Moscow: Kolos.* **2000**. 416p.(russian)
[11] M.M. Hismatullin. Study of nitrate accumulation in green mass of perennial grasses. *Agrohemicheskij vestnik.* **2010**. No.3. P.28-29. (russian)
[12] S.I. Kolesnikov, K.Sh. Kazeev, V. Valkov. Environmental consiquences of soil pollution with heavy metals. *Rostov na/D: Izd-vo «SKNTS VSH».* **2000**. 232p. (russian)
[13] O.V. Dyakonova. Heavy metals and mineral forms of nitrogen in the system soil - plant: Abstract of the Thesis of PhD in agricultural sciences: 06.01.04 и 03.00.16. *Barnaul.* **2005**. 16p. (russian)
[14] N.A. Misuryan, V.N. Stepanov, V.S. Kuznetsov, V.I. Lukyanuk, P.A. Chernomaz. Plant breeding. *Moscow: Izd-vo «Kolos».* **1965**. 472p. (russian)
[15] N.R. Zaripova. The effect of excess concentrations of heavy metals on expression of chloroplast genes of barley plants: avtoref. *Thesis of PhD in biological science:* 03.00.12. *Moscow.* **2008**. 21p. (russian)
[16] G. Shi, Q. Cai. Cadmium tolerance and accumulation in eight potential energy crops. *Biotechnol. Adv.* **2009**. Vol.27. P.555-561.
[17] L.N. Shihova, T.L. Egoshina. Heavy metals in soils and plants of the taiga zone of North-East European Russia. *Kirov: Zonalnyj NIICH Severo-Vostoka.* **2004**. 264p. (russian)
[18] J.L. Hall, L.E. Williams. Transition metal transporters in plants. *J. Exp. Bot.* **2003**. Vol.54. P.2601-2613.
[19] D.J. Eide. Zinc transporters and cellular trafficking of Zn. *Biochim. Biophys. Acta Mol. Cell. Res.* **2006**. Vol.1763. P.711-722.
[20] K. Demirevska-Kepova, L. Simova-Stoilova, Z. Petrova-Stoyanova, U. Feller. Cadmium stress in barley: growth, leaf pigment and protein composition and detoxification of reactive oxygen species. *J. Plant Nutr.* **2006**. Vol.29. P.451-468.
[21] L.E. Hernándes, E. Lozano-Rodriguez, A. Gárate, R. Carpena-Ruiz. Influence of cadmium on the uptake, tissue accumulation and subcellular distribution of manganese in pea seedlings. *Plant Sci.* **1998**. Vol.132. P.139-151.
[22] A. Kabata-Pendias, H. Pendias. Trace elements in soils and plants. *Moscow: Mir.* **1989**. 439p. (russian)
[23] V. Kumar, D.V. Yadav, D.S. Yadav. Effect of nitrogen sources and copper levels on yield, nitrogen and copper contents of wheat (Triticum aestivum L.). *Plant Soil.* **1990**. Vol.126. P.79-83.
[24] H. Gouia, A. Suzuki, J. Brulfert, M.N. Ghorbal. Effects of cadmium on the co-ordination of nitrogen and carbon metabolism in bean seedlings. *J. Plant Physiol.* **2003**. Vol.160. No.4. P.367-376.