ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 16, No. 7 2009

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ACTIVITY OF CHOSEN ORGANIC ACIDS ON THE GROWTH OF RYE SEEDLINGS TREATED WITH CADMIUM OR LEAD IONS

DZIAŁANIE WYBRANYCH KWASÓW ORGANICZNYCH NA WZROST SIEWEK ŻYTA TRAKTOWANYCH KADMEM LUB OŁOWIEM

Abstract: The influence of cadmium and lead ions on the growth of seedlings of selected inbred lines was studied after the application of three organic acids. The growth stunt of the researched seedling lines was a result of the harmful effects of the aforementioned elements. The application of ascorbic and gibberellin acids inhibited the stress caused by lead and cadmium ions, which was shown by the growth of shoots and roots of seedlings. However, 2,4-D acid did not minimize the toxic influence of cadmium and lead. It can be concluded that the application of ascorbic and gibberellin acids may lessen the negative effects of stress caused by those heavy metals.

Keywords: lead, cadmium, organic acid, rye, *Secale cereale* L.

There are many factors which pollute the environment. Some are natural, others are caused by humans (industry and agriculture) where *eg* heavy metals are released [1, 2]. Cadmium is especially harmful for plants which actively absorb this substance through their roots and transport it to all organs. A 5 mg/kg content is enough for symptoms of toxicity to appear. These are chlorophylic marks, the browning of leaves and reddening of nerves. The excess of this toxic substance leads to a change of DNA structure in plants, a reduction of membrane permeability and growth stunt [3]. Lead is also absorbed through roots but is transported to shoots to a lesser extent. It is then stored in cellular walls. The excess is manifested through withering, darkening of leaves and smaller roots [4].

For this reason, the aim of the work was to check whether the selected organic acids inhibit the toxic activity of those elements on the growth of seedlings of genetically differentiated rye inbred lines.

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Materials and methods

5 of 11 inbred lines (CH_7/99, L310, L176, M353, L299, L230, M15, 154/6) of the S_{25} generation of winter rye (*Secale cereale* L.) assessed by Kubicka and Pyza [5] were selected for the experiment. They differed on account of their sensitivity to lead and cadmium. The germinated seedlings of the rye lines were treated with ascorbic and dichlorophenoxyacetic acids at concentration of 10^{-2} M as well as gibberellin at concentration of 10^{-3} M for 72 hours, and then placed on the Hoagland nutrient containing lead ions at concentrations of 10^{-3} M and cadmium (10^{-4} M) for 48 hours. Next, 25 seedlings of each combination were placed on the Hoagland nutrient. Measurements of root and shoot lengths as well as the number of roots were conducted on the 14 day-old seedlings. Standard deviations were taken into account.

Results and discussion

In an earlier research [5] it was observed that cadmium at a concentration of 10^{-4} M caused a significant stunt of growth in rye inbred lines. However, a lower concentration of lead had a stimulating influence on the growth of shoots (above that of control) therefore both concentrations of lead 10^{-3} M and cadmium 10^{-4} M were applied.

Rye inbred lines subjected to the influence of lead at a concentration of 10^{-3} M were characterized by a significant reduction of growth. Line M15 occurred to be most sensitive with its shoot and root length decreased by 72 % and a 34 % reduction of root number. L299 line proved most tolerant. Cadmium caused a 9 % reduction of shoots and a 34 % reduction of the length of roots. In lines L230 the greatest reduction in the growth of roots (48 %) was observed (Fig. 1–4).

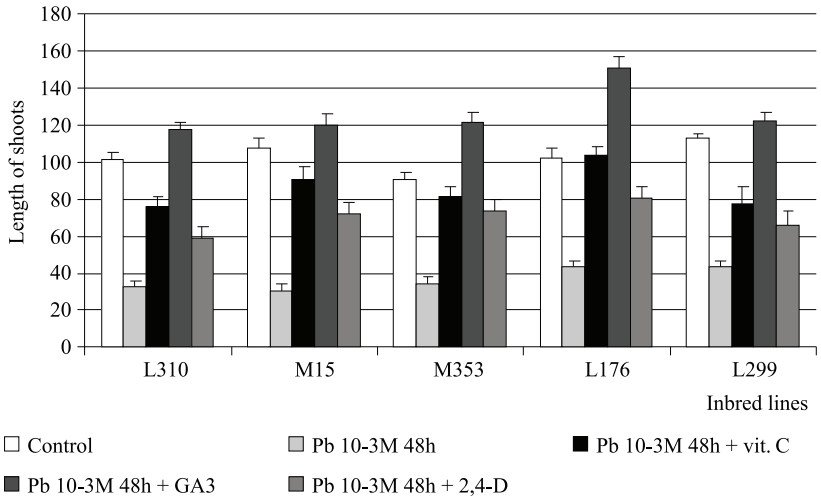

Fig. 1. The influence of lead on length of shoots of rye inbred lines [mm]

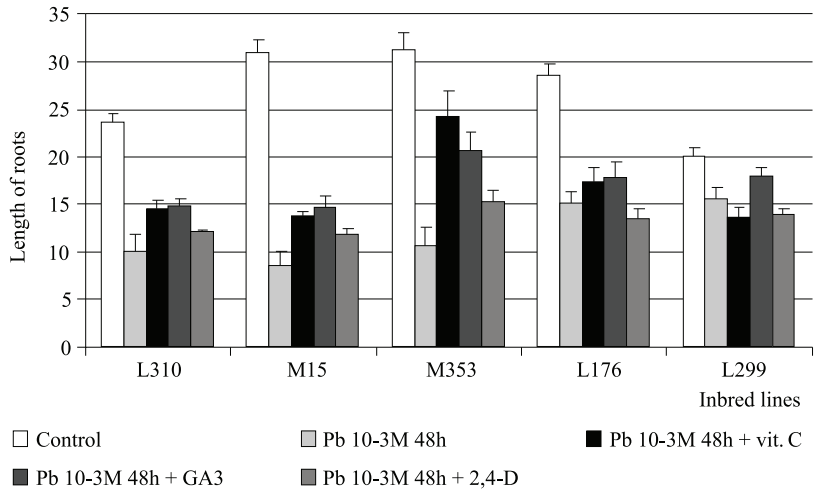

Fig. 2. The influence of lead on length of roots of rye inbred lines [mm]

Heavy metals found in soil are at first absorbed by roots which are at greatest risk to their toxic activity [6]. This is confirmed in the conducted experiments, in which the deformation, browning, reduction of root length and growth stunt of rye inbred line shoots was observed.

The lines selected for the experiment were characterized by a differing sensitivity to ions of those elements, and their reaction to the harmful activity of lead and cadmium was dependent on the genotype. A similar tolerance to cadmium in wheat and barley varieties caused by genetic variability was observed by Ozaruk et al [7] and Tiryakioglu et al [3].

Stress factors influencing the growth and development of organisms may be limited through the use of growth regulators [8] and antioxidants [3, 7]. Gibberellin and 2,4-D acids are commonly used *in vitro* cultures to regenerate plants. Taking this into account, 3 organic acids were used in this experiment: ascorbic, gibberellin and 2,4-D. Their influence on the reduction of stress to the activity of lead and cadmium ions was observed.

The application of organic acids (ascorbic and gibberellin) before the placement of inbred lines seedlings of rye on the lead nutrient reduced their toxic influence, which was observed by the growth of shoots and roots growth in inbred lines (Fig. 1, 2). In all lines a growth of seedlings was observed in combination with gibberellin. The greatest growth of shoots in lines: L176 – fourfold and M15 and M353 – threefold was founded. In the case of roots the greatest growth was observed in line M353 (twofold) in relation to combination with lead. The substances used also increased the number of roots in almost all lines with the exception of L299. 2,4-D had the weakest influence on lead stress reduction. It had little effect on root growth, and even reduced their length and number in lines L176 and L299.

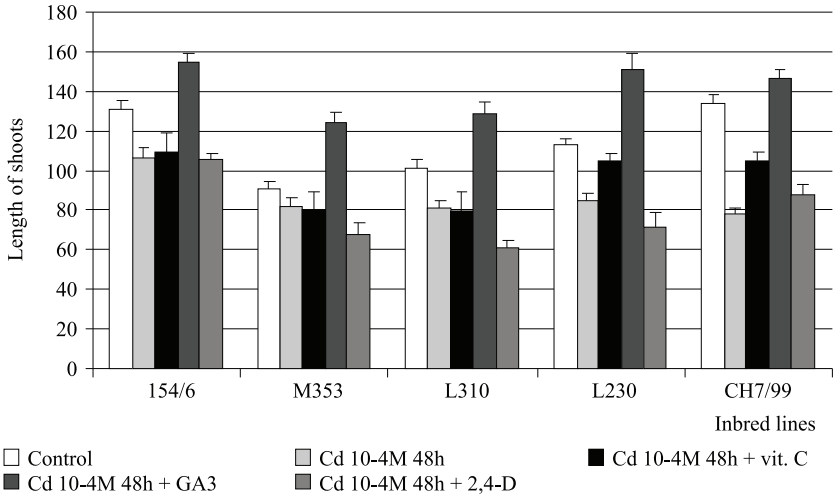

Fig. 3. The influence of cadmium on length of shoots of rye inbred lines [mm]

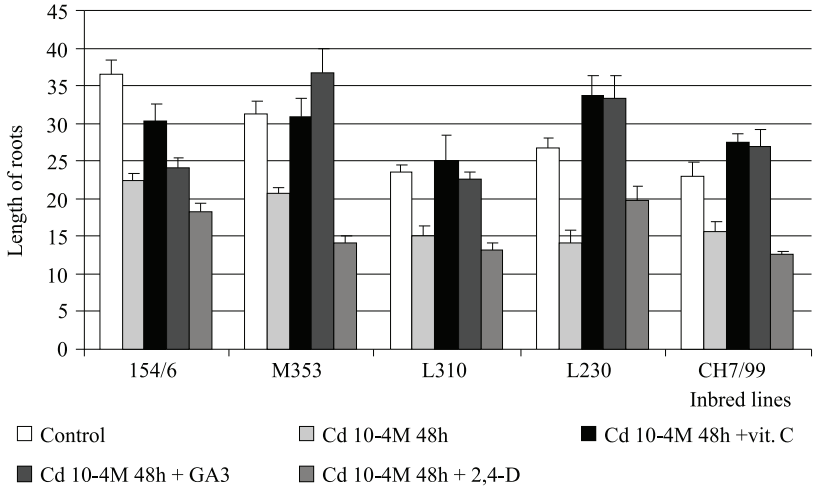

Fig. **4**. The influence of cadmium on length of roots of rye inbred lines [mm]

A similar to lead influence of organic acids on seedlings growth was observed in cadmium combinations. Gibberellin acid also appeared most efficient because it caused the greatest seedling growth, almost twofold in lines CH7/99 and L230 in comparison with control (Fig. 3). In line L230 the application of vitamin C resulted in the twofold growth the length of roots in comparison with cadmium combination (Fig. **4**). The positive influence of ascorbic acid on the reduction of stress was caused by the action of

cadmium on barley varieties [7]. However, gibberellin caused root growth only in line M353. Both substances had a negligible influence on the increase in roots in rye lines. 2,4-D acid almost did not reduce cadmium stress in the researched lines.

Gibberellin acid has an influence on many process accompanying plant development – *eg* elongation of stems [9]. This was proven in the research in which gibberellin caused a greater growth of shoots which were characterized by a brighter colour.

Lead and cadmium have induced the production of reactive forms of oxygen in plants which leads to oxide stress and the increase in antioxidant enzyme activity [3, 7].

In this research it was shown that initial incubation of rye seedlings in a vitamin C solution (antioxidant) before treatment with cadmium and lead ions – neutralized the stress caused by these elements with the exception of L299 (root length). However, the activity of gibberellin acid was more effective. Both substances can be applied to lessen the toxic stress researched in plants which is caused by those heavy metals.

References

[1] Masso E.L., Corredor L. and Antonio M.T.: J. Trace Elements Med. Biol., 2007, **21**, 210–216.
[2] Małkowski E., Kita A., Golas W., Karcz W., and Michael K.: Plant Growth Regul., 2002, **37**, 69–76.
[3] Tiryakioglu M., Eker S., Ozkutlu F., Husted S. and Cakmak I.: J. Trace Elements Med. Biol. 2006, **20**, 181–189.
[4] Yang Y.Y., Jung Ji-Y., Song W-Y., Suh H-S. and Lee Y.: Plant Physiol., 2000, **124**, 1019–1026.
[5] Kubicka H. and Pyza A.: Ecol. Chem. Eng., 2007, **14**, 1–7.
[6] Sharma P. and Dubey R.S.: J. Plant Physiol., 2005, **17**, 35–52.
[7] Ozturk L., Eker S. and Ozkutlu F.: Turk. J. Agric. For., 2003, **27**, 161–168.
[8] Kubicka H., Dec D. and Gilewska M.: [in:] Obieg pierwiastków w przyrodzie, Instytut Ochrony Środowiska, Warszawa 2003, vol. II, 672–676.
[9] Frigerio M., Alabadi D., Perez-Gomez J., Garcia-Carcel L., Philips A.L., Hedden P. and Blazquez M.A.: Plant Physiol., 2006, **14**, 553–563.

DZIAŁANIE WYBRANYCH KWASÓW ORGANICZNYCH NA WZROST SIEWEK ŻYTA TRAKTOWANYCH KADMEM LUB OŁOWIEM

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Abstrakt: W przeprowadzonym doświadczeniu analizowano wpływ kadmu i ołowiu na wzrost siewek wybranych linii wsobnych żyta ozimego po uprzednim zastosowaniu trzech kwasów organicznych. Szkodliwe działanie tych pierwiastków ujawniło się zahamowaniem wzrostu siewek badanych linii. Stosowane kwasy – askorbinowy i giberelinowy spowodowały zmniejszenie stresu wywołanego jonami kadmu i ołowiu, co uwidoczniło się zwiększonym przyrostem części nadziemnych i podziemnych siewek. Natomiast kwas 2,4-D nie miał wpływu na niwelowanie szkodliwego działanie kadmu i ołowiu. Wykazano, iż zastosowane kwasy organiczne – askorbinowy i giberelinowy mogą znaleźć zastosowanie do zmniejszania negatywnych skutków stresów wywołanych tymi metalami ciężkimi.

Słowa kluczowe: ołów, kadm, kwasy organiczne, żyto, *Secale cereale* L.