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CONTENT OF SELECTED ELEMENTS IN SEEDLINGS OF INBRED LINES OF WINTER RYE (*Secale cereale* L.)

ZAWARTOŚĆ WYBRANYCH PIERWIASTKÓW W SIEWKACH LINII WSOBNYCH ŻYTA OZIMEGO (*Secale cereale* L.)

Abstract: 9 inbred lines were chosen for the experiment (L176, L230, CH_7, L154, M353, L4, L299, L310, L28) of the winter rye S_{25} generation (*Secale cereale* L.). The 5 day-old seedlings of the line were treated with a cadmium sulfate solution at a concentration of 10^{-6} and 10^{-4} M for 36 h, and then placed on the Hoagland nutrient. The control materials were comprised of seedlings of the line growing on the same nutrient. The twenty-one day old seedlings were mineralized and the content of the following elements was marked: cadmium, magnesium, zinc, calcium, manganese and potassium, using the Perkin-Elmer1100 atomic absorption spectrophotometer. The lowest content of cadmium amounting to several mg/kg was observed in the control combination. The content of chemical elements in all inbred lines was higher at a lower concentration of cadmium 10^{-6} M/36 h (with the exception of L230 and L299 line).

Keywords: cadmium, rye, *Secale cereale* L, magnesium, potassium, calcium, zinc, manganese

Heavy metals are considered to be one of the main sources of pollution in the environment and are classified into two categories: essential (Fe, Cu, and Zn) and toxic metals (Pb, Cd, Ni and Cr) [1]. The excess of heavy metals in nature causes permanent damage of organisms. The elements of a very large degree of threat: Cd, Pb, Hg, Cr and Ni, accumulate in the kidneys, liver, brain and fat tissue of animals, interfering with their organisms' balance. In the case of plants their content in nature has increased mainly in cellular walls and vacuoles leading to a stunt in growth and development. The plants are characterized by a constant cation equilibrium, which is expressed by the stability and chemical ingredients. The changes in the equilibrium may be caused by the

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intake of heavy metals from the environment [2]. According to Kozanecka [3] and Krawczyk [4] plants growing in the same conditions accumulate heavy metals in various ways. This is determined by the features of a given species, which have been defined as the "chemical fingerprints" of plants [5].

The aim of the present work was to establish if the genetically differentiated inbred lines of winter rye, exposed to the action of cadmium stress, differ on account of the content of chosen chemical elements in the seedling stage.

Materials and methods

9 inbred lines of winter rye (*Secale cereale* L.) of the S_{25} generation were chosen for this experiment (L299, L230, L176, CH7, L154, M353, L4, L310, L29). Next, 25 (5-day) seedlings of each line were placed in three combinations: the control – the Hoagland nutrient (macroelements: $Ca(NO_3)_2 \cdot 4H_2O$, KNO_3, $MgSO_4 \cdot 7H_2O$, $NH_4H_2PO_4$, 1 % $Fe_3(C_6H_5O_7)_2 \cdot 6H_2O$ and microelements: H_3BO_3, $MnSO_4 \cdot 4H_2O$, $ZnSO_4 \cdot 7H_2O$, $CuSO_4 \cdot 5H_2O$, NaCl, $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$), the same nutrient at a two concentrations of cadmium sulphate:10^{-6} M and 10^{-4} M for 36 hours. After this time all seedlings were placed on the Hoagland nutrient. The 21-day seedlings of each combination were dried, mineralized and the content of the following elements was marked: cadmium, magnesium, zinc, calcium, manganese, and potassium with the application of the atomic spectrophotometric absorption technique.

In total, 27 combinations were analyzed. The results were given as mean values of 3 experiments.

Results and discussion

The influence of the toxic action of cadmium was seen of seedlings treated with this metal (especially at the cadmium concentration of 10^{-4} M/36 h). These seedlings were characterized by a reduced turgor, a lighter colour of leaves, and the browning of roots. This is confirmed in the work [6]. In the seedlings of inbred lines of rye, the growth of cadmium content was observed with of the increased at concentrations of this element in the nutrient (Table 1).

Table 1

The content of cadmium ions [mg/kg] in inbred lines of rye

Combination	Inbred lines of rye [mg/kg]								
	L176	L230	CH_7	L154	M353	L4	L299	L310	L29
Control	0.64	0.6	0.3	0.17	0.4	0.98	0.34	0.5	0.07
Cd 10^{-6}, 36 h	16.5	14.6	35.2	20.2	22.9	23	16.4	26.6	35
Cd 10^{-4}, 36 h	540.4	664.8	419.5	465.3	627.3	525.6	596.3	675.5	540.9

The most cadmium was accumulated by the lines at the highest concentration of this metal 10^{-4} M/36 h and amounted to 419.5 mg/kg (CH_7) to 675.5 mg/kg (L310). A considerably lower content of cadmium in seedlings of inbred lines of rye was noted

at a concentration of 10^{-6} M/36 h, which ranged from 14.6 (L230) to 35.2 mg/kg (CH_7). The CH_7 line also had the lowest content of ions of cadmium at the highest concentration. However, in the control, traces of this element, were observed at acceptable levels (0.05–1 mg/kg). The rye lines were characterized by a varying sensitivity to the action of cadmium ions.

The content of the biogenic elements (Mg, Zn, Mn, K and Ca) in seedlings of the inbred line of rye was several times higher in combinations with cadmium in comparison with the control (Fig. 1–5). Differences in the accumulation of these elements in seedlings depended on the dose of cadmium. Most of the lines accumulated more zinc, magnesium, calcium, manganese and potassium with a lower concentration of cadmium 10^{-6} M/36 h. An exception to this were lines L299 and L230, which contained the most zinc at a concentration of Cd10^{-4} M/36 h. According to Jang et al [7] and McKenna et al [8] the most probable reason for such a high content of zinc may be connected with joint penetrating canals for both elements and their mobility in plants.

A similar dependency took place in the case of calcium and manganese, whose highest content was observed in combinations of cadmium at a concentration of

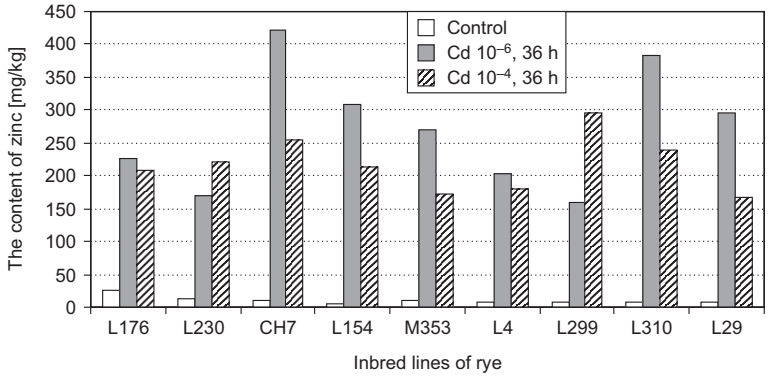

Fig. 1. The content of zinc ions [mg/kg] in inbred lines of rye

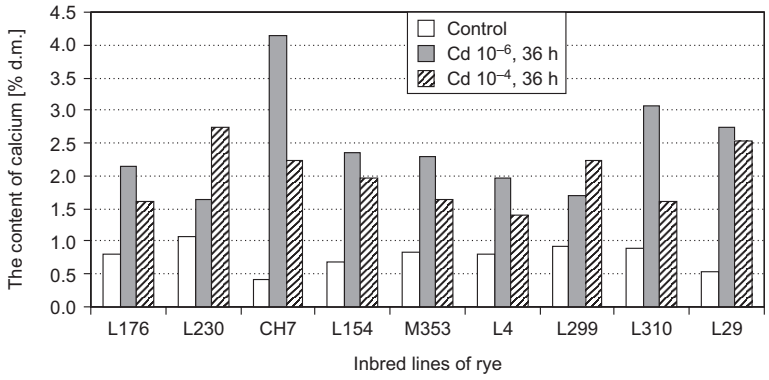

Fig. 2. The content of calcium ions [% d.m.] in inbred lines of rye

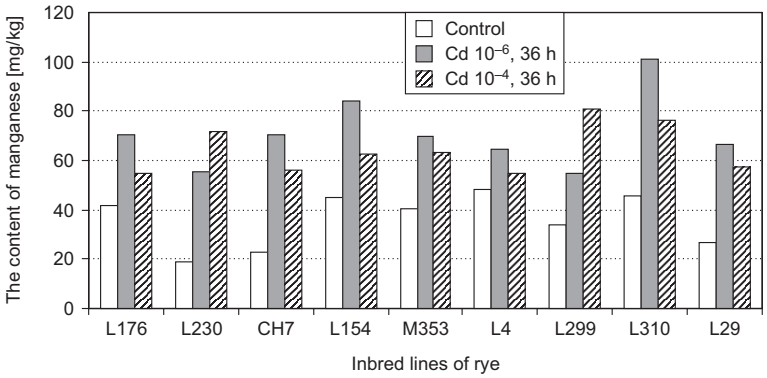

Fig. 3. The content of manganese ions [mg/kg] in inbred lines of rye

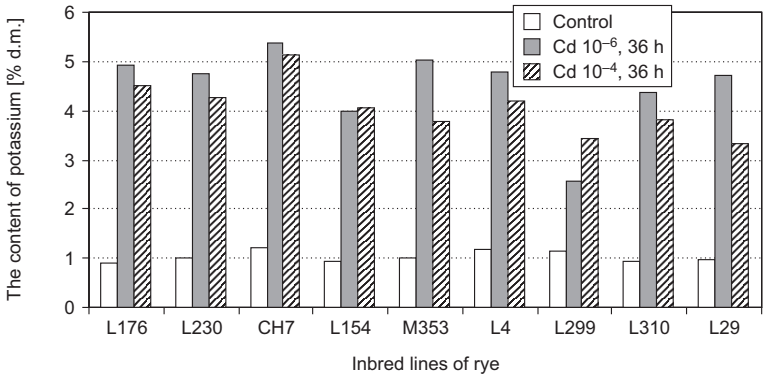

Fig. 4. The content of potassium ions [% d.m.] in inbred lines of rye

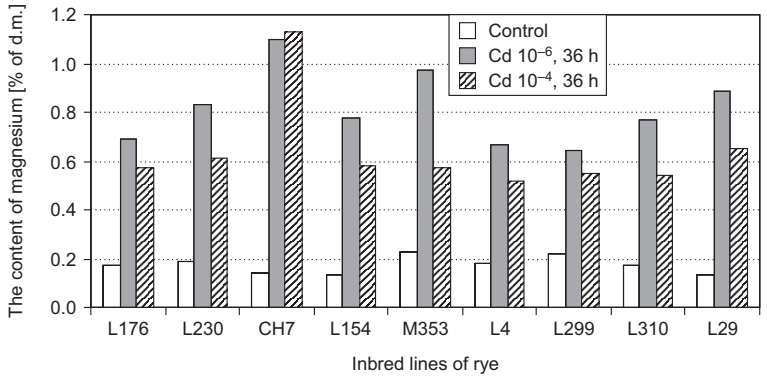

Fig. 5. The content of magnesium ions [% d.m.] in inbred lines of rye

10^{-6} M/36 h, whilst lines L299 and L230 constituted an exception (Fig. 2 and 3). At a lower concentration of cadmium the content of potassium increased several times in most lines. However, the growth of this element at the Cd concentration (10^{-4} M/36 h) was not observed in line L299 only (Fig. 4).

In the case of magnesium, a 6-fold increase of its content was observed in rye seedlings treated with cadmium at concentrations of 10^{-6} M/36 h, whereas at concentrations of 10^{-4} M/36 h only in line CH_7 (Fig. 5). In most lines the content of potassium and magnesium lessened with the growth of the dose of cadmium. Availability of biogenic elements and cadmium in the nutrient probably led to their excess intake by seedlings. The quite short time of their growth (21 days) did not allow the plants to remove or bind the ions of these elements.

In general, plants are more resistant to excess microelements concentration than to their deficit. In the case of heavy metals eg cadmium it increases over critical values in soil led to chlorotic leaves, deformity of roots and the consequent the growth stunt of rye lines. According to Kabata-Pendias and Pendias [9], the sensitivity of plants to excess heavy metals is associated with damage to the photosynthesis apparatus, which in effect disrupts the metabolic process.

On the basis of the results obtained it can be said that rye inbred lines of various genotypes accumulated the researched elements in seedlings in various ways. This is confirmed in the results of Kozanecka [3] and Krawczyk [4], according to whom plants growing in the same environment react differently to the action of heavy metals.

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ZAWARTOŚĆ WYBRANYCH PIERWIASTKÓW W SIEWKACH LINII WSOBNYCH ŻYTA OZIMEGO (*Secale cereale* L.)

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Abstrakt: Do doświadczenia wybrano 9 linii wsobnych (L176, L230, CH_7, L154, M353, L4, L299, L310 i L29) pokolenia S_{25} żyta ozimego (*Secale cereale* L.). Pięciodniowe siewki linii traktowano roztworem siarczanu kadmu o stężeniach 10^{-6} i 10^{-4} M przez 36 h, a następnie przenoszono je na pożywkę. Materiał kontrolny stanowiły siewki linii rosnące na pożywce Hoaglanda. Dwudziestojednodniowe siewki mineralizowano i oznaczono zawartość następujących pierwiastków: kadm, magnez, cynk, wapń, mangan i potas, przy

użyciu spektrofotometru absorpcji atomowej firmy Perkin-Elmer1100. Najniższą zawartość kadmu wynoszącą kilka mg/kg zanotowano w kombinacji kontrolnej. Zawartość biogennych pierwiastków była wyższa u wszystkich linii wsobnych żyta w niższym stężeniu kadmu 10^{-6} M/36 h (z wyjątkiem linii L230 i L299).

Słowa kluczowe: kadm, żyto, *Secale cereale* L., potas, mangan, wapń, cynk, magnez