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ASSESSMENT OF CADMIUM AND NICKEL TOLERANCE OF MAIZE CULTIVARS BASED ON ROOT AND SHOOT GROWTH

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Abstract. The test of tolerance degree of some maize cultivars to the heavy metals action (in particular cadmium and nickel) by the Wilkins root test has been conducted. It has been established that the greatest tolerance to the stress was in the cv. *'Dniprovski 425',* and the lowest in *'Premija 190'.*

Key words: maize, cadmium, nickel, tolerance, stress

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Under the influence of any kind of stress changes of various physiological parameters arise in organisms. As a total reflection of all primary physiological-biochemical disturbances (permeability of membranes, structural state of DNA, changes of cytoplasm osmoregulation and other) and secondary responses (braking of protein synthesis and inhibition of cell division) there are integrated changes of important physiological functions in plant organism: e.g. increasing of total biomass and size of a whole plant and its certain vegetative organs (Khalid & Tinsley 1980; Гуральчук 1994; Ouzounidou 1997; Ernst 1998).

The level of seedling tolerance to the heavy metals influence was determined by root test. For this purpose, seeds of maize after germination were transferred on a medium with the ions of Cd^{2+} and Ni^{2+} in followings concentrations: for Cd^{2+} – 4 mg/l (1 MPC) and 40 mg/l (10 MPC), for Ni^{2+} – 3 mg/l (1 MPC) and 30 mg/l (10 MPC). After 72-hour exposure the Wilkins root index (RI) was calculated (Wilkins 1978).

The analysis of experimental data in variants with the use of cadmium compounds at low concentration shows that it was not possible to differentiate the maize cultivars with the high- or low degree of tolerance to the stress. Therefore the analyzed cultivars were divided into two groups: with the low and high degree of metal tolerance. In the first group of cultivars (*'Blitz 160', 'Delikatesnaja', 'Euro 401', 'Premija 190', 'Euro 301', 'Tone 320'*) the diminishing of main root' length exceeded 10% in total and 15% – in average relation to control plants (Tab. 1). For the rest of cultivars (*'Svit 400', 'Dniprovski 425', 'Fond 404'*) the length of main root decreased by 6-7% in total or did not differ from control (*'Dniprovski 425'*). The second case belongs to the group with the highest tolerance to cadmium action.

After adding of the other heavy metal – nickel into the medium, length of shoot and main root were decreased in less extent comparing to cadmium. The grouping of cultivars was according to tolerance levels were comparing to the cadmium variants of experiment. So, the number of sensitive cultivars in this case diminished: *'Delikatesnaja', 'Euro 401', 'Premija 190', 'Euro 301'* and *'Tone 320'*. At this group of cultivars length of main root diminishes, and value of RI changes from 0.88 to 0.92 (Tab. 1). Absence of statistically reliable difference of main root length was fixed for the followings cultivars: *'Blitz 160', 'Svit 400', 'Dniprovski 425', 'Fond 404'*. Experimental information and expected values of RI allow including of these cultivars in a group with the high degree of metal tolerance. Thus, our research testified that using low concentration of cadmium and nickel compounds the tolerance to heavy metals in maize cultivars is relatively high. This tolerance

Table 1. Length of main root (cm) and root index (RI) of some maize cultivars under the influence of heavy metals, n = 100.

Cultivar	Control	1 MPC Cd		10 MPC Cd		1 MPC Ni		10 MPC Ni	
		M±m	RI	M±m	RI	M±m	RI	M±m	RI
'Blitz 160'	2.71±0.07	2.39±0.06*	0.88	2.07±0.06*	0.76	2.87±0.08	1.06	2.06±0.05*	0.76
'Delikatesnaja'	1.6±0.05	1.36±0.04*	0.85	1.07±0.03*	0.67	1.45±0.04*	0.91	1.18±0.05*	0.74
'Svit 400'	1.46±0.05	1.34±0.03*	0.91	1.06±0.04*	0.72	1.37±0.04	0.94	1.27±0.05*	0.87
'Euro 401'	2.16±0.06	1.84±0.06*	0.85	1.49±0.04*	0.69	1.98±0.05*	0.92	1.7±0.04*	0.79
'Premija 190'	2.76±0.06	2.33±0.08*	0.84	1.6±0.05*	0.58	2.35±0.06*	0.85	1.86±0.05*	0.68
'Euro 301'	2.35±0.07	2.05±0.05*	0.87	1.67±0.05*	0.71	2.09±0.06*	0.89	1.86±0.05*	0.79
'Dniprovski 425'	2.46±0.05	2.32±0.06	0.94	2.12±0.06*	0.86	2.59±0.06	1.05	2.26±0.06*	0.92
'Tone 320'	2.01±0.06	1.69±0.05*	0.84	1.47±0.05*	0.73	1.77±0.04*	0.88	1.58±0.04*	0.79
'Fond 404'	2.68±0.06	2.49±0.05*	0.93	2.07±0.04*	0.77	2.69±0.05	1.0	2.26±0.04*	0.84

* – statistically reliable difference in relation to control, $p < 0,05$.

is not only cultivar-specific but also depends on the used heavy metal.

Growth of maize on a medium which contains the high concentration of cadmium and nickel compounds have appeared as a better selective factor to display the tolerance degree to heavy metals influence and allowed more expressively to define steady and unsteady cultivars. Under the influence of cadmium in concentration 40 mg/l the shoots of the cultivar *'Premija 190'* were the most oppressed. In addition, the main root length has also decreased to 42% in comparison to control (Tab. 1). Shoots of *'Dniprovski 425'*, which showed no changes under low concentrations, at high metal doses (40mg/l) also shows the highest tolerance as resulted from RI values. Other cultivars which showed tolerance to low concentrations of heavy metals, in this case occupy an intermediate position. In plants of these cultivars (*'Blitz 160', 'Delikatesnaja', 'Svit 400', 'Euro 401', 'Euro 301', 'Tone 320'* and *'Fond 404'*) the diminishing of main root exceeded 20% and increased from 23% to 33% in relation to control.

Adding the nickel in high concentration (30 mg/l) also resulted in the statistically reliable suppression of main root and shoot lengths in all investigated maize cultivars. But it should be noted that the difference was not as clear as in the case of cadmium (Tab. 1). For the cultivar *'Premija 190'* the most substantial reduction of root growth (length of main root diminished by 32%) and accordingly the lowest degree of metal tolerance were noted. However, the cultivar *'Dniprovski 425'* did not show remarkable sensitivity to nickel what was expressed in the statistically reliable decreasing of main root just by 8%. As a result the cultivar *'Dniprovski 425'* was suggested as the most tolerant cultivar to a stress influence caused by the heavy metals. The other cultivars used in experiment both by RI calculations and by the absolute values of main root length were attributed to a group of moderate metal tolerance.

As a result of the conducted research it is possible to establish that under the obtained cadmium and nickel concentrations the cultivar *'Premija 190'* seems to be unsteady, while the cultivar *'Dniprovski 425'* is a relatively tolerant cultivar.

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References

Гуральчук Ж.З. 1994. Механизмы устойчивости растений к тяжелым металлам. *Физиология и биохимия культ. растений* **26 (2)**: 107–117.

Ernst W.H.O. 1998. Effects of heavy metals in plants at the cellular and organismic level. In: Shuurmann G., Markert B. Ecotoxycology. Ecological fundamentals. Chemical exposure and biological effect: 587–620. Heidelberg, Wiley.

Khalid B.Y., Tinsley J. 1980. Some effects of nickel toxicity on ryegrass. *Plant Soil* **55**: 139–143.

Ouzounidou G., Moustakas M., Eleftheriou E.P. 1997. Physiological and ultrastructural effects of cadmium on wheat (*Triticum aestivum* L.) leaves. *Arch. Environ. Contam. Toxicol.* **32**: 154–160.

Wilkins D.A. 1978. The measurement of tolerance to edaphic factors by means of root growth. *New Phytol.* **80 (3)**: 623–633.