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Tolerance to high copper ions concentration in the nutrient medium of some Bulgarian barley cultivars

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Abstract. The winter two-rowed barley cultivars Obzor, Krasii 2, Vihren and Karan were examined for tolerance to environmental copper ions pollution. The plants were treated with 10^{-6} M and 10^{-5} M $CuSO_4.5H_2O$ for 7 days. It was found that under 10^{-6} M the roots of cultivars Krassi 2 and Vihren were longer by 9% and 16% respectively, while plant green part was identical to that of the control. The root of cultivar Karan was severely inhibited its length reaching 77% that of the control. The green part was less affected. The data suggest that cultivars Krasii 2 and Vihren are tolerant while cultivar Karan is susceptible to increased copper ions concentration in the environment.

Key words: barley, tolerance, copper ions

Barley is an economically important crop being efficiently used in animal husbandry and brewing. Resistant to abiotic and biotic stress barley cultivars are a reliable tool to produce high quality stuff avoiding diverse chemical substances for pest control and other agricultural practices. Acevedo and Fereres (1993) concluded that breeding for abiotic stress resistance is becoming more promising with the recognition that selection showed be carried out in the target environment and that it is related to narrow adaption.

During the last decades barley resistance to certain heavy metals has been examined in different aspects. It was shown that increased boron concentration in the environment reduce plant growth rate, while relative susceptibility of the genotypes to boron toxicity was not affected (Nable et al.,1999). The effect of high boron concentration on barley was studied on cell level (Jenkin et al.,1993). Data from studies with leaf protoplasts revealed that lack of cell walls prevents manifestation of differences between tolerant and susceptible barley genotypes. Treatment of *H. vulgare* seeds with nickel sulphate resulted into morphological alterations and increased chlorophyll and protein percentage, as well as that of the aberrant cells (Mishra and Singh, 1999). Addition of copper (2-4 kg/ha) led to higher grain yield from wheat, rye and oats (Piening et al., 1989). Tang et al. (2000) studied the location of genes for tolerance to aluminium and found that the latter is disposed to the long arm of 4H chromosome, while according to Rigin and Yakovleva (2001) the tolerance is coded by two polygenes.

The purpose of this investigation was to examine the tolerance to increased copper ions concentration in the nutrient medium of four Bulgarian barley cultivars.

Materials and Methods

The winter two-rowed cultivars Obzor, Krassi 2, Vihren and Karan were studied. The seeds were germinated in moist filter paper rols in a semi-dark chamber at 18° C. After germination (2.5 – 3.5 cm root length) the shoots were transffered on a solution containing 10^{-6} M or 10^{-5} M $CuSO_4.5H_2O$ at a temperature of while the control plants were grown in distilled water. All plants were grown at 12 h illumination/12 h dark and 20°- 24° C. After 7 days treatment biometric data were collected. To determine copper tolerance of the plants usually the tolerance index (Simon, 1978) was used, i.e. the plant growth in a heavy metal polluted medium was compared to that under control conditions:

$$IT = \frac{\text{growth in a polluted medium}}{\text{growth under control conditions}} 100$$

The data of copper influence on length of root and shoot have been processed by the variation statistical method.

Results and Discussion

A three-fold treatment with 10^{-6} M copper ions concentration of the root (cultivar Obzor) caused inhibition (93-94% as compared to the control) or stimulation up to 103%. In the case of the cultivar Karan the roots were strongly inhibited their length varying from 62% to 94% of the control. The plants of the cultivar Krassi 2 and cultivar Vihren responded to two of the treatments through stimulated root growth from 122% to 135% and from 116% to 129%, respectively. The shoot length was less affected, some inhibition varying from 1% to 6% or stimulation up to 2 – 4% being manifested by the cultivars Obzor, Krassi 2 and Vihren. More significant inhibition was manifested by cultivar Karan.

The higher (10^{-5} M) copper ions concentration severely inhibited both root and shoot of the plants from all cultivars after the three treatment accomplished.

The mean data (Table 1) show that 10^{-6} M ions stimulate (9-16%) root growth of the plants from cultivars Krassi 2 and Vihren while the roots of the plants from Karan reaced only 77% of the control. The green part of the plants was equal to that of the control ones. The variation coefficients revealed slight heterogenic variation, while the plant green part length variation was homogenic, exept that for cultivar Karan. Higher (10^{-5} M) copper ions concentration highly reduced root growth, root length reaching 32-41% that of the control. The aboveground part of the plants from cultivar Krassi 2 and cultivar Vihren was identical to that of the control while those of cultivar Karan and Obzor were 69-75% that of the control. The variation coefficients revealed slight heterogenic variation.

Under 10^{-6}M copper ions concentration root mass of cultivar Obzor and cultivar Karan reaching 90-91% that of the control, the negative effect being stronger than that exerted on cultivars Krassi 2 and Vihren. The green part mass increased (1-3%) in the case of cultivar Obzor, cultivar Krassi 2 and cultivar Vihren, while that of cultivar Karan was slightly inhibited.

10^{-5} M copper ions concentration redused plant green part and root mass to 75-79% and 52-61%, respectively.

To conclude, the cultivars Krassi 2 and Vihren manifested tolerance to increased copper ions concentration in the environment as under 10^{-6} M the root was 9-16% longer than that of the control combined with less reduction of the mass (94%) of the control. The grain yield was 672 kg/da and 677 kg/da, respectively. Therefore, they are suitable for cultivation in highly polluted regions.

Cultivar Karan proved to be susceptible to copper pollution its root being severely reduced.

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Table 1. Influence of copper ions on the length of root and shoot

Variant	Cultivar	Length root			Length shoot		
		%control	M ± m	Vc%	%control	M ± m	Vc%
Control	Obzor	100	12.0 ± 0.13	10.57	100	14.30 ± 0.13	8.93
10^{-6}M		97	11.7 ± 0.18	12.84	99	14.20 ±.0.13	7.88
10^{-5}M		38	4.6 ±.0.36	14.82	75	10.67 ±.0.13	11.91
Control	Krassi 2	100	12.8 ± 0.21	15.28	100	14.40 ±.0.13	9.62
10^{-6}M		116	14.8 ± 0.23	15.51	100	14.40 ± 0.12	8.49
10^{-5}M		41	5.3 ± 0.25	12.40	73	10.50 ± 0.11	11.11
Control	Vihren	100	13.7 ± 0.29	19.65	100	16.40 ± 0.15	8.40
10^{-6}M		109	15.0 ± 0.23	15.29	99	16.20 ±.0.16	9.47
10^{-5}M		40	5.5 ± 0.08	15.75	72	11.80 ± 0.16	12.85
Control	Karan	100	14.5 ± 0.23	14.65	100	15.40 ± 0.18	10.26
10^{-6}M		77	11.2 ± 0.22	16.50	98	15.10 ± 0.21	12.16
10^{-5}M		32	4.6 ± 0.08	16.49	69	10.60 ± 0.19	16.15