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Influences of Salts of Copper on Growth and Development of some Monocotyledonous and Dicotyledonous Plants in Laboratorial Conditions.

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ABSTRACT

The influences of salts of copper on viability, growth and development of sprouts of some monocotyledonous and two-submultiple plants in laboratorial conditions are studied. Results have shown that pollution by copper in a dose from 30 mg/l and more has an adverse effect on germination and seed viability of both monocotyledonous and dicotyledonous plants above. The analysis of morphometric values shows what small concentration of copper doesn't make negative impact on growth of plants whereas at the increased content of salts of copper leads to growth oppression. Sprouts of oats were steadier against pollution of the soil of copper whereas young plants of haricot are more sensitive.

Keywords: copper, pollution, monocotyledonous plants, dicotyledonous plants, germination, growth.

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INTRODUCTION

Now the human civilization has fully felt global ecological crisis which unambiguously indicates anthropogenous intoxication of the biosphere, fast reduction of a biodiversity, degradation natural ecosystems of huge spaces [1]. It is important to note that harmful components are brought not just in water, atmospheric air or the soil, final object of pollution is the ecosystem. At the same time processes of a metabolism are broken, intensity of assimilation of producers, efficiency of a biocenosis in general decreases [2-4].

Excess of one substance in environment or just availability in her of other substances (new impurity) means change of the modes of ecological factors. At the same time processes of a metabolism are broken, intensity of assimilation of producers, so, and efficiency of a biocenosis in general decreases [5-8]. Accumulation of toxic connections is carried out under the law of progressive accumulation of toxic substances in trophic chains: concoction of substance increases in an ecosystem or a food chain at the highest trophic levels in comparison with the lowest [9, 10]. An initial element of this chain is technogenic activity of the person, then the soil which accumulates in itself ekotoksikant. Further they can migrate in plants (forages), then in an organism of animals and finally collect in production of animal husbandry.

Heavy metal sources in environment are very various: the enterprises of nonferrous and ferrous metallurgy, power plants burning coal and oil, motor transport, waste of livestock complexes, rainfall of sewage, mineral and organic fertilizers, mining, chemical industry and others.

Studying of heavy metals in soils and plants is given raised now, but everything, insufficient attention. So, results of the monitoring which is carried out by the State committee of sanitary and epidemiological surveillance of Russia demonstrate that in 4% of the studied tests of foodstuff excess of maintenance of TM was observed, including on lead, cadmium and mercury, especially considerable accumulation is noted in root crops [10]. Over the last 10 years the number of non-standard tests of food raw materials and the food polluted by cadmium, lead and arsenic has increased from 1 up to 1,5% on all group of production [11].

According to the international requirements developed by the joint commission of FAO/WHO control of contents in food products of eight minerals is necessary, first of all: mercury, cadmium, lead, arsenic, zinc, copper, tin and iron [1;12]. It should be noted that mercury, arsenic, cadmium and lead are included into the first group of the particularly hazardous substances carried to priority what токсикантам. Such elements as zinc and copper, being biogenous, in big concentration also have the expressed toxic effect [13]. Distribution of lead in plants uneven: the greatest concentration is usually observed in roots, it is less - in vegetative parts of plants, and his smallest contents is noted in reproductive organs - fruits, seeds [14]. In the root crops and cabbage which are grown up close highways the amount of lead at 5-10 times exceeds maximum permissible standard daily rate [15]. Significant increase in concentration of lead is found also in the vegetables which are grown up on the suburban sites remote from the large cities at distance to 25 km [16].

At the territory of the Central Kazakhstan is observed high pollution by copper salts that it was connected with extraction of copper ore and production of cathodic copper in the cities of Balkhash and Zhezkazgan.

To assess practical damages of such influence and its ecological consequences it is necessary to study experimentally regularities of reactions of organisms at receipt of toxic elements, both in directly in the nature, and in experiment. Laboratory experiments allow clearing in more detail a picture of oppression of plants against pollution by separate pollyutant whereas in the nature we can observe a big range of the polluting substances.

Research objective was to estimate influence of salts of copper on growth and development of some monocotyledonous and dicotyledonous plants (on the example of beans and oats).

MATERIALS AND METHODS

Objects of researches were seeds of red beans (a dicotyledonous plant) and oats sowing (a monocotyledonous plant).

Experiences put in the closed soil within 2015-2016 years on the basis of laboratory of biotechnology and molecular genetics of biologo-geographical faculty Ye.A. Buketov Karaganda State University.

The assessment of seed viability and energy of germination was carried out on Petri's dishes on 2-layer filter paper. Research of viability and energy of germination of seeds was carried out according to M.S. Zorina and S.P. Kabanov's methodical instructions and other authors [17-19]. In control seeds moistened with the distilled water, in skilled options – copper sulfate solutions in the following concentration of ions of copper: 3,0 mg/l; 30,0 mg/l; 300,0 mg/l and 3 g/l.

In plastic boxes made landing of seeds, on soil mixes modelled pollution by copper: background indicators in uncontaminated territories, maximum concentration limit and the pollution revealed in the neighborhood of the industrial cities (Temirtau, Zhezkazgan, Balkhash) [20]:

1) Control, without copper salts;
2) Concentration of salts of copper within maximum concentration limit of 4,5 mg/g;
3) Concentration of salts of copper of 11,4 mg/g;
4) Concentration of salts of copper of 17,2 mg/g;
5) Concentration of salts of copper of 21,6 mg/g;
6) Concentration of salts of copper of 32,3 mg/g;
7) Concentration of salts of copper of 32,8 mg/g;
8) Concentration of salts of copper of 48,8 mg/g;
9) Concentration of salts of copper of 3,3 mg/g;
10) Concentration of salts of copper of 0,09 mg/g.

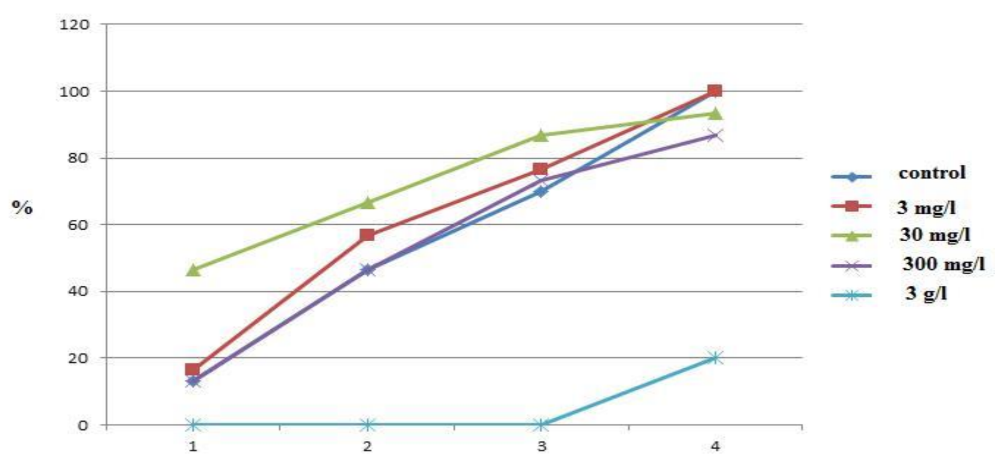
Cultivation of plants was carried out within 4 weeks during which considered morphological parameters of elevated bodies [21-23]. After the end of cultivation estimated extent of development of underground bodies and carried out an assessment of efficiency of elevated weight. The following morphological parameters are studied: height and diameter of plants, length and width of a leaf, scape length, diameter of a root neck. Measurements were taken by means of the electronic range Digital Caliper 0-150 mm.

Efficiency of the gained elevated weight was estimated on crude weight. Weighing of plants was carried out on analytical scales of Mettler Toledo BL – 3200 H. Statistical processing of the received results was carried out by N.L. Udolskaya's technique [24]. Results were expressed as the average value ± standard deviation.

RESULTS AND DISCUSSION

Results of seed germination have shown that in various options of experience germination of seeds happens differently.

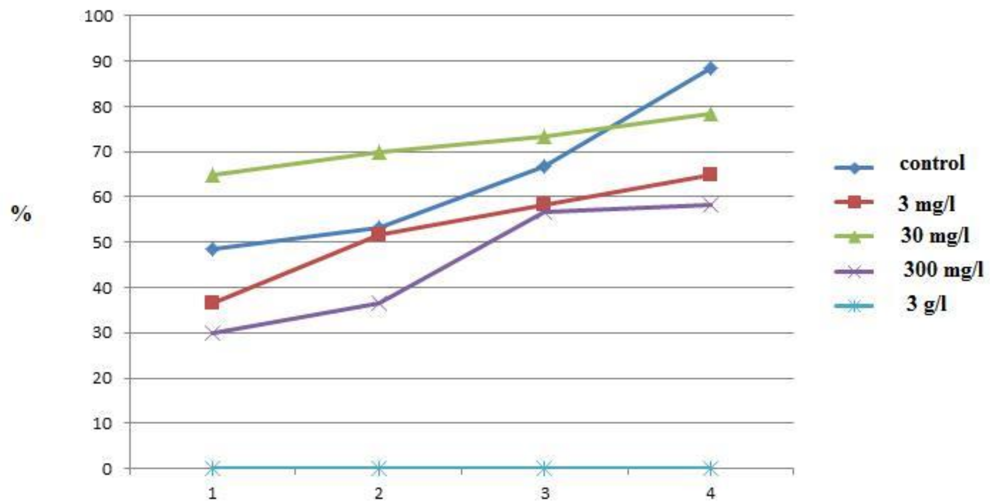
Fig 1: Dynamics of germination of seeds of red beans against pollution by copper salts. Days of germination: 1 – the 3rd, 2 – the 5th, 3 – the 10th, 4 – the 14th



The beginning of germination of seeds of haricot was identical to all options of experience, except one (Fig. 1). So, the first shoots have appeared on the 3rd days after crops whereas in control option whereas in option with a dose of pollution of copper of 3 g/l single shoots have been noted for the 12th days, and they were not viable. Sprouts have a deformation of root system and a hypocotyl.

The beginning of germination of seed material of oats sowing was more amicable, four options of experience have shown single shoots for the 3rd days after crops. Shoots for option with concentration of copper of 3 g/l (Fig. 2) aren't received.

Fig 2: Dynamics of germination of seeds of oats sowing against pollution by copper salts. Days of germination: 1 – the 3rd, 2 – the 5th, 3 – the 10th, 4 – the 14th



Thus, we can observe that control options and skilled option at concentration of copper of 3 mg/l (maximum concentration limit value) have shown the maximum values of viability and energy of germination. Seeds ascend amicably; final values of germination are close to 100%. At increase of concentration of copper decrease in indicators of germination of seeds is noted. So, at concentration of 3 g/l seeds of haricot have given single shoots whereas seeds of oats haven't sprouted.

Also distinctions in formation of sprouts of plants are noted. Against high concentration of copper (from 300 mg/l to 3 g/l) not full expansion of sheet plates, an underdevelopment of a hypocotyl and a reduction of root system was observed. The plants which are grown up at concentration of copper of 30 mg/l developed with normal morphology, but lagged behind on parametrical indicators.

Thus, our researches have shown that pollution by copper in a dose from 30 mg/l has an adverse effect on growth and development of sprouts of both monocotyledonous and dicotyledonous plants.

Cultivation in boxes on artificially polluted soil was conducted within 4 weeks. Results of experiences have shown that at artificial pollution of the soil copper salts in concentration of 32,8 mg/g; 32,3 mg/g; 48,8 mg/g shoots at two-submultiple and monocotyledonous plants haven't appeared. In experience options with concentration of copper of 21,6 mg/g single shoots of oats and haricot are received. Good viability of seeds of oats is noted against pollution by copper in concentration of 17,2 mg/g and 11,4 mg/g of the soil. Though, in both options of experience it wasn't succeeded to receive normal shoots of red beans. Sprouts died off or at a stage of emergence of a hypocotyl, or at an expansion stage a cotyledon.

Satisfactory shoots of monocotyledonous and two-submultiple plants managed to be received in experience options with the low content of salts of copper and in control – 0,09 mg/g; 3,3 mg/g and 4,5 mg/g (Fig. 3).

Fig 3: Shoots of monocotyledonous and two-submultiple plants in control option (left) and concentration of copper within maximum concentration limit (right)

The analysis of morphometric indicators of even-aged plants has shown that the difference in a structure of elevated and underground bodies (tables 1 and 2) is observed.

Table 1: Morphometric indicators of sprouts of beans in different options of experience

Variant of experience	Height of a plant, cm	Length of a leaf, cm	Width of a leaf, cm	Length of a scape, cm	Length of a root, cm	Diameter of a root neck, mm
Control	40,20±1,81	7,30±0,63	5,72±0,64	5,22±0,18	18,40±1,12	3,61±0,11
21,6 mg/g	26,00±0,00	6,00±0,00	5,00±0,01	3,00±0,00	5,22±0,08	3,21±0,06
3,3 mg/g	39,80±1,37	7,36±0,41	6,46±0,27	5,00±0,52	22,40±1,22	3,62±0,04
4,5 mg/g	33,10±1,80	6,54±0,35	5,37±0,35	2,88±0,55	14,83±1,15	3,60±0,10
0,09 mg/g	45,42±3,80	7,93±0,39	6,67±0,40	4,20±0,34	15,85±1,27	3,40±0,06
11,4 mg/g	41,84±4,15	7,86±0,33	7,23±0,36	4,33±0,14	20,54±1,86	3,58±0,06
17,2 mg/g	31,40±1,87	7,22±0,29	5,90±0,32	4,56±0,35	9,40±0,92	3,42±0,05

Table 2: Morphometric indicators of sprouts of oat in different options of experience

Variant of experience	Height of a plant, cm	Width of a leaf, cm	Length of a scape, cm	Length of a root, cm	Diameter of a root neck, mm
Control	35,00±3,55	20,46±1,16	0,38±0,01	22,61±1,24	1,89±0,05
21,6 mg/g	29,80±0,90	21,80±1,32	0,28±0,01	8,90±0,41	1,10±0,03
3,3 mg/g	31,60±0,81	22,20±0,95	0,32±0,01	22,45±1,09	1,80±0,06
4,5 mg/g	37,84±1,07	25,65±0,82	0,60±0,02	22,06±1,99	1,88±0,06
0,09 mg/g	35,03±1,85	24,55±1,37	0,59±0,05	12,48±1,25	1,71±0,08
11,4 mg/g	37,61±1,28	23,96±1,50	0,69±0,04	10,13±0,44	1,64±0,09
17,2 mg/g	36,54±0,69	25,80±1,02	0,32±0,01	9,03±0,45	1,14±0,05

Results of measurements of sprouts in height have shown that for haricot the greatest indicators are noted in option of background value of 0,09 mg/g. Control values and options with concentration of copper of 3,3 mg/g, 11,4 mg/g take the second position on growth. The smallest growth at haricot is noted in option with the maximum concentration of copper 21,6 mg/g. For oats sprouts the maximum growth the smallest observed in experience option with concentration of copper 4,5 mg/g and in control, - at concentration of copper of 21,6 mg/g.

The analysis of length and width of a leaf of plants of haricot and oats has shown an insignificant difference between experience options. So, the largest sizes of sheet plates of haricot are noted in experience options control, concentration of copper of 3,3 mg/g, 0,09 mg/g and 11,4 mg/g. The smallest metric

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parameters are revealed in experience options with concentration of copper of 21,6 mg/g and 17,2 mg/g (fig. 4).

Fig 4: Haricot plants in control (left) and at concentration of copper of 21,6 mg/g (right)

For oats sowing width of a leaf had no essential differences by options of experience (Fig. 5) whereas on leaf length the maximum values are noted in option of 4,5 mg/g and 0,09 mg/g, the smallest – in option with control and kontsetratsiy copper of 21,6 mg/g.

For oats sowing width of a leaf had no essential differences by options of experience (Fig. 5) whereas on leaf length the maximum values are noted in option of 4,5 mg/g and 0,09 mg/g, the smallest – in option with control and concentration copper of 21,6 mg/g.

Fig 5: Plants of oats sowing at concentration of copper of 0,09 mg/g (left) and 11,4 mg/g (right)

For haricot indicators of length of a sheet scape have been in addition measured. It is noted that the maximum length of a scape is recorded in experience option 21,6 mg/g, maximum is in control option.

The analysis of underground bodies has allowed revealing a difference in development of root systems in options of experience (Fig. 6). For both cultures (monocotyledonous and two-submultiple) it is possible to see similar indicators at various level of pollution by copper salts. So, for haricot and oats oppression of growth of root systems is observed – metric indicators were minimum.

Good indicators for both cultures are observed against concentration of copper of 3,3 mg/g though oats show high development of a root in experience options – control, 4,5 mg/g. Haricot on the second position on the size of root system has an option with concentration of copper of 11,4 mg/g, and also control.

Oppression of growth of a root at haricot is observed at concentration of 21,6 mg/g and 17,2 mg/g, at oats of sowing experience in options – 21,6 mg/g, 17,2 mg/g and 11,4 mg/g.Studying of diameter of a root neck of haricot I haven't allowed to reveal essential distinctions in experience options at haricot (Fig. 7) though essential decrease in parameters at concentration of copper of 21,6 mg/g is observed.

Fig 6: Length of a root of sprouts of haricot and oats in various options of experience. Row 1 - length of a root of sprouts of haricot, a row 2 – length of a root of sprouts of oats; experience options: 1 – control, 2 – 21,6 mg/g, 3 – 3,3 mg/g, 4 – 4,5 mg/g, 5 – 0,09 mg/g, 6 – 11,4 mg/g, 7 – 17,2 mg/g

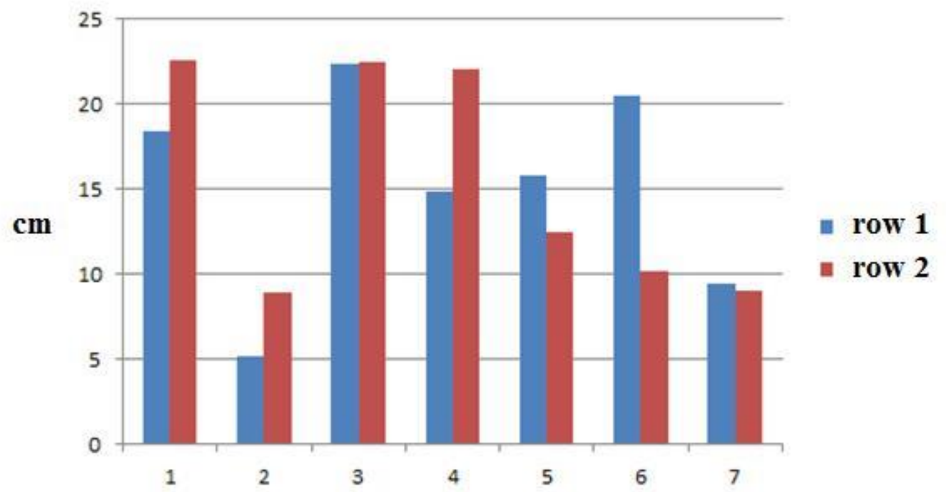
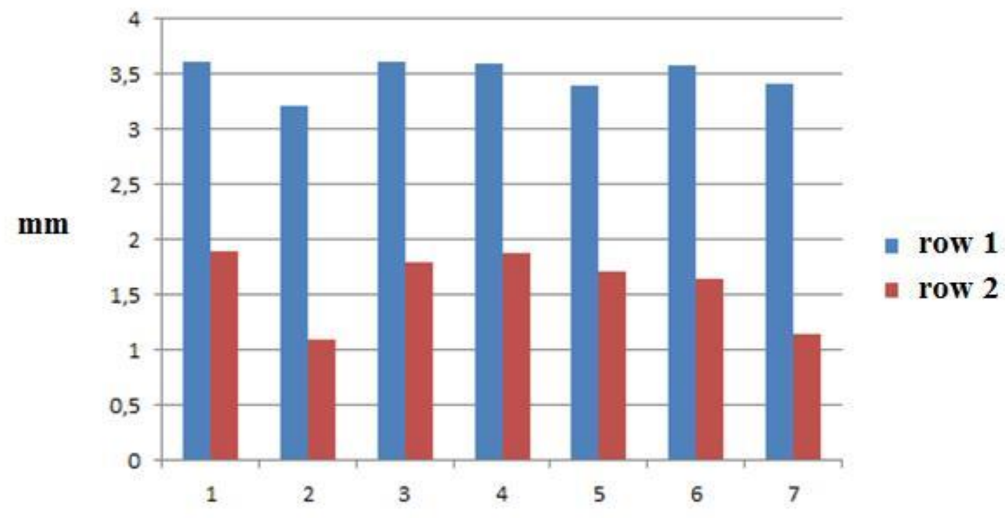


Fig 7: Diameter of a root neck of sprouts of haricot and oats in various options of experience. Row 1 - indicators of sprouts of haricot, a row 2 – indicators of sprouts of oats; experience options: 1 – control, 2 – 21,6 mg/g, 3 – 3,3 mg/g, 4 – 4,5 mg/g, 5 – 0,09 mg/g, 6 – 11,4 mg/g, 7 – 17,2 mg/g



At sprouts of oats sowing the variation of the sizes is more expressed. So, the smallest sizes are revealed at concentration of copper of 21,3 mg/g and 17,2 mg/g; the greatest – in control, at concentration of copper in the soil of 3,3 mg/g, 4,5 mg/g and 0,09 mg/g. After an assessment of morphometric indicators we have analysed efficiency of elevated bodies in various options of experience (Table 3).

Table 3: Indicators of crude weight of plants of beans and oats experience in various options against pollution by copper salts

Plant	Variant of experience	Weigth, g
Bean	Control	3,62±0,05
	21,6 mg/g	3,02±0,32
	3,3 mg/g	5,26±0,01
	4,5 mg/g	6,79±0,35
	0,09 mg/g	6,62±0,03
	11,4 mg/g	4,06±0,42
	17,2 mg/g	4,59±0,04
Oat	Control	0,87±0,04
	21,6 mg/g	0,50±0,02
	3,3 mg/g	0,88±0,02
	4,5 mg/g	0,93±0,06
	0,09 mg/g	1,30±0,01
	11,4 mg/g	0,78±0,06
	17,2 mg/g	0,75±0,06

For haricot the considerable difference between experience options, by 1,5-2,8 times is revealed. Data show that haricot sprouts in option of experience of 4,5 mg/g and 0,09 mg/g had the largest crude weight that corresponded to maximum concentration limits values and background indicators of copper in Karkaraly mountains. The second position is taken by options of experience of 3,3 mg/g. The smallest weight at sprouts of haricot is described in experience option from 21,6 mg/g.

For plants of oats sowing the maximum crude weight is noted in experience option with background values 0,09 mg/g of the soil. Weight indicators in control option and at skilled options with concentration of copper of 3,3 mg/g and 4,5 mg/g differ slightly and take the second position. Slightly less oats plants had a weight in options of experience of 11,4 mg/g and 17,2 mg/g. The lowest weight indicators are revealed in experience option with pollution of the soil in a dose of 21,6 mg/g.

CONCLUSIONS

In summary, our results revealed that pollution by copper in a dose from 30 mg/l and more has an adverse effect on germination and seed viability of both monocotyledonous and dicotyledonous plants above.

The analysis of morphometric values shows what small concentration of copper (background values, maximum concentration limits values and small excess of maximum concentration limit) doesn't make negative impact on growth of plants whereas at the increased content of salts of copper it is possible to see growth oppression. So, at concentration of copper of 21,3 mg/g the most undersized and oppressed plants have been grown up, and at higher values of copper in the soil – it is noted or seed swore at lack of germination, or death of sprouts at early stages of development.

Sprouts of monocotyledonous plants were steadier against pollution of the soil copper whereas young plants of haricot - are more sensitive.

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