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The exposure of lead nitrate on germination and vigor processes of *Helianthus* (sunflower) and *Lathyrus* (pea) seeds

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MBD: Investigation; Writing — original draft, review & editing.
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It is hereby studied the exposure of lead ions on germination and growth viability of helianthus and lathyrus seeds in laboratory conditions. Certain tendencies have been revealed showing the impact of different doses of the lead ions on germination of helianthus and lathyrus as well as on the length of the root and sprout in germinating the seed. Furthermore, a particular decrease (P<0.99) in the helianthus seed germination was observed under the lead exposure at the concentration of 5×10^{-3} mol/L. Whereas, at the lead ions concentration in their amount from 5×10^{-6} mol/L to 5×10^{-4} mol/L, no considerable influence on helianthus and lathyrus seed germination was noticed. However, the helianthus and lathyrus root length has been exposed by the lead ions more significantly. It was noticed that the helianthus root had significantly decreased in length at the lead ions concentration of 5×10^{-3} mol/L, 5×10^{-4} mol/L, 5×10^{-5} mol/L and 5×10^{-6} mol/L (P<0.999, P<0.999, P<0.99 and P<0.999, respectively). The difference in terms of the lathyrus root length at 5×10^{-3} mol/L, 5×10^{-4} mol/L, 5×10^{-5} mol/L and 5×10^{-6} mol/L concentration of lead ions was found significant (P<0.955, P<0.99, P<0.95 and P<0.99, respectively). The study results with regard to the exposure of different doses of the lead nitrate on the average length of the helianthus sprout showed an significant difference rate (P<0.999) in these values at the lead ions concentration in the solution of 5×10^{-3} mol/L, 5×10^{-5} mol/L and 5×10^{-6} mol/L. There was no significant difference between the lathyrus sprout length under the lead ions exposure between 5×10^{-6} mol/L and 5×10^{-3} mol/L. Thus, as far as the research results are concerned, there has been highlighted a significant lead nitrate exposure on economically useful indicators of the helianthus and lathyrus growing. A clear tendency of the lead nitrate impact on the helianthus and lathyrus seed germination and on their root and sprout length was revealed.

Key words: lead ions, the helianthus (sunflower) seed, the lathyrus (pea) seed, germination, root, sprout

Analysing Primary Sources

The activity of a technogenic agent, i.e. the people, has led to the accumulation of toxic contaminants in the soil, among which heavy metals are the leading ones.

The analysis of the harshness of accumulation of heavy metals in soil shows that this process increases on the year-over-year growth basis. Heavy metals enter the soil mainly as insoluble compounds and over the time a part of them becomes soluble. Heavy metals may accumulate in the soil environment in large quantities and move both horizontally and vertically.

Part of the heavy metals, being in their exchangeable form, is absorbed by plants and their products.

The major part of heavy metals is concentrated in the root system of the plant, owing to the plant's buffering system, and only some of these toxicants pass into the vegetative mass: the stem, leaves and inflorescence, including the seed. [3, 5].

It has been found that heavy metals in large quantities, the lead in particular, negatively affect the plant's physiological and biochemical processes. It is commonly known that the lead-induced toxicity for most plants is in the range of 1000–2000 mg/kg. However, some plants are highly resistant to lead exposure even up to 10 g/kg. The intensity of lead accumulation in plants vary depending on many factors, and first of all, on their botanical origin. A high level of heavy metals accumulation is observed in plants of the *Brassicaceae* family, i.e. the cabbage, mustard, etc. [2, 7].

Adaptive responses of plants to lead ions are shown in their ability to tolerate high concentrations of lead ions without any significant metabolic disorders. The level of tolerance to heavy metals is determined by the ratio between their accumulation in plants and their effective detoxification. Research has revealed a difference in the distribution of these pollutants and their particles between the roots and sprouts of the helianthus plants. The roots, immersed into such ion's environment, accumulated much larger amounts of pollutants and the toxic exposure of cadmium ions was much stronger than the exposure of lead ions. Obviously, the sensitivity of plants heavy metals exposure, and, accordingly, the tolerance index depends primarily on their effective binding and deposition into the vacuoles. Plants showed adaptation only under conditions of stress that caused no irreversible damage, while exposure to extreme stress did not allow adaptive mechanisms to manifest, and the tolerance index under the mentioned conditions was decreasing. [1, 4].

One of the effects of heavy metals on plants is the production of hydrogen peroxide, which in its excess negatively affects proteins and lipids of membranes and leads to DNA damage. This may indicate that one of the adaptive responses of plants to the heavy metal's exposure is the accumulation of hydrogen peroxide, which likely acts as a signalling molecule for further triggering of protective mechanisms in the plant cell. However, there is a need for further research of the adaptation response involving hydrogen peroxide, since there is a lack of knowledge with regard to accurate concentration of peroxide necessary to stimulate the antioxidant response and the adequate conditions for its regulation.

The exposure of lead ions on the activity of glutathione reductase means that these pollutants produce the stimulating effect at low concentrations, which leads to an increase in the activity of the enzyme, while high concentrations, with some exceptions, suppress activity of the enzyme.

The studies of oats in the conditions of anthropogenic contamination of the turf and podzolic soil revealed that when the concentration of lead in the soil was increased to the level of 5 and 10 TLV, the growth and development of plants was suppressed, the absorbent hairs and the root itself undergone deformation and were underdeveloped, there was observed an inhibitory effect on plant development, and, in some cases, a plant death. [6, 8].

Materials and Methods

The helianthus and lathyrus seeds were germinated at different concentrations in the distilled water with the addition of lead nitrate as follows: control stage — distilled water without the lead nitrate, experiment no. 1 — lead nitrate at concentration of 5×10^{-3} mol/L, experiment no. 2 — lead nitrate at concentration of 5×10^{-4} mol/L, experiment no. 3 — lead nitrate at concentration of 5×10^{-5} mol/L, experiment no. 4 — lead nitrate at concentration of 5×10^{-6} mol/L.

The exposure of lead nitrate on helianthus and lathyrus seeds was evaluated by the following parameters: germination, root and sprout length.

Statistical processing of the research results was carried out using the Student's *t*-test.

Results and Discussion

Our research results proved that there is a certain exposure of different concentrations of lead nitrate in the aqueous solution on the germination of helianthus seeds, the length of root shoots and stem (see table 1).

Moreover, at the concentration of lead nitrate in the aqueous solution of 5×10^{-3} mol/L, 5×10^{-4} mol/L and 5×10^{-6} mol/L, the germination of helianthus seeds decreased by 7%, 3%, and 3%, respectively, as compared to the experiment where the lead nitrate was not added to the aqueous solution.

The root length on the third day of its germination was lower by 33.4%, 42.2%, 38.2% and 34.8% upon adding into an aqueous solution the lead nitrate in the concentration of 5×10^{-3} mol/L, 5×10^{-4} mol/L, 5×10^{-5} mol/L and 5×10^{-6} mol/L respectively, as compared to helianthus seeds at their control stage, where the lead nitrate was not added to the aqueous solution. A similar tendency was displayed on the seventh day of the helianthus root ontogeny. Thus, upon adding into an aqueous solution the lead nitrate in the amount of 5×10^{-3} mol/L, 5×10^{-4} mol/L, 5×10^{-5} mol/L and 5×10^{-6} mol/L, there was noticed a decrease in helianthus seed root length by 25.5%, 19.0%, 20.0% and 25.2%, respectively, as compared to the stage where the helianthus seeds were germinated without adding the lead nitrate into an aqueous solution.

The analysis of the lead nitrate exposure on the growth vitality of the sprout of helianthus seed vegetative mass showed that at 5×10^{-3} mol/L, 5×10^{-5} mol/L and 5×10^{-6} mol/L concentrations of the named toxicant in the aqueous solution the sprout decreased in length by 20.6%, 0.3% and 13.1%, respectively, as compared to the control stage values.

Table 1. The exposure of lead nitrate on germination and vigor processes of helianthus seeds

Experiment stages	Seed germination, %	Root length, mm		Sprout length on the 7th day, mm
		3rd day	7th day	
Control stage	100	64.1±26.2	177.8±70.4*	143.2±31.9
5×10^{-3} mol/L	93**	42.7±15.9*	136.0±27.8*	113.7±36.1*
5×10^{-4} mol/L	97	37.0±13.3*	143.9±46.3*	142±46.9
5×10^{-5} mol/L	100	39.6±16.4**	142.1±57.3*	108.6±27.2*
5×10^{-6} mol/L	97	41.8±15.2*	132.9±59.7*	124.4±27.0*

Table 2. The exposure of lead nitrate on germination and vigor processes of lathyrus seeds

Experiment stages	Seed germination, %	Root length, mm		Sprout length on the 7th day, mm
		3rd day	7th day	
Control stage	98	48.1±17.5	204.±137.5	92.3±23.7
5×10^{-3} mol/L	99	43.9±20.3***	148.7±27.6*	90.9±30.7
5×10^{-4} mol/L	98	41.7±21.4**	177.1±34.8*	89.1±23.8
5×10^{-5} mol/L	99	42.1±19.9**	163.2±44.5*	88.4±24.9
5×10^{-6} mol/L	100	48.1±17.5***	183.6±41.0*	91.4±21.2

There is also a proved exposure of the lead nitrate on germination of lathyrus seeds, their root and sprout length (see table 2). Thus, at the concentration of lead nitrate in the aqueous solution of 5×10^{-3} mol/L, 5×10^{-5} mol/L and 5×10^{-6} mol/L, the germination of lathyrus seeds increased by 1%, 1%, and 2%, respectively, as compared to the control stage values. At the lead nitrate concentration of 5×10^{-4} mol/L in the aqueous solution, no difference between the experimental and control stage values was found. Analysing the lead nitrate exposure on the lathyrus seed root length, it should be highlighted that at 5×10^{-3} mol/L, 5×10^{-4} mol/L and 5×10^{-5} mol/L concentrations of the named toxicant in the aqueous solution, the lathyrus root length was found lower on the third day by 87%, 13.3% and 12.4%, respectively, as compared to the control stage values. At the lead nitrate concentration of 5×10^{-6} mol/L in the aqueous solution, no difference between the experimental and control stage values was found. The lathyrus root length on the seventh day at 5×10^{-3} mol/L, 5×10^{-4} mol/L, 5×10^{-5} mol/L and 5×10^{-6} mol/L lead nitrate concentrations in the aqueous solution, was lower by 27.1%, 13.2%, 20% and 10.0%, respectively, as compared to the control stage values.

There is also proved that on the seventh day of the experiment the lathyrus seed sprout length at the lead nitrate concentration of 5×10^{-3} mol/L, 5×10^{-4} mol/L, 5×10^{-5} mol/L and 5×10^{-6} mol/L in the aqueous solution, was lower by 1.5%, 3.4%, 4.2% and 1.0% as compared to the control stage value.

Thus, the results of the research show a particular impact of the lead nitrate on economically useful indicators of the helianthus and lathyrus growing. A clear tendency of the lead nitrate exposure on the helianthus and lathyrus seed germination and on their root and sprout length was revealed.

A particular decrease (at $P<0.99$) in the helianthus seed germination was revealed at the lead nitrate concentration of less than 5×10^{-3} mol/L in the aqueous solution.

As far as a particular decrease in the helianthus and lathyrus seeds root length at the lead nitrate concentration between 5×10^{-6} mol/L and 5×10^{-3} mol/L is concerned, i.e. in all experiments regarding the lead nitrate exposure on the length of helianthus seed sprout, it should be specified that a particular difference likely occurs at all experiment stages, except for the one where the concentration of the named toxicant amounted to 5×10^{-4} mol/L.

As far as the experiment on the lathyrus seed is concerned regarding the exposure of the lead nitrate on the sprout length, no particular difference was found.

As suggested by the results of the research, it was found that the germination of the helianthus and lathyrus seeds in the aqueous solution (distilled water) with the addition of the lead nitrate in the amount between 5×10^{-6} mol/L and 5×10^{-3} mol/L contributed to a slight increase in seed germination, a particular decrease in root length on the third and seventh day of experiment and the length of the sprout.

References

1. Demura TA. Comparison of cadmium and nickel complex influence on the root system growth of different by tolerance plants. *Sci Found Biotic Divers Conserv*. 2006; 7: 158–163. Available at: https://ecoinst.org.ua//b7-2006/fbs3.pdf (in Ukrainian)
2. Dovgalyuk A. Environmental contamination by toxic metals and its indication by plant test systems. *Studia Biologica*. 2013; 7 (1): 197–204. DOI: 10.30970/sbi.0701.269. (in Ukrainian)
3. Hlinka NL. *General Chemistry*. Leningrad, Chemistry, 1988: 702 p.
4. Parashchenko IV. Ecotoxicological evaluation of lead dangers in the components of agroecosystem. PhD thesis in 03.00.16 — ecology. Kyiv, Institute of Agroecology, Ukrainian Academy of Sciences, 2009: 204 p. (in Ukrainian)
5. Parashchenko IV. On the necessity of lead control. *Materials of the Scientific and Practical Conference "Ecolological problems of agricultural production"*, Kyiv, 2007: 94–95. (in Ukrainian)
6. Patsula OI, Vorobets NM. The reaction of *Helianthus annuus* L. on the action of lead with participation of glutathione peroxidase. *Sci Found Biotic Divers Conserv*. 2001; 3: 150–155. https://ecoinst.org.ua/b3-2001/fbs5.pdf (in Ukrainian)
7. Samokhvalova VL, Fateyev AU, Miroshnychenko MM. Heavy metals toxicity thresholds for agricultural crops. *Bull Agr Sci*. 2001; 11: 61–65. (in Ukrainian)
8. Zviahintsev DH, Kurakov AV, Umarov MM, Filip NS. Microbiological and biochemical indicators of lead contamination of the turf and podzolic soil. *Soil Sci*. 1997; 9: 1124–1131.

Вплив нітрату свинцю на схожість та ростові процеси насіння соняшнику та гороху

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Вивчено вплив іонів свинцю на схожість та ростові процеси насіння соняшнику та гороху за їх пророщування в лабораторних умовах. Виявлено певні тенденції щодо впливу різних доз іонів свинцю на схожість соняшнику і гороху та довжину кореня і паростка за пророщування насіння. Зокрема, вірогідне зниження ($P<0.99$) схожості насіння соняшнику спостерігали за впливу свинцю, концентрація якого складала 5×10^{-3} моль/л, тоді як за концентрації іонів свинцю від 5×10^{-6} моль/л до5×10^{-4} моль/л вірогідного впливу на схожість насіння соняшнику та гороху не спостерігали. Помітніший вплив іонів свинцю виявлено на довжину кореня соняшнику та гороху. Спостерігали вірогідне зниження довжини кореня соняшнику за концентрації іонів свинцю 5×10^{-3} моль/л, 5×10^{-4} моль/л, 5×10^{-5} моль/л та 5×10^{-6} моль/л ($P<0.999$, $P<0.999$, $P<0.99$ та $P<0.999$ відповідно). Різниця в довжині кореня гороху за концентрації іонів свинцю 5×10^{-3} моль/л, 5×10^{-4} моль/л, 5×10^{-5} моль/л та 5×10^{-6} моль/л виявилась вірогідною ($P<0.955$, $P<0.99$, $P<0.95$ та $P<0.99$ відповідно). Результати досліджень з вивчення впливу різних доз нітрату свинцю на середню довжину паростка соняшнику засвідчили вірогідну різницю ($P<0.999$) у цих показниках за концентрації іонів свинцю у розчині 5×10^{-3} моль/л, 5×10^{-5} моль/л та 5×10^{-6} моль/л. Вірогідної різниці між довжиною паростка гороху за впливу іонів свинцю від 5×10^{-6} моль/л до 5×10^{-3} моль/л не виявлено. Отже, за результатом проведених досліджень виявлено суттєвий вплив нітрату свинцю на господарсько корисні показники вирощування соняшнику та гороху. Встановлено певну тенденцію впливу нітрату свинцю на схожість насіння соняшнику і гороху та довжину кореня і паростка.

Ключові слова: іони свинцю, зерно соняшнику, зерно гороху, схожість, корені, паростки

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