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RESEARCH ARTICLE

Intensity of heavy metal accumulation in plants of *Silybum marianum* L. in conditions of field rotation

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Goal. Estimation of the influence of mineral fertilization of *Silybum marianum* L. on the intensity of accumulation of heavy metals in its leaf mass and seeds. Methods. field, laboratory atomic absorption method, mathematical and statistical processing. Results. Intensive absorption and accumulation of leaf mass and seeds of *Silybum marianum* L. lead, cadmium and zinc in quantities far exceeding the maximum permissible levels were questioned the possibility of its useproducts in the medical needs of the population and requires measures to reduce their accumulation in plants. In particular, the least accumulated is lead, cadmium and zinc in the leaf mass and the seeds of *Silybum marianum* L. in the absence of any fertilization of its crops. When applying fertilizers, the least amount of lead accumulates by the plants of *Silybum marianum* L. when using a mixture of ammonium nitrate, simple phosphate and potassium chloride. The greatest accumulation of lead by seeds is observed when fertilizing *Silybum marianum* L. with ammonium nitrate, and leaf mass – when fertilizing with potassium chloride. The least cadmium accumulates with the leaves of *Silybum marianum* L. for fertilization with superphosphate simple, and the seeds for fertilization with a mixture of fertilizers. Most absorb the leaf mass and seeds of *Silybum marianum* L. cadmium for fertilizing plants with ammonium nitrate. When fertilizer is applied, the least zinc accumulates in the seeds of the *Silybum marianum* L. when using a mixture of ammonium nitrate, simple phosphate and potassium chloride, and in the leaf mass – using potassium chloride. The highest accumulation of zinc by the seeds and leaf mass of the *Silybum marianum* L. was observed for the fertilization of its crops with ammonium nitrate.

Keywords: Heavy metals; Accumulation; Medicinal plant; Rotation

Introduction

Silybum marianum L. is a valuable medicinal plant. It is used for medicinal purposes as leaves and fetuses with seeds. In particular, the fetuses of *Silybum marianum* L. have an anti-hepatitis protection effect, help to improve the functioning of the liver, normalize digestion (Pourjabar et al., 2019, Parveen et al., 2010). *Silybum marianum* L. prophylactically protects intact hepatocytes and increases their resistance to infection and various poisons. This medicinal plant enhances the formation of bile and accelerates its excretion, thereby normalizing the processes of digestion and metabolism. The fetuses of *Silybum marianum* L. contain flavonoids and flavonoids (silibin, silicristin, silidianin, etc.), in addition, alkaloids, saponins, mucus, organic acids, vitamin K, bitterness, fatty oils, proteins and other proteins. Flavonoids are the main active substances of *Silybum marianum* L. (Jowkar et al., 2020, Kato et al, et al., 2020).

In addition to the proven medicinal properties of this plant for the prevention of human diseases, the use of *Silybum marianum* L. in other areas is increasing. *Silybum marianum* L. is used as a vegetable plant because its young leaves have nutritional value. It is also grown as a valuable summer honey plant capable of providing honey productivity at the level of 50-70 kg of honey per hectare (Dumludag et al., 2020, Ayati et al., 2020). The use of *Silybum marianum* L. as an unconventional forage crop is practiced (Ahmad et al., 2020, Dogaru et al., 2020).

The *Silybum marianum* L. is not demanding on soils and climatic conditions. In wild form it is known as weed; occurs on wastelands, along roads and on railway embankments (Ceribasi et al., 2020, Toth et al., 2020). *Silybum marianum* L. belongs to the early crops. Friendly seedlings of the plant appear on the 8th to 10th day after sowing at an average daily temperature of 10°C. It is suitable for growing loose slightly acidic sandy soils. Industrial cultivation of *Silybum marianum* L. in Ukraine for the procurement of medicinal raw materials is carried out in the Zhytomyr region, where favorable soil and weather conditions (Xia et al., 2020, Valkova et al., 2020).

The favorable soil and weather conditions of Zhytomyr region for the cultivation of *Silybum marianum* L. for medicinal purposes may be a certain limitation, since they are light in mechanical composition and poor in humus, nutrient macronutrients (N, P, K) acidic by nature such soils require significant fertilization of crops with mineral fertilizers, which significantly increases their productivity (Hunce et al., 2019, Saleemi et al., 2019). At the same time, migration of toxicants contained in mineral fertilizers, in particular heavy metals, is increasing on such soils (Ghanadi et al., 2019, El-Alam et al., 2018).

Increasingly, there are reports of the introduction of *Silybum marianum* L. into the modern rotation (Hammami et al., 2018, Dominguez et al., 2017). However, often the technology of growing it has not yet been studied, so traditional technologies are used that are adapted to regional conditions for the cultivation of spring early crops of a wide-row sowing method (Aziz et al., 2016, Rudnyk-Ivashchenko et al., 2015). Lead, cadmium and zinc are among the most dangerous heavy metals that can get into the raw materials of *Silybum marianum* L. with mineral fertilizers (Martinez-Fernandez et al., 2014).

In the body, lead enters the brain, liver, kidneys and bones (Ibrar et al., 2013). Subsequently, this substance accumulates in the teeth and bones. Younger children are especially vulnerable. At high levels of exposure, lead disrupts the functioning of the brain and central nervous system, causing coma, seizures and even death (Pradhan et al., 2006). Children who have survived severe lead poisoning may suffer from mental disorders (mental retardation) and behavioral disorders (Grippo et al., 2006).
Zinc is a trace element for plants that is needed for them in microquantities. It promotes the absorption of nitrogen from the soil, takes part in the enzymatic processes of the plant, promotes the formation of starch (Jordan et al., 2003). Zinc has a great influence on the redox processes in the plant organism, is involved in the synthesis of growth hormone (auxin), in the formation of chlorophyll, the elements of mineral nutrition, in the division of cells, the formation of mitochondria, accelerates the passage protein biosynthesis, a component of 40 respiratory enzymes, increases the content of ascorbic acid, dry matter, influences the nutrition, transport of substances, membrane permeability, accelerates growth and development, enhances the processes of reproductive organs, increases disease resistance, drought, heat, frost resistance in plants (Szentmihalyi et al., 1998).
Zinc promotes the absorption of copper, boron, regulates the exchange of phosphorus. However, over-nutrition of plants with zinc leads not only to changes in the structure of the leaf, but also to the toxicity of the plant (Del Rio-Celestino et al., 2002).
A limiting factor for the entry of heavy metals into the plant is a system of regulatory indicators – the maximum permissible concentration of toxicants in soil and plant (Hussain et al., 2005). However, due to the lack of study of this crop, control of the heavy metals content in the vegetative mass and the seeds of *Silybum marianum* L. is very rare (Brunetti et al., 2009). This requires an additional study of the intensity of lead, cadmium and zinc accumulation in the *Silybum marianum* L. plant with modern cultivation technologies that involve the use of a spectrum of mineral fertilizers (Perrino et al., 2014).
The risk of damage to the body by heavy metals increases with the use of medicinal herbs, when the body is weakened and unable to resist toxicants. Therefore, the control of the accumulation of lead, cadmium and zinc in the leaf mass and seeds of *Silybum marianum* L. is an urgent problem that needs to be addressed.

Materials and Methods

Field researches were conducted during 2018–2019 on gray podzolized medium loam soil within the farms of Vinnytsia region. *Silybum marianum* L. was sowed in the spring time with five fertilizer options: application of nitrogen mineral fertilizer ammonium nitrate at 60 kg/ha of active ingredient, application of phosphorus mineral fertilizer superphosphate simple in norm of 60 kg/ha of active substance, introduction of potassium mineral fertilizer potassium chloride in norm of 60 kg/ha of active substance, introduction of mixture of fertilizers: ammonium nitrate, superphosphate simple, potassium chloride in norm: N – 60 kg/ha, P – 60 kg/ha, K – 60 kg/ha; without the use of mineral fertilizers. In the fetus phase, they were collected together with a leaf mass for laboratory analysis of lead, cadmium and zinc content in seeds and leaves, using the atomic absorption method.
Laboratory analyzes were performed in a certified and accredited laboratory of the Vinnytsia Branch of the Institute of Soil Conservation. Based on the results of laboratory analysis of lead, cadmium and zinc in the leaf mass of *Silybum marianum* L., the coefficient of accumulation was calculated as the ratio of heavy metals in the plant to their mobile contents soil forms and hazard ratio, as the ratio of heavy metals in the plant to their MPC.
Mathematical processing of research results was carried out on the basis of statistical deviation of the average value of indicators from its extreme values.
The ethical standards of research are: no copyright claims on the results of research by persons other than the authors of this scientific work; the author's team used their own funds to conduct field and laboratory researches; at experimental work with medicinal plants has been adhered to biological standards.

Results and Discussion

The results of the researches revealed the accumulation of lead by leaf mass of thistle *Silybum marianum* L. in the application of mineral fertilizers in quantities significantly exceeding the maximum permissible concentration (MPC) of lead in the leaf mass of plants, whichis 5.0 mg/kg of dry matter.
In the version without fertilizers, the lead content in the leaf mass of *Silybum marianum* L. was 1.7 MPC, when using a mixture of fertilizers of ammonium nitrate, simple phosphate and potassium chloride – 2.1 MPC, ammonium nitrate – 2.4 MPC superphosphate of simple and potassium chloride – 2.5 MPC, which does not allow the leaf mass of *Silybum marianum* L. grown for fertilizer and without it under the specified soil conditions to use without special preparation for medical treatment needs of the population (Table 1).

Table 1. The intensity of lead accumulation in the leaf mass of *Silybum marianum* L., M ± m.

Researching material	Fertilizer variant	Lead concentration, mg/kg	MPC of lead, mg/kg	Lead accumulation coefficient	Lead-baking coefficient
Soil	-	26.00±0,13	6.0	-	0.34
Leaves	Ammonium Nitrate	12.05±0,05	5.0	4.63	2.41
	Potassium Chloride	12.70±0,07	5.0	4.88	2.40
	Superphosphate is Simple	12.40±0,06	5.0	4.76	2.48
	Ammonium Nitrate, Superphosphate Simple, Potassium Chloride	10.40±0,07	5.0	4.00	2.08
	No Fertilizer	8.40±0,09	5.0	3.20	1.68

The content of mobile lead forms in the soil where *Silybum marianum* L. was grown was 2.6 mg/kg. The rate of accumulation of lead by leaf mass of *Silybum marianum* L. on the variant without fertilizer was the lowest and was 3.2. When using a mixture of ammonium nitrate, superphosphate simple and potassium chloride, the accumulation factor was 4.0, when making ammonium nitrate – 4.63, superphosphate simple – 4.76, potassium chloride – 4.88. Such high rates of lead accumulation indicate intense absorption by the leaf mass of *Silybum marianum* L. from soil at much higher concentrations than the content of mobile lead forms in the soil. The highest lead hazard ratio in the leaf mass of *Silybum marianum* L. was set for the application of simple superphosphate – 2.48. when introducing ammonium nitrate, the hazard ratio of lead decreased to 2.41, when applying potassium chloride – to 2.40, and mixtures of fertilizers of ammonium nitrate, superphosphate simple and potassium chloride – to 2.08.

In particular, in the non-fertilizing embodiment, the lead content in the leaf mass was 8.40 mg/kg of dry matter. When used as a fertilizer, a mixture of ammonium nitrate, simple phosphate and potassium chloride lead content in the leaf mass of *Silybum marianum* L. increased by 19.2% and amounted to 10.40 mg/kg. Fertilization of sowing of *Silybum marianum* L. with ammonium nitrate causes an increase in the rate of lead accumulation in the leaf mass by 30.3%, up to 12.05 mg/kg of dry matter, the use of simple phosphate by 32.3% to the level of 12.40 mg/kg, and the use of potassium chloride – by 33.9% to 12.70 mg/kg.

Our reseaches also were founded a significant accumulation of lead in the seeds of *Silybum marianum* L. The maximum allowable concentration of lead in plant seeds is much lower than in leaf mass and is 0.5 mg/kg of dry matter. In the version without fertilizers, the lead content in the seeds of *Silybum marianum* L. was 6.6 MPC, with fertilizer with a mixture of ammonium nitrate, superphosphate simple and potassium chloride – 7.3 MPC, superphosphate simple – 7.9 MPC, potassium chloride – 8.0 MPC, ammonium nitrate – 8.6 MPC (Table 2).

The highest rate of lead accumulation by the seeds of *Silybum marianum* L. was set on the variant of ammonia nitrate application – 1.6. When using potassium chloride and superphosphate simple the accumulation factor is slightly reduced and is 1.5. The use of a mixture of fertilizers of ammonium nitrate, superphosphate simple and potassium chloride further reduces the accumulation factor to 1.4. In the non-fertilizer version, the lead accumulation rate of *Silybum marianum* L. was the lowest and was 1.3.

Table 2. Lead accumulation intensity in seeds of *Silybum marianum* L., M ± m.

Researching material	Fertilizer variant	Lead concentration, mg/kg	MPC of lead, mg/kg	Lead accumulation coefficient	Lead-baking coefficient
Soil	-	26.00±0.13	6.0	-	0.34
Seed	Ammonium Nitrate	4.30±0.06	0.5	1.6	8.60
	Potassium Chloride	4.00±0.04	0.5	1.5	8.00
	Superphosphate is Simple	3.95±0.05	0.5	1.5	7.90
	Ammonium Nitrate, Superphosphate Simple, Potassium Chloride	3.65±0.06	0.5	1.4	7.30
	no fertilizer	3.30±0.07	0.5	1.3	6.60

The lowest lead hazard in the *Silybum marianum* L. was found in the non-fertilizer version – 6.6. When introducing a mixture of ammonium nitrate, superphosphate simple and potassium chloride, the hazard ratio was 7.3, using superphosphate simple – 7.9, potassium chloride – 8.0, ammonium nitrate – 8.6.

The experimental data obtained regarding the lead content in the seeds of the *Silybum marianum* L. indicate that the levels are exceeded and that it is not possible under these conditions to use its seeds for medicinal purposes. In particular, the lowest lead content was found in the seeds of the *Silybum marianum* L. from the version without fertilizer application – 3.3 mg/kg of dry matter. The use of a mixture of ammonium nitrate, superphosphate simple and potassium chloride causes the lead content to increase in the solids content of *Silybum marianum* L. by 9.6% compared to the version without fertilizer – up to 3.65 mg/kg. Introduction of superphosphate simple promotes lead content increase by 16.5% to 3.95 mg/kg, potassium chloride – by 17.5% – to 4.00 mg/kg, ammonium nitrate – by 23.3% – to 4.3 mg/kg.

The cadmium accumulation coefficient in the vegetative mass of *Silybum marianum* L. was in the range from 10 to 24. The highest cadmium accumulation coefficient in the vegetative mass was when fed with its ammonium nitrate and the lowest in the non-fed version.

The cadmium accumulation coefficient in the vegetative mass of *Silybum marianum* L. was higher in mineral fertilizers compared to similar raw materials obtained without nutrition, in particular, in NPK fertilizers – 1.5 times, simple phosphate – 1.4 times, potassium chloride – 1.7 times, ammonium nitrate – 2.4 times.

The cadmium hazard ratio ranged from 1.0 to 2.4. The highest hazard ratio was found in the vegetative mass of *Silybum marianum* L. grown with mineral fertilizers, while the lowest – without mineral fertilization. In particular, in the vegetative mass of *Silybum marianum* L. grown without nutrition, the cadmium hazard ratio was lower, compared to similar feedstock obtained by NPK 1.5 times, and simple phosphate 1.4 timespotassium chloride – 1.7 times, ammonium nitrate – 2.4 times.

Different concentrations of cadmium in the vegetative mass of *Silybum marianum* L. were found depending on the type of mineral fertilizers. So, the cadmium concentration in the vegetative mass of *Silybum marianum* L. was 1.5 times higher than that of its NPK, 1.4 times that of simple phosphate, 1.7 times that of potassium chloride and 2,4 times – for nutrition with ammonium nitrate compared to similar raw materials grown without fertilizing with mineral fertilizers (Table 3).

Table 3. The intensity of cadmium accumulation in the leaf mass of *Silybum marianum* L., M ± m.

Researching material	Fertilizer variant	Cadmium concentration, mg/kg	MPC of cadmium, mg/kg	The cadmium accumulation coefficient	Cadmium-free heat coefficient
Soil	-	0.10±0.02	0.7	-	0.14
Leaves	Ammonium Nitrate	2.40±0.04	1.0	24.0	2.40
	Potassium Chloride	1.70±0.02	1.0	17.0	1.70
	Superphosphate is Simple	1.36±0.02	1.0	13.6	1.36
	Ammonium Nitrate, Superphosphate Simple, Potassium	1.50±0.03	1.0	1.5	1.50
	No Fertilizer	1.00±0.01	1.0	10.0	1.00

Analysis of the results obtained from researches examining the effect of mineral nutrition of *Silybum marianum* L. on the concentration of cadmium in seeds also showed some influence of potassium, nitrogen and phosphorus fertilizers on the level of accumulation of this element in the plant (Table 4).

Table 4. The intensity of cadmium accumulation in the seeds of *Silybum marianum* L., M ± m.

Researching material	Fertilizer variant	Cadmium concentration, mg/kg	MPC of cadmium, mg/kg	The cadmium accumulation coefficient	Cadmium-free heat factor
Soil	-	0.10±0.02	0.7	-	0.14
Seed	Ammonium Nitrate	0.60±0.02	0.1	6.0	6.00
	Potassium Chloride	0.52±0.01	0.1	5.2	5.20
	Superphosphate is Simple	0.53±0.02	0.1	5.3	5.30
	Ammonium Nitrate, Superphosphate Simple, Potassium Chloride	0.48±0.02	0.1	4.8	4.80
	No Fertilizer	0.40±0.01	0.1	4.0	4.00

In particular, the concentration of cadmium in the seeds of *Silybum marianum* L., which was grown without fertilizing with mineral fertilizers, was 4 times higher than the MPC, while it was 4.8 times higher with NPK fertilizers and 5.3 times with superphosphate, potassium chloride – 5.2 times, ammonium nitrate – 6 times. The highest levels of MPC were found in the seeds of the *Silybum marianum* L. by fertilizing it with nitrogen fertilizer.

The increase of cadmium accumulation factor and danger in *Silybum marianum* L. seeds for the use of mineral fertilizers in its cultivation was found. So, the cadmium accumulation and hazard coefficients in the seed of *Silybum marianum* L. were higher than their NPK fertilizer by 1.2 and 1.2 times, respectively; superphosphate simple – 1.3 and 1.3 times, potassium chloride – 1.3 and 1.3 times, with ammonium nitrate 1.5 and 1.5 times compared to similar raw materials obtained without mineral nutrition.

Analyzing the intensity of contamination of seeds of *Silybum marianum* L. cadmium, it is necessary to note a certain dependence of its concentration on the type of fertilizer. Thus, the concentration of cadmium in the seeds of *Silybum marianum* L. without fertilization with mineral fertilizers was 0.4 mg/kg, where as with the fertilizer NPK fertilizer, superphosphate simple, potassium chloride and ammonium nitrate was 1.2 times higher; 1.3; 1.3 and 1.5 times, respectively.

Therefore, feeding *Silybum marianum* L. with ammonium nitrate, potassium chloride, superphosphate simple and their mixture increases the cadmium concentration in the vegetative mass by 2.4 times; 1.7; 1.4 and 1.5 times and in seeds 1.5 times; 1.3; 1.3 and 1.2 times, respectively.

The results of researches revealed the accumulation of zinc by leaf mass of *Silybum marianum* L. in the application of mineral fertilizers, especially for the application of ammonium nitrate, in quantities significantly exceeding the maximum permissible concentration zinc in the leaf mass of plants, which is 10.0 mg/kg of dry matter.

On the variant without fertilizers, the zinc content in the leaf mass of *Silybum marianum* L. was 2.9 MPC, when using potassium chloride and superphosphate simple zinc content in the leaf mass increases to 3.4 MPC, a mixture of mineral fertilizers of ammonium nitrate, superphosphate of simple and potassium chloride – up to 5,0 MPC. The concentration of zinc in the leaf mass of *Silybum marianum* L. increased most significantly with the introduction of ammonium nitrate – 15.6 MPC (Table 5).

The content of mobile forms of zinc in the soil where *Silybum marianum* L. was grown was 10.0 mg/kg. The zinc accumulation factor of leaves of *Silybum marianum* L. on the variant without fertilizer was the lowest and was 2.9. When using superphosphate simple and potassium chloride, the zinc accumulation factor was 3.4, when making a mixture of ammonium nitrate, superphosphate simple and potassium chloride – 5.0, when using ammonium nitrate – 15.5. Such high zinc accumulation rates indicate intense absorption by the leaf mass of *Silybum marianum* L. zinc from soil as a trace element at much higher concentrations than the content of mobile forms of zinc in soil.

The highest zinc hazard coefficient in leaf mass of *Silybum marianum* L. was set on the application of ammonium nitrate – 15.6. When applying a mixture of fertilizers of ammonium nitrate, superphosphate simple and potassium chloride the hazard ratio of zinc decreased to 5.0, when introducing potassium chloride and superphosphate simple – to 3.4.

Table 5. The intensity of zinc accumulation in the leaf mass of *Silybum marianum* L., M ± m.

Researching material	Fertilizer variant	Zinc concentration, mg/kg	MPC of zinc, mg/kg	Zinc accumulation coefficient	Zinc - baking coefficient
Soil	-	10.0±0.9	23.0	-	0.4
Leaves	Ammonium Nitrate	156.1±5.6	10.0	15.5	15.6
	Potassium Chloride	33.7±1.7	10.0	3.4	3.4
	Superphosphate is Simple	34.2±1.5	10.0	3.4	3.4
	Ammonium Nitrate, Superphosphate Simple, Potassium Chloride	50.3±2.0	10.0	5.0	5.0
	No Fertilizer	28.8±1.3	10.0	2.9	2.9

The highest zinc hazard coefficient in leaf mass of *Silybum marianum* L. was set on the application of ammonium nitrate – 15.6. When applying a mixture of fertilizers of ammonium nitrate, superphosphate simple and potassium chloride the hazard ratio of zinc decreased to 5.0, when introducing potassium chloride and superphosphate simple – to 3.4.

On the variant without fertilization of sowing *Silybum marianum* L. zinc content in its leaf mass was 28.8 mg/kg of dry matter. When used as a potassium fertilizer, the zinc content increased by 14.5% and amounted to 33.7 mg/kg, the simple superphosphate increased by 15.8% and amounted to 34.2 mg/kg. A mixture of ammonium nitrate, simple phosphate and potassium chloride provides zinc in the leaf mass of *Silybum marianum* L. 50.3 mg/kg, which is 42.7% more than the variant without mineral fertilizers.

Fertilization of sowing of *Silybum marianum* L. with ammonium nitrate causes the most significant increase of zinc concentration in leaf mass – by 81,6%, to 156,1 mg/kg of dry matter.

Our researches also revealed a significant accumulation of zinc in the seeds of the *Silybum marianum* L. The maximum permissible concentration of zinc in plant seeds is much higher than in the leaf mass and is 50.0 mg/kg of dry matter. On the variant without fertilizers, the zinc content in the seeds of *Silybum marianum* L. is 1.6 MPC, with fertilizer with a mixture of ammonium nitrate, simple phosphate and potassium chloride – 1.9 MPC, simple superphosphate – 2.0 MPC, potassium chloride – 2.1 MPC, ammonium nitrate – 2.3 MPC (Table 6).

Table 6. Zinc accumulation intensity in seeds of *Silybum marianum* L., M ± m.

Researching material	Fertilizer variant	Zinc concentration, mg/kg	MPC of zinc, mg/kg	Zinc accumulation coefficient	Zinc - baking coefficient
Soil	-	10.0±0.9	23.0	-	0.4
Seed	Ammonium Nitrate	112.2±5.6	50.0	11.1	2.2
	Potassium Chloride	107.0±5.4	50.0	10.6	2.1
	Superphosphate Simple	99.0±4.5	50.0	9.8	2.0
	Ammonium Nitrate, Superphosphate Simple, Potassium Chloride	93.0±4.6	50.0	9.2	1.9
	no fertilizer	82.0±3.7	50.0	8.1	1.6

The highest rate of zinc accumulation by the seeds of *Silybum marianum* L. was set on the variant of ammonia nitrate application – 11.1. When using potassium chloride, the accumulation factor decreases to 10.6, and the superphosphate of simple – 9.8. The use of a mixture of fertilizers of ammonium nitrate, superphosphate simple and potassium chloride further reduces the accumulation factor to 9.2. In the no fertilizer version, the zinc accumulation rate of *Silybum marianum* L. was the lowest and was 8.1.
The lowest zinc hazard coefficient in the seeds of *Silybum marianum* L. was found in the no fertilizer version – 1.6. When introducing a mixture of ammonium nitrate, superphosphate simple and potassium chloride, the hazard ratio was 1.9, using superphosphate simple – 2.0, potassium chloride – 2.1, ammonium nitrate – 2.2.
The lowest zinc content was found in the seeds of *Silybum marianum* L. from the no fertilizer version – 82.0 mg/kg of dry matter. The use of a mixture of ammonium nitrate, superphosphate simple and potassium chloride causes the increase of zinc content in the seeds of *Silybum marianum* L. by 11.8% compared to the variant without fertilizer – up to 92.0 mg/kg. The introduction of superphosphate simple contributes to the increase of zinc content by 17.2% to 99.0 mg/kg, potassium chloride – by 23.4% – to 107.0 mg/kg, ammonium nitrate – by 26.9% – to 112.2 mg/kg.

Conclusion
The results of the researches revealed intense absorption and accumulation of lead, cadmium and zinc in the leaves, seeds of *Silybum marianum* L. in quantities significantly exceeding the maximum levels and questioning the possibility of using such products for the medical needs of the population and requires measures to reduce their accumulation in plants. In particular, the least accumulated is lead, cadmium and zinc in the leaf mass and the seeds *Silybum marianum* L. in the absence of any fertilization of its crops. When applying fertilizers, the least amount of lead accumulates by the plants of *Silybum marianum* L. when using a mixture of ammonium nitrate, phosphate simple and potassium chloride. The greatest accumulation of lead by seeds is observed when fertilizing *Silybum marianum* L. with ammonium nitrate, and leaf mass - when fertilizing with potassium chloride.
The least cadmium accumulates with the leaves of *Silybum marianum* L. for fertilization with superphosphate simple, and the seeds for fertilization with a mixture of fertilizers. Most absorb the leaf mass and seeds of *Silybum marianum* L. cadmium for fertilizing plants with ammonium nitrate.
When fertilizer is applied, the least zinc accumulates in the seeds of the *Silybum marianum* L. when using a mixture of ammonium nitrate, phosphate simple and potassium chloride, and in the leaf mass - using potassium chloride. The highest accumulation of zinc by the seeds and leaf mass of the *Silybum marianum* L. was observed for the fertilization of its crops with ammonium nitrate.

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