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THE INFLUENCE OF PERENNIAL LEGUMES ON SOIL CONDITION AND GRAIN QUALITY OF WINTER WHEAT

Abstract.
The accumulation of heavy metals in soils for the cultivation of major crops of crop rotation with intensive fertilization was calculated. The concentration of heavy metals in the soil before and after growing bean precursors was determined. The positive effect of growing perennial legumes on reducing the concentration of heavy metals in the soil and grain of winter wheat has been established. Four-year cultivation of perennial legumes in intensive agriculture has reduced the concentration of lead and cadmium in soils compared to cereals, which has improved the quality of winter wheat grain by reducing the concentration of lead and cadmium.

Keywords: *heavy metals, legumes, pollution, precursors, winter wheat.*

I. Introduction.

Intensification of agriculture involves a high level of chemicalization, in particular the use of mineral fertilizers, pesticides, herbicides to stimulate plant growth and other substances. Practice shows that from year to year the use of chemicals in crop production is growing.

One of the main reasons for the increase in the use of chemicals in crop production is the violation of crop rotations, reduction, and in some cases minimization of the use of organic matter, new intensive technologies for growing plants and more [1, 2].

Under such conditions, there is some contamination of agricultural land, as well as crop products with various toxicants, including heavy metals in some cases above acceptable levels.

Heavy metals have the property of moving along the trophic chain getting into plants above acceptable levels. They disrupt the vegetation processes by reducing their productivity, and accumulating in the grain increase the danger of this product [3, 4].

II. Literature review.

The use of grain products as raw materials for food increases the development of various diseases. In particular, it was found that even at low levels of lead in human blood there are serious metabolic disorders. Excessive intake of lead to the human body causes its toxic effects. Damage to the body by cadmium causes a decrease in protective functions and damage to bone tissue and kidneys, etc. [5, 6].

Therefore, under such conditions, to reduce the supply of heavy metals in food chains, there is a need to develop ways to improve the environmental safety of food raw materials, including cereals.

The objectives of the research were to develop measures to reduce the accumulation of heavy metals in agricultural soils in the conditions of modern crop rotation, limited by the number of cultivated crops and grains of winter wheat.

The purpose of the article is to study the influence of inclusion in crop rotation of different types of perennial legumes on the intensity of accumulation of heavy metals in the soil and grain of winter wheat in comparison with traditional predecessors of winter wheat.

III. Methodology

Field research was conducted during 2013-2017 on gray podzolic medium loam soils of the Research Farm "Agronomichne" of Vinnytsia National Agrarian University. We calculated the volumes of heavy metals with optimal rates of mineral fertilizers for the most common types of crops grown in crop rotation.

Four types of perennial legumes were sown: alfalfa, meadow clover, bird's-foot trefoil, sand sainfoin and oriental goat weed. After four years of use, winter wheat was sown. The control was the predecessors in the following sequence: winter wheat - sunflower - winter wheat - corn.

Laboratory studies of the content of mobile forms of heavy metals in the soil were conducted in the Vinnytsia branch of the State Center for Soil Fertility.

IV. Analysis and results.

Analysis of soil contamination with heavy metals during fertilization of major cereals (Table 1) showed that the amount of mineral fertilizers is from 257 kg / ha to 571 kg / ha for ammonium nitrate, from 175 to 225 kg / ha for double superphosphate and from 58 up to 75 kg / ha for potassium chloride.

According to the data on the use of mineral fertilizers in the cultivation of winter wheat, 1944 mg / ha of lead and 339 mg / ha of cadmium enter the soil.

Of these, with ammonium nitrate - 51.4% and 7.4%, respectively, with double superphosphate - 39.6% and 41.3% and with potassium chloride - 9.0% and 51.3%.

When growing corn per 1 ha with mineral fertilizers, 2357 mg of lead and 434 mg of cadmium are applied, of which 48.4% and 6.7% with ammonium nitrate, 42% and 41% with double superphosphate and potassium chloride. - 9.6% and 51.8%.

The cultivation of spring barley leads to the supply of mineral fertilizers to soils 1458 mg / ha of lead and 327 mg / ha of cadmium, of which with ammonium nitrate - respectively 35.2% and 4.0%, with double superphosphate - 52.8% and 42 , 8% and with potassium chloride - 12.0% and 53.2%.

Mineral fertilization of winter rape leads to the entry into the soil per 1 ha of 2223 mg of lead and 390 mg

of cadmium, of which with ammonium nitrate - respectively 51.4% and 7.4%, with double superphosphate - 39.6% and 41% and with potassium chloride - 9.0% and 51.5%.

With mineral fertilizers for growing sunflower in the soil per 1 ha gets 2073 mg of lead and 427 mg of cadmium, of which with ammonium nitrate - 41.4% and 5.2%, respectively, double superphosphate - 47.8% and 42.2 % and potassium chloride - 10.8% and 52.6%.

Table 1

Inflow of heavy metals into the soil during the cultivation of major crops in intensive agriculture

Cereals	Actual norms of mineral fertilizers application in physical weight, kg / ha			Content of heavy metals in mineral fertilizers, t / kg						Received heavy metals with mineral fertilizers, mg / ha						Total	
	Nitrogen (ammonium nitrate)	Phosphorus (superphosphate simple)	Potassium (potassium chlorine)	Nitrogen (ammonium nitrate)		Phosphorus (superphosphate simple)		Potassium (potassium chlorine)		Nitrogen (ammonium nitrate)		Phosphorus (superphosphate simple)		Potassium (potassium chlorine)			
				Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd
Winter wheat	500	175	58	2,0	0,05	4,4	0,8	3,0	3,0	1000	25	770	140	174	174	1944	339
Corn	571	225	75	2,0	0,05	4,4	0,8	3,0	3,0	1142	29	990	180	225	225	2357	434
Spring barley	257	175	58	2,0	0,05	4,4	0,8	3,0	3,0	514	13	770	140	174	174	1458	327
Winter rape	571	200	67	2,0	0,05	4,4	0,8	3,0	3,0	1142	29	880	160	201	201	2223	390
Sunflower	429	225	75	2,0	0,05	4,4	0,8	3,0	3,0	858	22	990	180	225	225	2073	427

The results of research to identify the effect of perennial legumes on the intensity of accumulation in the soils of heavy metals, which are shown in table. 2 indicate a positive effect of reducing pollution of agricultural land with lead and cadmium.

Thus, during the cultivation of cereals in the four-year crop rotation on the studied agricultural lands in the soils, the concentration of lead decreased by 7.7%, and cadmium, on the contrary, increased by 10.2%. Whereas in the cultivation of alfalfa, sand sainfoin, bird's-foot trefoil and eastern goat weed revealed a more noticeable decrease in lead and cadmium in the soil, in particular by 29.4%, 32%, respectively.

Table 2

Influence of legumes and cereals on the concentration of heavy metals in soils, mg / kg

Numbering of sites involved in the experiment	Concentration of heavy metals in soils at the beginning of research (2013)		Crops involved in crop rotation for 4 years	Concentration of heavy metals at the end of research (2017)	
	Pb	Cd		Pb	Cd
№1	5,2±0,22	0,49±0,06	wheat, sunflower, corn for silage	4,8±0,22	0,54±0,08
№2	5,1±0,21	0,06±0,08	alfalfa sowing	3,6±0,19	0,02±0,01
№3	5,3±0,23	0,066±0,09	sand sainfoin	1,5±0,08	0,01±0
№4	5,0±0,20	0,064±0,08	bird's-foot trefoil	3,4±0,08	0,02±0,01
№5	4,9±0,19	0,050±0,07	eastern goat weed	2,6±0,08	0,01±0

Compared to the soils of agricultural lands, which were used for four years for the cultivation of cereals, the concentration of lead and cadmium in the soil decreased by 1.33 times and 27 times for the cultivation of alfalfa, 32 and 54 times for the cultivation of sand sainfoin, by 32% and 3.2% for bird's-foot trefoil and 1.88 times for eastern goat weed.

Reduction of soil contamination by heavy metals due to four-year cultivation of perennial grasses has had some effect on the quality of grain products (Table 3).

Thus, the concentration of lead in the grain of winter wheat grown after perennial grasses, including alfalfa, sainfoin, bird's-foot trefoil and eastern goat weed was 2.1 times lower, 2.4 and 2.1 times lower than the predecessors of cereals.

The concentration of cadmium in the grain of winter wheat was 2.1 times lower than the predecessors of alfalfa, sand sainfoin 2.0 times, bird's-foot trefoil 1.7 times and eastern goat weed 1.4 times compared to the predecessors of cereals.

Table 3

The intensity of accumulation of heavy metals in the grain of winter wheat for perennial legumes and annual cereal precursors

Precursor	The duration of the precursor period in crop rotation	Heavy metals, mg / kg	
		Pb	Cd
Annual cereals: - winter wheat, - sunflower, - winter wheat, - corn	4	3,9±0,02	0,34±0,002
Perennial legumes: - alfalfa sowing	4	1,86±0,01	0,16±0,001
Sand sainfoin	4	1,58±0,02	0,17±0,001
Bird's-foot trefoil	4	2,23±0,02	0,20±0,002
Eastern goat weed	4	1,83±0,02	0,24±0,003

V. Conclusion and discussion.

In the conditions of intensive agriculture of Vinnytsia region for the use of mineral fertilizers lead and cadmium get into the soil respectively 1944 mg / ha and 339 mg / ha for growing winter wheat, 2357 mg / ha and 434 mg / ha for growing corn, 1458 mg / ha and 327 mg / ha for growing spring barley, 2223 mg / ha and 390 mg / ha for growing sunflower.

Four-year cultivation of perennial legumes in intensive agriculture reduced the concentration of lead in soils from 1.33 to 3.2 times and cadmium from 37 to 54 times compared to cereals, which helped improve the quality of winter wheat grain by reducing the concentration of lead from 1 , 7 to 2.4 times and cadmium from 1.4 times to 2.1 times.

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