UDC 631.95:628.516:615.849

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FEATURES OF REMOVAL OF 137CS BY GRAIN AND LEGUMINOUS CROPS IN CONDITIONS OF ZHITOMIR POLISSIA

The purpose. To find out features and character of removal of radioactive nuclides by grain and leguminous crops in Zhitomir Polissia for formation of economically effective and ecologically balanced systems of agrarian production in the region. **Methods.** Sampling and preparation of samples for measurements was carried out with the help of standard procedures. **Results.** Variability of correlation between potential ability of agricultural plants to accumulate radioactive nuclides and intensity of torrents of removal of radioactive nuclides with crops is revealed. Efficient fertilizer systems are selected for decrease of accumulation of radioactive nuclides by grain and leguminous crops. **Conclusions.** Radioecological situation in the low-purity agroecosystems of Ukrainian Polissia owing to termination of counter-measures varies extremely slowly and is completely determined by physical disintegration of radioactive nuclides 137Cs and raise of motility of 90Sr in the system «soil — plant». Therefore it is necessary to possess the full information on properties of soils and density of contamination with the purpose of optimum utilization of resources at conducting counter-measures that, in its turn, demands scientific accompaniment.

Key words: removal of radioactive nuclides with crops, rehabilitation of farm-production, Ukrainian Polissia, counter-measures.

Formulation of the problem.

In the region of Ukrainian Polesie, agricultural land contamination with radionuclides after the Chernobyl accident has radically changed the ecological situation and the conditions of activity of rural commodity producers. During the period of socioeconomic transformations that took place in agriculture in recent decades, the specialization of agrarian production has narrowed towards the field of plant growing and, accordingly, the branches of animal husbandry have decreased. As a result, the volumes of production and use of organic fertilizers have significantly

decreased, and the main chain of agro-ecosystems has been disturbed, which ensures their ecologically stable functioning.

On contaminated radionuclide territories, unauthorized, chaotic and uncontrolled use of land for growing crops is increasingly occurring, and the risk of receiving radioactive contaminated agricultural products remains rather high [1]. An important problem that requires a quick solution is the restoration of agricultural production on radioactive contaminated land, which involves the cultivation of crops with a low ability to accumulate radionuclides. Such crops are cereals and some legumes, provided they grow on grain. Therefore, it is objectively relevant to study the peculiarities of the transition of radionuclides to such plants in the distant after the Chernobyl accident.

The purpose of the work is to find out the peculiarities and nature of the removal of radionuclides by grain and leguminous crops in Zhytomyr Polissya with the aim of creating economically efficient and ecologically balanced agricultural production systems in the region.

Materials and methods of research. Analysis of the current level of contamination of products of agricultural enterprises and private farms of peasants in the remote period after the Chernobyl accident conducted by the research results obtained in long-term experiments on the experimental farm territory "Hrozynske" ISHP NAAS and in the floodplain. Uh near the village. Khristinivka Narodychi district, Zhytomyr region., And by summarizing radiological official information of the Ministry of Agricultural Policy and Food of Ukraine in Volyn, Zhytomyr, Rivne, Kyiv and Chernihiv regions. The influence of different options fertilization (№ 1 - no fertilizer, № 2 - $N_{60}P_{60}K_{60}$, № 4 - $N_{30}P_{60}K_{60} + N_{30}$ as feeding, № 8 - $N_{30}P_{60}K_{60} + N_{30}$ as feeding, № 11 - $N_{30}P_{90}K_{100} + N_{35}$ - in the phase of the output of the receiver + N_{35} - Pouring of grain) was carried out on sod-podzolic sandy soils with a density of ^{137}Cs contamination within the limits of 37-185 kBq/m^2. The intensity and accumulation of radionuclides ^{137}Cs and ^{90}Sr plants winter wheat, corn and soybeans were studied on sod-meadow soils lehkosuhlynkovyh 2nd zone of radioactive contamination.

Sampling and their preparation for measurements were carried out according to generally accepted methods [2]. The specific activity of ^{137}Cs in soils and products was determined by spectrometric method on the scintillation β-γ-spectrometer SBG-001 ACP.

To estimate the accumulation of radionuclides in the crop at different densities of soil contamination, the transfer factor (Tf) and accumulation factor (Af) of ^{137}Cs and ^{90}Sr from the soil in plants were used. The release of radionuclides with crop yields was determined by the calculated method for crop yields (t/ha) and the specific activity of radionuclide in products or in biomass (kBq/ha).

Research results.

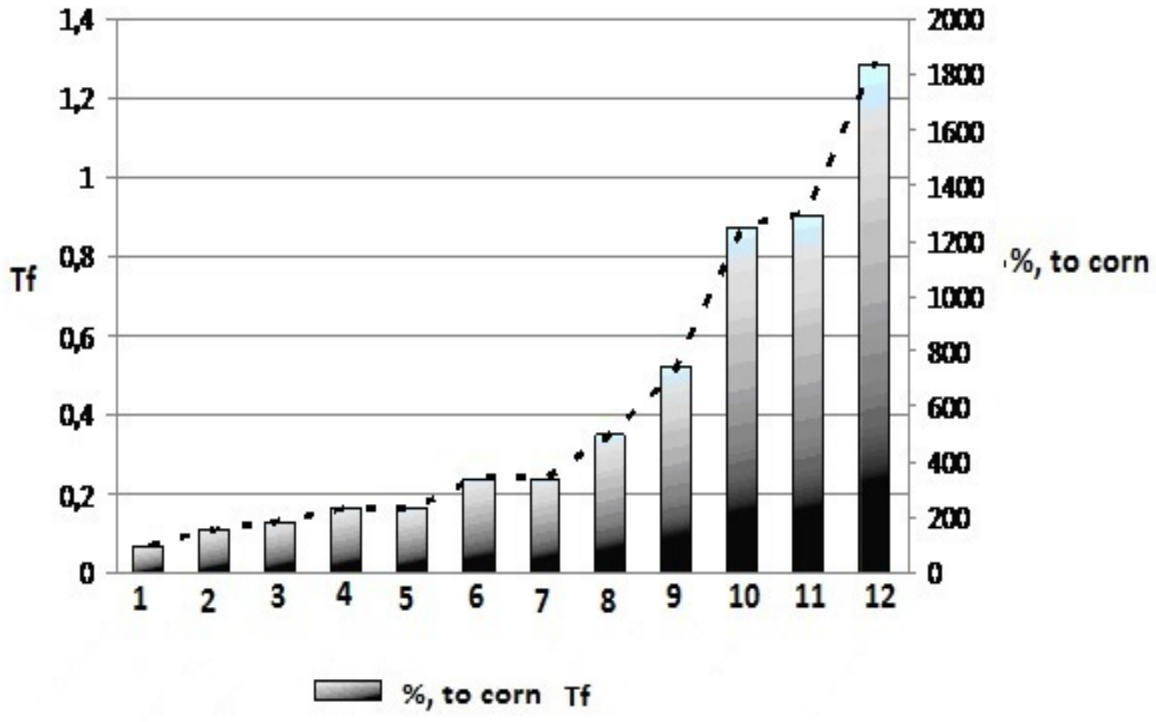
According to the data of the radiation survey, the area of agricultural land with a density of radioactive contamination of soil with radioisotopes of cesium more than 37 kBq/m^2 in Polissya is 1172 thousand hectares, of which 774.3 - arable land and 423.0 thousand hectares - hayfields and pastures. Agricultural lands with high levels of radioactive contamination on the area of 130.6 thousand hectares were withdrawn from economic use and now require rehabilitation [3].

In April 2017, it was 31 years after the Chernobyl disaster, which in the time dimension is equal to one half-life of the main dose-forming radionuclides ^{137}Cs and ^{90}Sr. Due to the processes of physical decay of radionuclides, their non-intrusive absorption in the soil, and also the agrochemical countermeasures that were carried out during the first ten years after the accident, the specific activity of ^{137}Cs in the upper layers of soil in agrocenoses decreased almost twice as compared with the feathers, and therefore the radiation situation in the contaminated territories has changed for the best.

However, due to the cessation of countermeasures, the level of soil contamination by agroecosystems is changing very slowly and is completely determined by the physical decay of ^{137}Cs radionuclides and the increase in the mobility of ^{90}Sr in the soil-plant system. There is every reason to assert that the state of radioactive contamination of land for a long time will be determined almost exclusively by the processes of soil self-rehabilitation [1, 3, 4].

When cultivating crops on soddy-podzolic soils of the Polissya of Ukraine contaminated with Chernobyl accidental discharges, the minimum Tf ^{137}Cs was found in corn grain, and the maximum in the corn of lupine yellow. The multiplicity of differences in percentages of corn grain at the same time reaches up to 20 times (Pic. 1) [8, 9].

It should be noted that among the studied crops the least accumulated ^{137}Cs of grain cereal crops. The transition of radionuclide to grain of winter rye exceeded that for maize grain 3.5 times, and for oat grain the excess was almost 5 times higher. But the maximum accumulation of ^{137}Cs is characteristic of grain and legume crops. Among the representatives of the group of grain and legume crops, the minimum content of radionuclide was in the grain of beans. Soybeans and peas are almost 2 times higher than the grain group. Specific activity of ^{137}Cs in grain of lupine yellow exceeded the maximum indicator for grain crops by almost 4 times.



Pic. 1. Accumulation of ^{137}Cs from grain and leguminous crops from sod-podzolic soils of Polissya Ukraine: 1 - corn, 2 - winter wheat, 3 - barley, 4 - triticale, 5 - wheat yar, 6 - millet, 7 - rye, 8 - oats, 9 - beans, 10 - soybeans, 11 - peas, 12 - lupine yellow.

Assessment of the impact of fertilizer on the degree of radioactive contamination of agricultural products held in areas with ^{137}Cs contamination 233-320 kBq m^2, ^{90}Sr - 5 kBq/m^2 and specific activity ^{137}Cs in the soil of 1351 ± 317 Bq/kg and ^{90}Sr from 48.6 ± 10,0 Bq/kg, respectively. According to the data (Tab. 1), while making corn seeding complete mineral fertilizer at a dose of 1 ha $N_{60}P_{60}K_{90}$ Tf ^{90}Sr in grain was higher in the order, and Tf - 35 times than the corresponding coefficients ^{137}Cs. The specific activity of ^{137}Cs in corn vegetative mass varies within 87-132 Bq/kg, that does not exceed the permissible levels of pollution and can be used for animal feed without restrictions. In corn specific activity of ^{137}Cs and ^{90}Sr respectively 51.0 and 19.9 Bq/kg, that corresponds to the upper limit of acceptable contamination level for food grains.

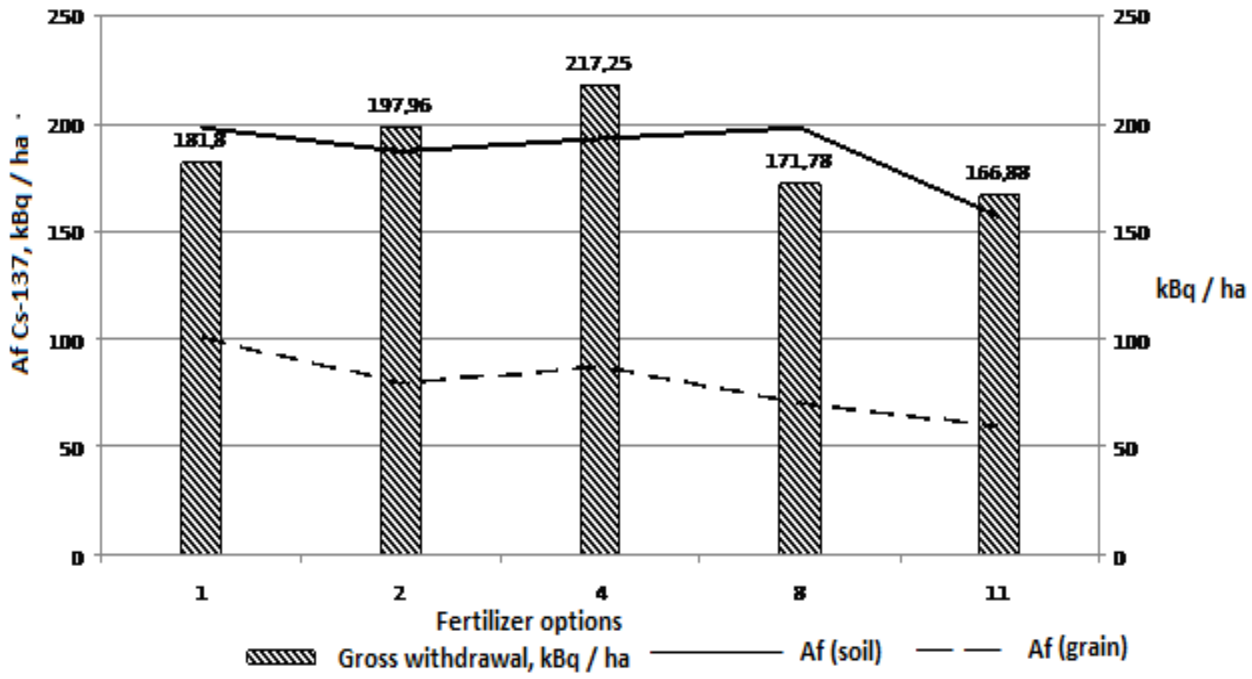
Table 1

Contamination of corn and soybeans ^{137}Cs and ^{90}Sr, Bq/kg

Types of samples	^{137}Cs	^{90}Sr	^{137}Cs		^{90}Sr	
			Tf	Af	Tf	Af
Corn						
Stem (without leaves)	87,0±22,0	–	0,27	0,06	–	–
Leaf	132,0±33,0	–	0,41	0,10	–	–
Rods of cobblestones (Without grain)	89,0±22,0	–	0,28	0,06	–	–
Wrapping sheets Cabins	108,0±27,0	–	0,34	0,08	–	–
Grain	51,0±13,0	19,9±4,0	0,16	0,04	4,10	0,41
Wheat						
Straw	12	7	0,05	0,003	1,4	0,07
Grain	427	25	1,85	0,19	5,4	0,26
Soy						
Grain	1300	15,3	0,96	0,23	2.10	0,21
Leaf	227,0	276,0	0,17	0,40	3,79	0,38
Stem	169	59,5	0,13	0,03	8,16	0,81
Roots	270	76,0	0,20	0,05	10,43	1,04
Streams	638	90,4	0,47	0,11	12,40	1,24

Accumulation of ^{137}Cs radionuclides in soybeans (pollution density ^{137}Cs 1348,7 kBq/m^2, ^{90}Sr – 7,29 kBq/m^2, specific soil activity – 5680,0 ± 911,0 Bq/kg and 73,1 ± 15,3 Bq/Kg respectively) was 6 times higher (Tab. 1) than in maize grain, and contamination of soybeans by radionuclides ^{90}Sr was almost 2 orders of magnitude lower than ^{137}Cs. Vegetative weight of soybeans - stems and pods have 1.9 and 5.9 times higher contamination by ^{137}Cs radionuclides compared with corn.

Also, according to the results of studies (Pic. 2), the most effective effect of good was noted in experiment No. 8 - ($N_{30}P_{60}K_{60}$ + N_{30} as nutrition). It should be emphasized that in this variant of fertilization, the correlation coefficients between the level of soil contamination and the gross evolution of radionuclide by oat grain are somewhat different: for the dependence of the total removal of ^{137}Cs with the yield from the level of soil pollution - 0,39, and for the dependence of grain pollution on the level of soil contamination - 0.72.



Pic. 2. Effect of fertilizer systems on the accumulation and removal of ^{137}Cs with oat (grain) yield

That is, in addition to the potential ability of agricultural plants to accumulate radionuclides, the intensity of the radionuclide streams with the yield is significant, which determines the collective dose of radiation. In the remote period after the

Chernobyl disaster, it is logical and expedient to take into account not only measures aimed at reducing the individual effective dose of exposure to the population through the production of guaranteed radioecologically safe food products, but also the collective dose for certain groups of the population.

Therefore, countermeasures should be spent on cultivating such crops that would least accumulate radionuclides from the soil. The obtained results make it possible to conclude that the most effective and expedient measure to reduce the input of radionuclides into plant products is the use of complete mineral fertilizers with high doses of potassium.

CONCLUSIONS

The radioecological situation that has developed today in the contaminated agroecosystems of the Ukrainian Polissya as a result of the cessation of comprehensive countermeasures is changing very slowly and completely determined by the physical decay of ^{137}Cs radionuclides and the increase in the mobility of ^{90}Sr in the soil-plant system.

By highlighting the radiation-ecological problems of rehabilitation of agricultural production in affected areas, one should pay attention not only to the potential of agricultural plants to accumulate radionuclides, but also to the intensity of radionuclide streams with crop. It is this indicator that determines the collective radiation dose of inhabitants of radioactive contaminated territories.

The potential ability of crops to accumulate ^{137}Cs and ^{90}Sr and the intensity of their crop yields are not always positively correlated with each other. Therefore, the need for countermeasures is not in doubt. Since the funds for their holding by the state are not allocated now, it is necessary to have as much information as possible about the properties of soils and the density of surface pollution in order to optimize the use of resources during countermeasures, which in turn requires scientific support.

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