Features of the main elements of organic farming in agro-landscapes contaminated with ^{137}CS (on the example of the Chernobyl accident)

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Abstract. It is shown that the use of mineral fertilizers in areas contaminated with radioactive cesium has a radio-ecological specificity, caused by the need to obtain the guaranteed normatively safe agricultural product. The radiological effectiveness of mineral fertilizers is differentiated depending on the belonging of plants to different biological species. In conditions of sod-podzolic soils of Polissya it is much higher than on chernozems.

1 Introduction

In the conditions of modern national economy, anthropogenic and technogenic pollution of the environment [15, 17] and methods of its neutralization [14, 16, 18] are of great importance.

Among all types of contamination, accidental radioactive contamination is the most urgent and extreme one.

One of the characteristic features of the remote period of radiation situation development after radionuclide contamination of the environment due to nuclear and radiation accidents and incidents is that the main way of radionuclide inclusion into food chains is its root intake from soil into plants [1, 2], and internal irradiation prevails in the structure of total population exposure dose - with food products produced on radioactively contaminated territories [1, 3]. It was established that at the same density of contamination the accumulation of radionuclides in plants in the so called "critical soils" characterized by abnormally high transfer coefficients can differ in tens and hundreds of times [4, 5, 6]. Thus, the development of a set of measures aimed at obtaining guaranteed radiation safe products necessarily takes into account the soil-agrochemical features of the contaminated territory [7], and the study of soil-agrochemical aspects of the criticality of radioactively contaminated agricultural landscapes remains an important and relevant task in the distant period of radiation situation development after localization of nuclear and radiation accidents and incidents.

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2 Materials and methods of research

Study of soil and agrochemical aspects of radionuclide contaminated agrolandscapes criticality in the long-term period of radiation situation development was conducted in full-scale conditions of resettlement zone after Chernobyl catastrophe and zone of residence with the right of resettlement. Soil ^{137}Cs contamination density is from 5 to 40 Ci/km^2.

Specific activity of ^{137}Cs as the main dose-forming radionuclide was determined by spectrometric method on gamma-spectrometric equipment with semiconductor detectors GEM-30185, Ge (Li), GMX series "EG & G ORTEC") with multichannel analyzer ADCAM - 300. Sampling and their preparation for the analysis was carried out according to the generally accepted methods taking into account specifics of research work in the field of agricultural radiology [8].

To estimate radionuclide accumulation in the crop we used the transfer coefficient (CT) of radiocaesium from soil to plants - radionuclide content in a plant by soil contamination density equal to one (Bq/kg air-dry weight of plants)/ (kBq/m^{2}soil).

3 Results and their discussion

It is known that radiation-ecological approaches to determination of soil criticality degree in the distant period after the Chernobyl catastrophe are largely determined by its type and potential fertility [9. 10, 11].

Analysis of soil structure of agricultural lands subjected to the highest radionuclide contamination (Fig. 1) showed that most of them are represented by radiation-critical peat-bog and sod-podzolic soils of different texture (70%) and by grey forest and chernozem soils (30%).

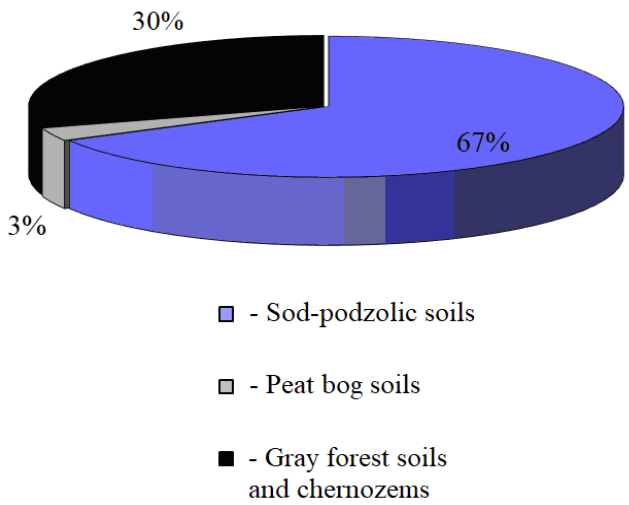

Fig. 1. Soil cover structure of the area most affected by the Chernobyl accident.

Potential fertility indicators of peat-bog and sod-podzol soils are lower in comparison with chernozems, so the use of mineral fertilizers has always been considered as one of the most effective factors of intensification of crop production, getting consistently high yields of crops, formation of its quality indicators. Their role does not change in conditions of radioactive soil contamination. But in this case it has also a well-defined radiation-

ecological specificity conditioned by the necessity of obtaining normatively safe agricultural products.

The analysis and generalization of long-term data (Fig. 2) showed that intensity of ^{137}Cs accumulation in a crop of all crops studied in experiment (winter rye and wheat, potatoes and oats) to a large extent is determined by separate application of nitrogen and potassium fertilizers as well as by their combinations.

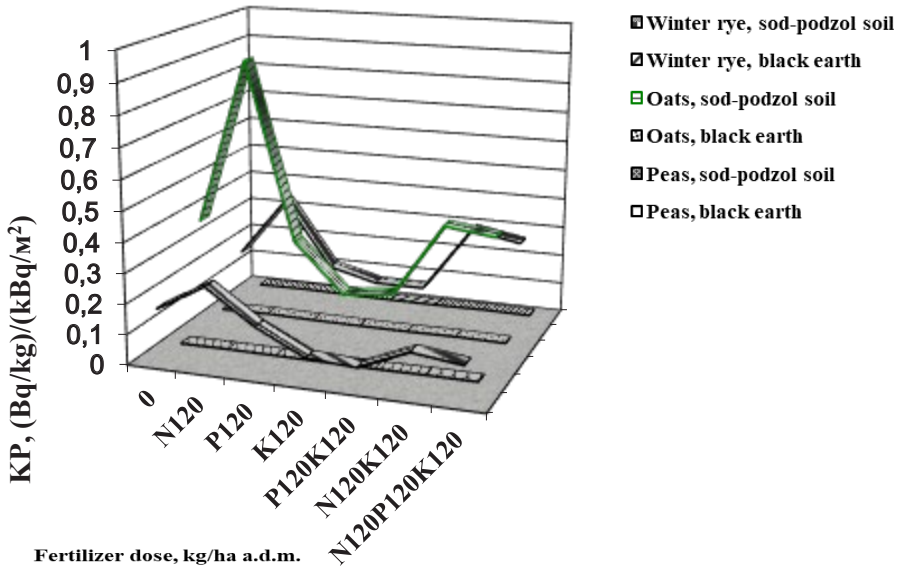

Fig. 2. Effect of mineral fertilizers on the intensity of ^{137}Cs accumulation in crop yield on sod-podzolic soil and chernozem.

Thus, at the application of nitrogen only at the dose of 120 kg/ha a.d.m. there was an increase of ^{137}Cs content in all crops without exception. At one-sided application of phosphorus fertilizers (120 kg/ha a.d.m.) in potato tubers, oat grain and lupine there was a tendency to decrease the radionuclide content (up to 17%).

At the same time, the application of potassium fertilizers both alone and in combination with phosphorus fertilizers ($K_{120}$and P_{120} K_{120}) caused a significant (up to 3 times) decrease in ^{137}Cs content in crop yield. The influence of nitrogen fertilizers together with potassium ($N_{120}K_{120}$), as well as full mineral fertilizer (N_{120} P_{120} K_{120}) manifested differently. So in tubers of potato, grain of peas and lupine also decrease in the content of^{137} Cs almost in 1,5 times was observed. At the same time, at their application to oats the radionuclide content in the grain increased by 15 and 19% respectively and in winter wheat by 42 and 58%. In our opinion, the differences in radionuclide accumulation are explained by biological peculiarities of the crops studied in the experiment.

Somewhat different influence of different kinds of mineral fertilizers on Cs accumulation^{137} in the crop yield took place in the conditions of chernozem with characteristic for the soil high fertility indices. In this case a significant increase of radionuclide content took place only in winter wheat grain at the unilateral application of ammonium nitrate at the dose of 120 kg/ha a.d. The unilateral application of superphosphate (P_{120}), as well as the application of total mineral fertilizer ($N_{120}P_{120}K_{120}$), did not influence significantly the intensity of ^{137}Cs transfer from soil to plants. However, it should be noted that both at unilateral application of potassium salt (K_{120}) and at its

application together with superphosphate ($P_{120}K_{120}$) the tendency to reduction of radionuclide accumulation parameters in the crop of all crops studied in the experiment was observed.

Thus, the efficiency of mineral fertilizers as a means of reducing the radiation-ecological criticality of agrolandscapes contaminated after the Chernobyl catastrophe in the conditions of sod-podzolic soils of Polissya and chernozem of Lesostepi is different. So, ^{137}Cs accumulation in the yield of potato tubers in the control variant without introducing mineral fertilizers in the conditions of soddy-podzolic soil was 20 times higher than in chernozem, in oat grain - 18 times and in pea grain - 32 times, respectively.

In addition, it should be noted that the main difference in the accumulation of ^{137}Cs in potato tubers under the influence of various types of mineral fertilizers on soddy-podzolic soils was 3.9 times, and when growing a crop on chernozem - only 1.1 times, in oat grain - 5 times. , 1 and 1.2 times and peas 2 and 1.3 times, respectively.

Thus, the ecologo-radiological estimation of potassium fertilizers efficiency in the complex of measures aimed at reducing the criticality of Cs-contaminated ^{137}agrolandscapes remains topical also in the remote period of radiation situation development after localization of nuclear and radiation accidents and incidents. At the same time the intensity of radionuclide transfer into plants in different soil and climatic conditions depended on the potassium dose, and differentiated depending on biological features of agricultural crops which were studied in the experiment (Fig.3).

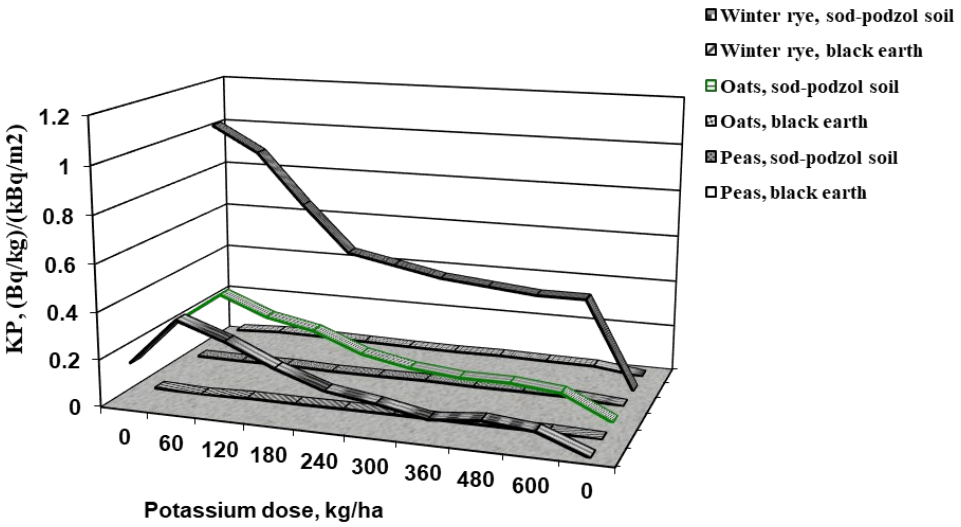

Fig. 3. Doses of potassium fertilizers and ^{137}Cs accumulation in crop yield on chernozem and sod-podzolic soil.

The presented research results show that the minimum level of ^{137}Cs accumulation was observed in the yield of winter cereal grains and the maximum - in pea grains. The increase of potassium fertilizer dose significantly reduced the radionuclide content in the crop of all crops without exception. At the same time, on chernozem the transfer coefficients of ^{137}Cs into the crop were much lower. So depending on the dose of potassium fertilizer, the differences in ^{137}Cs accumulation in winter rye grain on soddy-podzolic soils of Polissya were in the range 0.08-0,38 (Bq/kg) / (kBq/m^2), then on chernozem 0,001 - 0,008 (Bq/kg) / (kBq/m^2), oats 0,10 - 0,38 and 0,016 - 0,026 (Bq/kg) / (kBq/m^2), peas 0,38 - 1, 03 and 0,026 - 0,042 (Bq/kg) / (kBq/m^2), respectively.

Radiological efficiency of potassium fertilizer was much less on chernozem. If on sod-podzolic soil ^{137}Cs content in grain yield in variant with application of maximum dose of

potassium (K_{600}) decreased in comparison with control without fertilization almost in 2,5-3 times, on chernozem in 1,2 - 1,6 times, respectively.

Different efficiency of potassium fertilizers in relation to radiocaesium, in our opinion, is caused by different ratio in soils of radionuclide concentration and its non-isotope carrier - potassium at the same density of soil contamination. When potassium is applied, the gross content of ^{137}Cs in the soil does not change. Only the caesium/exchange potassium ratio changes, i.e. the rated level of soil contamination by potassium decreases. Thus, radiological efficiency of potassium fertilizer application is largely determined by the initial content of exchangeable potassium in the soil.

Decrease in radiological efficiency of potassium at increasing the dose of potassium fertilizer is caused by the fact that potassium fertilizer can also actively transfer from the exchangeable form to the non-exchangeable one. Thus, in experiments using ^{40}K [12, 13**]**, it was shown that plants absorb up to 40% of potassium from the fertilizer applied. About 50% of its amount passes into low-mobile forms. At the same time the amount of its fixation increased with increasing the dose of potassium fertilizer and depended on the type of soil and its granulometric composition.

4 Conclusions

Soil-agrochemical aspects of agrolandscapes criticality in the distant period of radiation situation development after radiation accidents consist in decrease of radionuclides migration intensity in the soil-plant system. Under the conditions of radionuclide contamination of soil, the application of mineral fertilizers is one of the main measures aimed at reducing the criticality of agrolandscapes and obtaining guaranteed radiation-safe agricultural products. The efficiency of mineral fertilizers in the system of anti-radiation measures on sod-podzolic soils of Polissya is much higher in comparison with chernozems of Lesostepi.

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