

Effect of plant growth regulators on accumulation of radiocaesium in potato tubers

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Article info

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An important place among the problems of modern agriculture is occupied by the problems of rational use and protection of land and the ecologically dangerous state of the environment. The Zhytomyr region is one of the most affected by the accident at the Chernobyl nuclear power plant. A significant part of agricultural land has a density of contamination with cesium-137 up to 5 Ki/km², which is 75 % of all contaminated land in the districts, about 20 % of agricultural land has a density of contamination from 5 to 15 Ki/km², 5 % – above 15 Ki/km². On lands with a higher density of pollution, it is necessary to apply a complex of agrochemical, agrotechnical and organizational measures to reduce the transfer of radionuclides from the soil to plants. Solving problems related to farming in radioactively contaminated territories occupies one of the leading places in the complex of measures to mitigate the consequences of the Chernobyl accident. The purpose of the research was to establish the effect of different doses and types of plant growth regulators on the productivity of potatoes, the level of radioactive contamination in the agro-ecological conditions of Polissia. Our research was carried out in the agro-ecological conditions of Polissia LLC. Councilors of Ovrutsky district of Zhytomyr region. The transition of the radioactive isotope cesium-137 from the soil to the plants depends on the content of exchangeable potassium in the soil, the saturation of the soil-absorbing complex with bases, the reaction of the soil solution, the bonification of the soil, and the content of humus. When the agrochemical parameters of the soil improved, in particular when the content of exchangeable potassium in the soil increased from 2.3 mg/100 g of soil to 14.8 mg/100 g of soil, the specific activity of radiocaesium in plants decreased by 3.4 times. The results of our research show that the foliar treatment of potato plants with Biosil and Poteitin contributed to a decrease in the specific activity of tubers from 29.2 to 6.4–2.1 Bq/kg. It was established that foliar spraying of potato plants with Biosil and Poteitin contributed to the reduction of the coefficient of ¹³⁷Cs transition to 0.03 and 0.01.

Keywords: ¹³⁷Cs, pollution, radionuclide, potato tubers, growth stimulants.

Вплив використання регуляторів росту на накопичення радіоцезію бульбами картоплі

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Важливе місце серед проблем сучасного землеробства займають проблеми раціонального використання і охорони земель та екологічно небезпечний стан навколишнього середовища. Житомирська область – одна з найбільш постраждалих внаслідок аварії на Чорнобильській АЕС. Значна частина сільськогосподарських угідь має щільність забруднення цезієм-137 до 5 Ки/км², що складає 75 % всіх забруднених угідь районів, біля 20 % сільськогосподарських угідь мають щільність забруднення від 5 до 15 Ки/км², 5 % – вище 15 Ки/км². На землях з більшою щільністю забруднення необхідно застосовувати комплекс агрохімічних, агротехнічних і організаційних заходів для зменшення переходу радіонуклідів із ґрунту в рослини. Вирішення проблем, пов'язаних з веденням сільського господарства на радіоактивно забруднених територіях, займає одне із провідних місць у комплексі заходів з послаблення наслідків Чорнобильської аварії. Метою досліджень було встановити вплив різних доз і видів регуляторів росту рослин на продуктивність картоплі, рівень радіоактивного забруднення в агроекологічних умовах Полісся. Наші дослідження були проведені в агроекологічних умовах ТОВ ВП «Полісся» с. Радичі Овруцького району Житомирської області. Перехід радіоактивного ізотопу цезію-137 із ґрунту в рослини залежить від вмісту в ґрунті обмінного калію, насиченості ґрунтового-поглинального комплексу основами, реакції ґрунтового розчину, бонітації ґрунту та вмісту гумусу. При покращенні агрохімічних показників ґрунту, зокрема при збільшенні вмісту обмінного калію в ґрунті з 2,3 мг/100 г ґрунту до 14,8 мг/100 г ґрунту, питома активність радіоцезію в рослинах зменшилась у 3,4 рази. Результати наших досліджень свідчать, що позакоренева обробка рослин картоплі препаратами Біосил і Потейтин сприяла зниженню питомої активності бульб з 29,2 до 6,4–2,1 Бк/кг. Встановлено, що позакоренева обприскування рослин картоплі Біосилом і Потейтином сприяло кратності зниження коефіцієнта переходу ¹³⁷Cs до 0,03 і 0,01.

Ключові слова: ¹³⁷Cs, забруднення, радіонуклід, бульби картоплі, регулятори росту.

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Introduction

Natural caesium is represented by one stable isotope Cs-133. Its content in the earth's crust is $3.7 \cdot 10^{-4}\%$. The fission products include two caesium radioisotopes: Cs-137 and Cs-134. They are among the biologically mobile in agricultural chains. The release of a pair of radionuclides Cs-134 and Cs-137, which have the same atomic number, into the environment usually occurs in a certain proportion, so the level of pollution is characterized by the density of the long-lived Cs-137 [1, 5, 8–10].

Cs-137 is one of the main dose forming radionuclides among fission products. The half-life of Cs-137 is about 30 years; it is a β - and γ -emitter with maximum β -radiation energy. Greater mobility of Cs-137 is determined by the fact that it is a radioisotope of the alkaline element, a chemical analogue of the biologically important element potassium (K), which is a chemical carrier of Cs-137 in natural systems.

The soil cover is not always the primary layer into which radionuclides enter. However, as a rule, radionuclides settle quickly on the soil cover, which has a large absorption capacity of radionuclides [2, 7, 11–14].

The fact that the soil sorbs radionuclides has a double meaning for their migration in agriculture. On the one hand, their fixation in the upper soil layers ensures the existence of a long-acting source of radionuclides in nature; and plant roots accumulate them. On the other hand, the strong sorption of radionuclides by the solid phase of the soil limits their assimilation through the root system of plants. Thus, the accumulation of radionuclides, namely Cs-137, by plants from the soil determines the input scale of the inclusion of radionuclides in food chains. Linked to this is the significance of the soil-plant link in the overall cycle of radionuclide circulation in agricultural production [3, 6, 15–18].

Just like for most radionuclides, the absorption of caesium by soil is determined by the processes of its distribution between the two main phases – solid and liquid and is carried out mainly through the processes of sorption-desorption, coagulation-peptization of colloids and precipitation-dissolution of sparingly soluble compounds.

Radionuclides are usually found in soils in ultramicro-concentrations: at a content of $3.7 \cdot 10^{10}$ Bq/km² mass concentration of caesium-137 in the arable soil layer is $3.9 \cdot 10^{-12}\%$ [1, 4, 20].

The purpose of the study

The purpose of the study was to establish the effectiveness of different doses and types of plant growth regulators on potato productivity, as well as the level of radioactive contamination in agri-environmental conditions.

To achieve this purpose, the following tasks were to be solved: to determine the features of the effect of plant growth regulators on the specific activity of potato tubers, the transition coefficient and the multiplicity of its reduction.

Materials and methods

We conducted the study of the effect of plant growth stimulators on the accumulation of radiocaesium in potato

tubers in agri-environmental conditions of LLC Industrial Company Polissya in village Radchytsi of Ovruch raion of Zhytomyr oblast.

The experiment was conducted on sod-podzolic and sandy-loam soil, which is characterized by the following agrichemical parameters:

humus – 1.4 %,
PH (KCl) – 5.9,
P₂O₅ – 90 mg/kg of soil,
K₂O – 100 mg/kg of soil.

In order to study the migration of radiocaesium within the soil-plant system using different types of plant growth regulators, the experiments were conducted according to the following scheme:

Scheme of the experiment:

1. Control;
2. Treatment of plants with the plant growth regulator Biosyl, 15 ml/ha;
3. Treatment of plants with the plant growth regulator Poteitin, 15 ml/ha.

Fertilizers investigated according to the scheme of the experiment were applied under spring plowing at a dose of 40 t/ha of manure+N₉₀P₈₀K₉₀.

The Luhovska variety of potato was used in the experiment. This variety has been bred at the Institute of Potato Farming of Ukrainian Academy of Agricultural Science.

Exchangeable and total caesium was determined in the soil on an AK-01C gamma spectrometer. The exchangeable form of radiocaesium was determined by the method of soil extraction using the extracting agent 1n KCl.

Results and discussion

One of the criteria which determine whether the pure products in organic farming are produced is a more extensive use of the biological potential of plants. Given this, one of the effective ways to use the reserves of the plant organism is to use a method of regulating its unctons with the help of plant growth regulators, in this case Biosyl and Poteitin.

When these preparations were applied, there were no harmful consequences for both potato plants and the environment. Even the technology of production of this preparation is environmentally friendly, as can be seen from its characteristics.

Biosyl is an improved analogue of plant growth regulator Agrostymulin. It is a complex plant growth regulator of natural origin, synthetic analogues of phytohormones and micronutrients. It is a transparent colorless water-alcohol solution [2].

Scientifically substantiated use of these preparations in the technology of potato cultivation will make it possible to spend almost all types of resources, including plant protection agents and mineral fertilizers, more efficiently and economically and to reduce the use of agricultural technology and, accordingly, decrease energy costs.

The use of these preparations if also energy efficient, because pesticides and fungicides are used less and the technology chains (spraying, poisoning, etc.) are shortened.

Due to the action of factors under investigation, it was possible to increase the yield of potatoes and reduce the use of mineral fertilizers to some extent. Currently, it is relevant not only from an economic point of view, but also due to the reduction of anthropogenic pressure on the environment.

The results of our study show that foliar treatment of

potato plants with Biosyl and Poteitin helped to reduce the specific activity of tubers from 29.2 to 6.4–2.1 Bq/kg (Fig. 1). The best option was Poteitin, which reduced the specific activity of tubers to 2.1 Bq/kg; the option with Biosyl was slightly inferior and showed the result amounting to 6.4 Bq/kg.

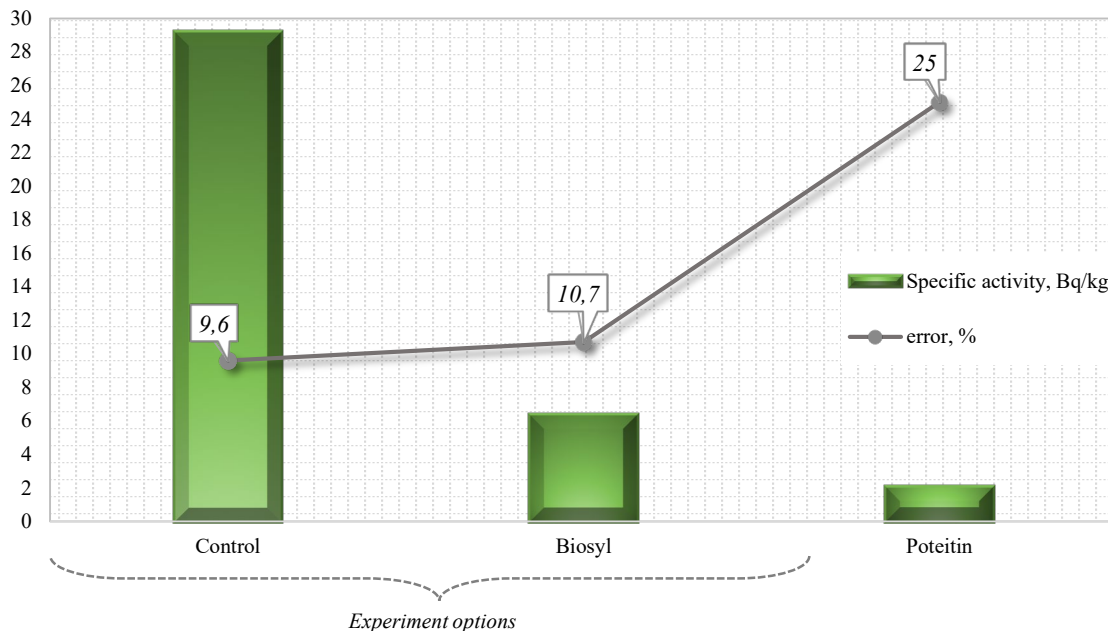


Fig. 1. Effect of types and doses of plant growth stimulators on the specific activity of potato tubers

It is known that the transition coefficient of Cs-137 makes it possible to more accurately forecast the migration of the radionuclide in the soil-plant system. Therefore, in our experiments, we calculated this figure depending on the doses and types of fertilizers according to the following formula:

$$TC = \frac{\text{Plant activity рослин, Bq/kg}}{\text{Soil contamination density, kBq/m}^2}$$

Based on Fig. 2, the transition coefficient in potatoes without the use of plant growth regulators was 0.15 on soils with a contamination density 200 kBq/m².

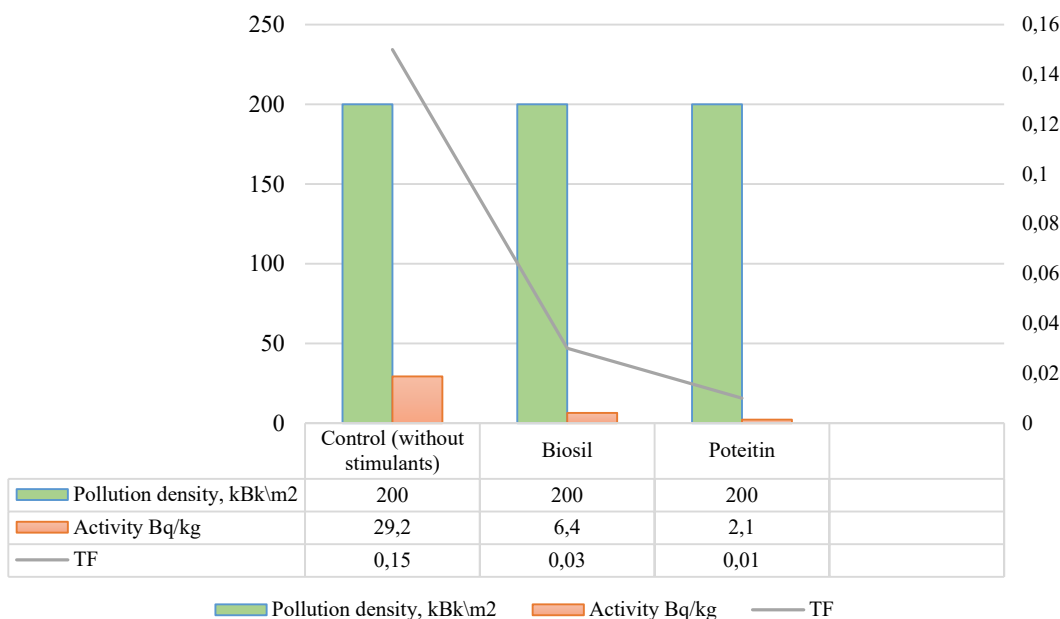


Fig. 2. Dependence of transition coefficients of Cs-137 on the types and doses of plant growth regulators

When Biosyl was used, the transition coefficient was 0.03, while the use of Poteitin contributed to an even more significant reduction in the transition coefficient of Cs – 137.

It should be noted that V. Kuhar and O. Lyashenko [21] in their research substantiated the concept of non-distribution of radionuclides from contaminated land and developed a number of technologies for its implementation based on long-term studies of the transformation of ¹³⁷Cs and ⁹⁰Sr in the soil–plant–water system, carried out in laboratory and natural conditions (the Chernobyl nuclear power plant exclusion zone). It was determined that relatively simple methods (including the use of plant growth regulators) can limit the spread of ¹³⁷Cs and ⁹⁰Sr from radionuclide-contaminated lands by 2–10 times and significantly improve the radiation situation on these lands [21].

The team of authors [22], based on the results of their own research, claimed that growth stimulators have a significant radiophotovoltaic effect, the CP of radiocesium in potato tubers decreased by 23–35 % compared to the control.

A. S. Malinovskyi [9] claimed that the use of growth regulators contributes not only to increasing the yield and improving the quality indicators of tubers, but also reduces the accumulation of radionuclides. Foliar treatment of potatoes with sodium humate, emistim C, agrostimulin, and poteitin reduced the coefficient of ¹³⁷-cesium transition from soil to tubers to 32 % over two years of research.

Conclusions

The transition of the radioactive isotope caesium-137 from soil to plants depends on the content of exchangeable potassium in the soil, the saturation of the soil-absorbing complex with bases, the reaction of the soil solution, soil grading and the humus content. When soil agrochemical parameters were improved, in particular when the exchangeable potassium content in soils increased from 2.3 mg/100 g of soil to 14.8 mg/100 g of soil, the specific activity of radiocaesium in plants reduced to 3.4 times.

It has been found that foliar spraying of potato plants with Biosyl and Poteitin contributed to the multiplicity of reduction of the transition coefficient of ¹³⁷Cs.

Conflict of interest

The authors declare no conflict of interest.

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