SCREENING OF VARIETY COLLECTIONS OF SUNFLOWER AND WINTER WHEAT FOR CADMIUM LOW ACCUMULATION

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Cadmium pollution in soil is a long-term and urgent problem, which directly affects the edible value of sunflower and winter wheat and may cause harm to human health. Breeding new varieties with low cadmium accumulation can effectively reduce the content of this element in seeds and fundamentally solve the risk of cadmium entering the human body through seeds and oil. In this paper, the method and significance of breeding sunflower and winter wheat with low cadmium accumulation were discussed.

**Keywords:** collection, samples, sunflower, winter wheat, Cd accumulation, breeding

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**Introduction.** Cadmium (Cd) is a heavy metal widely known to be the most toxic in nature, and is listed as the primary heavy metal pollution source by the US Environmental Protection Agency (EPA). As an essential element for plants and animals, cadmium (Cd) naturally exists in the soil during the development of the parent material of soil, and usually does not harm the soil ecological environment [1, 2, 3, 4]. With the continuous development of industry, agriculture and human activities, soil cadmium pollution may become more and more serious. The problem of soil Cd pollution caused by the unreasonable use of pesticides and fertilizers is increasingly serious. Crops absorb cadmium from the soil and accumulate in plants, affecting the yield or quality of crops, and further enter into the human’s body through the food chains, affecting human health [5, 6, 7]. This has become a very serious environmental problem.

In order to prevent the accumulation of heavy metals in the soil, many countries in the world have formulated limit standards of heavy metals in some fertilizers. The EU countries do not have uniform heavy metal limits in chemical fertilizers, and they manage the fertilizers by their own laws and regulations [9]. It is of great significance to study the mechanism of Cd tolerance of crops and select breeding of low Cd materials.

At present, various crops such as rice, maize, wheat, and cotton have been studied for their Cd tolerance mechanism and low-Cd material screening [10, 11, 12]. Compared with other cereals, wheat mainly accumulates Cd through the root system, and migrates to the above-ground part, and finally accumulates in the wheat grain [13]. It was reported that Cd is more toxic to wheat than other toxic metals. Cd toxicity reduces the absorption and transport of essential elements in wheat. The root growth and morphology of wheat is seriously affected, resulting in the decrease of plant growth, biomass and grain yield [13].

Previous studies have shown that phosphate fertilizers often contain high amounts of heavy metals such as Cd, and long-term application of phosphate fertilizers will inevitably lead to excessive Cd content in soil. But for conditions of Ukraine with average dose of phosphorus fertilizers 60 kg in the soil it is introduced annually 30–35 g/hectare of cadmium. This is the factor that determines a rather high average concentration of Cd in the arable lands of Ukraine – about 0.15 mg/kg of soil.

Sunflower and winter wheat are of important economic crops in Ukraine. According to EU standards, sunflower cadmium accumulation should not be more than 0.05 mg/kg. However, Cd can be accumulated to a relatively high level with no disadvantage to its ontogenesis [14].

The problem must be confronted with reducing Cd-contaminated to be solved urgently. The fact that genetic variability exists with a species in the tendency to accumulate Cd provides an opportunity to utilize plant breeding to select for genetically low-Cd concentration.

Breeding of new sunflower and winter wheat varieties with low cadmium accumulation genotypes that can grow under different soil environmental conditions is a very effective solution. Although the breeding of new varieties resistant to cadmium is the fundamental method to solve the problem of low cadmium intake, the breeding process is long and complicated. The breeding process probably includes: 1) finding materials with low cadmium genes; 2) finding materials with high yield capacity, wide adaptability and other high quality materials besides low cadmium characteristics [15].
It is a practical and feasible way to select new varieties with low accumulation of Cd to reduce the absorption and accumulation of Cd in crops and thus reduce the content of Cd in agricultural products.

Aim of research: to study collection of winter wheat and sunflower and carried out the screening of samples with low cadmium accumulation.

Materials and methods. The research was carried out on the basis of educational research and production complex of Sumy National Agrarian University, located in the northeastern part of Forest-Steppe of Ukraine.

Plant sample collection includes 104 genotypes of sunflower (varieties, lines, hybrids) and 42 varieties of winter wheat. In greenhouse they were grown in plastic pots (for sunflower – 2 liter, for wheat – 1 liter) filled with special substrate. Mixture soil content was: peat-substrate (80 %) and sand (20 %), source of Cd – CdSO₄, added to the substrate by spraying. Concentration of Cd in the substrate was 0.88 mg/kg. In order to improve contact seeds coat with Cd we will add another part of Cd during sowing (with watering the pots). Finishing concentration of Cd in substrate was 1 mg/kg. Cd content in root and shoot (winter wheat) and in stem and leaves (sunflower) was determined at stages of shooting (wheat) and flowering (sunflower). Subsamples were dried and then Cd concentration in them were determined by a spectrometer (CAS-120).

Results and discussion. The variety collection of 104 sunflower samples was formed. The largest part was the group of samples from Ukraine, the Russian Federation, the USA, Cuba, Bulgaria, Kazakhstan, Moldova provided by the National Centres of Genetic Resources. The collection were supplemented by samples provided by the Institute of Oil Crops, the Institute of Agriculture of North-East of Ukraine and Sumy National Agrarian University.

It was established that the final phase of growth of vegetative mass of sunflower plants (more than 90 %) from the final values of the index (termination of vegetation) in the conditions of vegetation experiment was the beginning of flowering phase. The range of plant mass indices in the experiment ranged from 1.3 to 2.9 g/plant. The duration of the period of "seedlings-flowering" varied from 55 to 73 days. The values range of the cadmium content indicator in the above-ground part varied from 0.66 to 2.62 mg/kg. The average content of cadmium in the above-ground part of the plants was 1.42.

Within the collection, 4 groups with different level of cadmium accumulation in the above-ground part of plants were identified: "low" (less than 0.99 mg/kg); "middle" (1.0 – 1.5 mg/kg); "satisfactory " (1.6 – 2.0 mg/kg); "high" (greater than 2.1 mg/kg). Frequency of each groups in the collection was 14.5; 44.2; 32.7 and 8.7 % respectively.

An additional parameter characterizing the overall ability of genotypes to absorb heavy metals (phyto-ameliorative selection direction) was the proportion of cadmium absorbed by the plants from the substrate. The average for this high-resistance group was 0.34 %, groups with good, satisfactory and low resistance respectively 0.49; 0.6 and 0.83 %.

The variety collection of winter wheat, which included 41 varieties, was formed on the basis of crop regional distribution and its yield in the demonstration grounds. The collection includes varieties: 17 – (originator -Selection-Genetic Institute – National Center for Seed Research and Variety Studies), 6 – (originator - Institute of Crop Science named after Yuriev), 5 – Bila Tserkva experimental- breeding station, 5 – Institute of Agriculture, 5 – Institute of Irrigated Agriculture, 2 – Myronivskyi Institute of Wheat named after Remeslo, 2 - Ivanivska experimental breeding station. The working collection was analyzed for the ability of plants to accumulate cadmium under the conditions of an analyzing background. The range of values of the cadmium content in plants varied from 0.94 to 2.02 mg/kg, with an average of 1.42 mg/kg for the experiment. The average values of the cadmium content depending on the origin of the varieties were: 1.42; 1.47; 1.27; 1.58; 1.16 and 1.24 mg/kg, respectively (tabl.1).

| Variety | Cd content, mg/kg |
|---------|------------------|
| Alliance | 1.41 + 0.16 |
| Rozkisha | 1.4 + 0.02 |
| Pryvtna | 1.61 + 0.13 |
| Vidrada | 1.34 + 0.08 |
| Zdobna | 1.47 + 0.06 |
| Pryvabyla | 1.64 + 0.12 |

| Institute of Crop Science named after Yuriev |
|------------------|
| Kraevy | 1.61 + 0.03 |
| Rusyava | 1.66 + 0.05 |
| Oysyna | 1.29 + 0.03 |
| Zaotar | 1.57 + 0.15 |
| Polisanka | 1.51 + 0.07 |

| Institute of Irrigated Agriculture |
|------------------|
| Rosinka | 1.57 + 0.10 |
| Konka | 1.54 + 0.02 |
| Ovidiy | 1.11 + 0.09 |
| Maria | 1.21 + 0.08 |

| Selection-Genetic Institute – National Center for Seed Research and Variety Studies |
|------------------|
| Kantata odeska | 1.83 + 0.04 |
| Conata odeska | 1.53 + 0.02 |
| Duma odeska | 2.02 + 0.07 |
| Liga odeska | 1.29 + 0.02 |
| Oxtava odeska | 0.91 + 0.01 |
| Optima odeska | 1.43 + 0.01 |
| Rodzinka odeska | 1.4 + 0.04 |
| Melody odeska | 0.95 + 0.10 |
| Pylypivka odeska | 1.43 + 0.02 |
| Hurt | 1.5 + 0.11 |
| Rozkivit | 1.68 + 0.02 |
| Sich | 1.76 + 0.11 |
| Kvala | 1.42 + 0.01 |
| Slaven | 1.05 + 0.01 |
| Klad | 1.59 + 0.09 |
| Krugozir | 1.62 + 0.03 |
The largest variation in cadmium content was observed in varieties of Selection-Genetic Institute. This group included three (among four) varieties with a minimum cadmium content (<1.00 mg/kg), namely the Kubok – 0.96; Melody odeska – 0.95 and Octava odeska – 0.95 mg/kg. However, in this group there were varieties with maximum cadmium accumulation rates (> 1.75 mg/kg): the Duma odeska – 2.02; Cantata odeska – 1.83 and Sich – 1.76 mg/kg.

Among the varieties of other establishments, the low rate of cadmium content with the minimum level of error was characterized by the Svitanok mironivsky – 0.94 + 0.01 mg/kg. The general distribution of frequencies of the working collection of winter wheat varieties in terms of cadmium content is presented in Fig. 1.

**Fig. 1.** Frequency distribution of the working collection of winter wheat varieties according to the indicator of cadmium content under conditions of anilizing background, 2019

Conclusions. As a result of the screening, the range of cadmium content in the samples of winter and sunflower varieties was determined which enables the formation of working collections and the introduction of breeding programs for varietal provision of technologies for obtaining environmentally safe products and phytomeliorative technologies.

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Кадмій (Cd) – важливий метал, який є одним з найбільш поширених природних елементів. З розвитком промисловості та сільського господарства збільшення грунту кадмієм, спричиненого необґрунтованим використанням пестицидів та поживних добавок, стає все більш загрозливим. Рослини поглинають кадмій з грунту і накаплюють у своїх тканинах, що впливає на їдальну цінність продукції. В подальшому кадмій надходить в організм людини через харчування, впливаючи на стан здоров’я.

Соняшник та озима пшениця є важливыми культурними культурами в Україні. Забруднення кадмієм збільшує небезпеку для здоров’я населення, оскільки цей елемент може накопичуватися в організмі людини через харчування. Відповідно до стандартів ЄС, накопичення кадмію в насінні соняшнику не должно превышать 0,05 мг/кг. Однак Cd може накаплюватися до відносно високого рівня. Проблема, пов’язана з забрудненням сільськогосподарської продукції, має терміновий характер, оскільки збільшення вмісту кадмію може нанести шкоду здоров’ю людини. Відповідно до стандартів ЄС, накопичення кадмію в насінні соняшнику не должно превышать 0,05 мг/кг. Однак Cd може накаплюватися до відносно високого рівня. Проблема, пов’язана з забрудненням сільськогосподарської продукції, має терміновий характер, оскільки збільшення вмісту Cd у сільськогосподарській продукції може нанести шкоду здоров’ю людини.

Це приспівкує до необхідності розв’язання проблеми з низькою акумуляцією кадмію низькою акумуляцією кадмію. Отримання насіння з низькою акумуляцією кадмію може ефективно використовуватися для розведення сортів, що мають низьку здатність до акумуляції цього елементу.

1. Ключові слова: колекція, зразки, соняшник, озима пшениця, накопичення кадмію, селекція

2. Ключові слова: колекція, зразки, соняшник, озима пшениця, накопичення кадмію, селекція

3. Ключові слова: колекція, зразки, соняшник, озима пшениця, накопичення кадмію, селекція
методи селекції рослин для отбору форм і образців, імуючих генетично обумовлену співвідношність до низької аккумуляції цього елемента.

Получение новых сортов подсолнечника и озимой пшеницы с генотипами, имеющими низкую способность к накоплению кадмия и произрастанию в различных условиях, является очень эффективным путем решения. Выведение новых сортов, устойчивых к аккумуляции кадмия, является основным путем решения – долгим и сложным. Процесс селекции, вероятно, включает: 1) поиск исходного материала с содержанием генов, отвечающих за низкую аккумуляцию кадмия; 2) поиск исходного материала с высокой урожайностью, необходимыми технологическими качествами и другими характеристиками, за исключением способности к низкой аккумуляции кадмия.

Этот практичный способ создания новых сортов с низким накоплением Cd для уменьшения поглощения и накопления этого металла в культурах обеспечит снижение содержания элемента в сельскохозяйственной продукции. Создание новых сортов с низкой аккумуляцией кадмия может эффективно снизить содержание этого элемента в семенах и принципиально решить риск попадания кадмия в организм человека через семена и масло.

В этой работе рассмотрены способ и значение создания исходного материала подсолнечника и озимой пшеницы с низким накоплением кадмия.

Ключевые слова: коллекция, образцы, подсолнечник, озимая пшеница, накопление кадмия, селекция.

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