

R E V I E W of the official opponent for PhD thesis of **YUANZHI FU** “**Selection of sunflower for resistance to cadmium accumulation**” submitted for a for a Doctor Philosophy Degree (PhD). Field of study: 20 – Agricultural sciences and food. Specialty: 201 – Agronomy

Relevance and justification of the research topic. Sunflower is one of the main oil crops in the world with a cultivated area of about 30 million hectares. The complex of biological characteristics and peculiarities of the physiological processes of the formation of the fruits of the *Helianthus annuus L.* characterizes the species as an accumulator of certain heavy metals, primarily cadmium. A steady tendency to increase the concentration of heavy metals in arable lands will lead to the beginning of the processes of cadmium migration along the trophic chain, which will subsequently accumulate in the sunflower seeds. The creation of a theoretical basis and the development of practical directions for the sunflower breeding for resistance to the accumulation of certain toxic elements is one of the important directions to solve the quality problem of basic food products. Thus, the problem set for study in the dissertation is relevant now, as well as in the near and distant perspectives.

Connection of the research with scientific programs, plans, and topics. The researches of Yuanzhi FU were carried out according to the thematic plans and within the framework of the state scientific topics of the Sumy National Agrarian University for 2019–2023: «Creating the source material of cereals and oilseeds resistant to the accumulation of heavy metals» (state registration number 0119U101581) and the scientific topic of the Institute of Agriculture of the North-East of Ukraine "Development of a genotype model and creation of source material of sunflower resistant to cadmium accumulation" (state registration number 0121U108674, 2021-2023).

Scientific novelty of the obtained results. For the first time, the author developed and tested a method of indirect assessment of selected sunflower samples for resistance to cadmium accumulation. The methodology is based on conducting a vegetation experiment

with an analyzing background of cadmium concentration of 1.0 mg/kg, (cadmium source – cadmium monosulfate), plant vegetation up to the R5 phase.

A working sunflower collection was formed with a range of cadmium content in the above-ground part of plants (background 1.0 mg/kg) - 0.5-2.6 mg/kg, in seeds (background 0.21 mg/kg) - 0.23 - 0.43 mg/kg. Samples with a high level of differentiation in terms of resistance to cadmium accumulation were selected.

It was established that the predominant type of inheritance of the trait of resistance to cadmium accumulation is depression and partial negative dominance. The total value of these types was: when crossing genotypes with a low content of cadmium - 62%, when crossing genotypes with a high content of cadmium and between group crossing - 85.7 and 66.7%, respectively.

Based on the results of the analysis of JB231AC 62\3 samples, it was established that the level of resistance to cadmium accumulation is determined by the difference in the activity of MDA (malondialdehyde), SOD (superoxide dismutase) and POD (peroxidase), as well as the ability of genotypes to remove toxic substances, reactive oxygen species (ROS) from cells.

One NRAMP (natural macrophage resistance-associated protein) gene was identified that was up-regulated and expressed at a higher level in genotypes with low levels of resistance to cadmium accumulation.

The practical significance of the obtained results. Sunflower raw material with a controlled level of cadmium accumulation with an estimated productivity of 0.94-1.48 t of oil/ha was created. The working collection of intervarietal hybrids of sunflower was transferred to the Institute of Agriculture of the Northeast of the National Academy of Sciences of Ukraine for the continuation of breeding work. The materials of the articles and annual reports were used in the training programs of disciplines in the specialty "Agronomy" at the Sumy NAU.

Reliability and approbation of research results. Field research was carried out in accordance with current methods, taking into account the soil and weather characteristics of the research area. Laboratory experiments were conducted in certified laboratories using modern analytical equipment. Primary digital material was mathematically processed. The

conclusions made in the work are based on the results of statistically reliable dependencies.

Based on the results of the dissertation work, the author published 11 scientific works, including 3 publications in professional journals of Ukraine, 1 publication in a scientific publication included in the Scopus database, 7 abstracts of reports at scientific conferences.

According to Clause 8 of the CMU Resolution No. 44 of January 12, 2022, the estimated number of publications in which the results of the dissertation work are highlighted is 4.5. The content of articles and theses and the chronology of their publication correspond to the declared stages of work on the dissertation.

The structure and content of the work. The dissertation has a traditional structure for natural science research. There are 5 separate Chapters that reveal the study level of problem, the research methodology, and the results of field and laboratory experiments. The conclusions drawn correspond to the tasks, the progress of research and intermediate results are highlighted in the relevant chapters. The material presented in the appendices illustrates the intermediate results of individual experiments.

Chapter 3 is thoroughly presented, with a high level of breeding content, which highlights the progress and results of screening sunflower breeding samples for resistance to cadmium accumulation. This section also presents the results of intervarietal crossings and gives a generalized characteristic of the resulting hybrids.

Chapter 4, which is devoted to the study of physiological and transcriptomic mechanisms of accumulation and control of Cd in certain parts of sunflower plants, is rich in information with a detailed scheme of conducting experiments. Research was conducted on selection samples 62\3 and JB231AC with high and low cadmium content, respectively.

The presentation of the material of Chapter 5 is successful in the applied aspect of the work. In the Chapter material on the results of testing the created selection material for a complex of breeding valuable traits is summarized in tabular form. The conclusions of the Chapter are the logical basis of the proposals made by the author.

Taking into account the large volume and significant level of differentiation of the conducted research (vegetation, field and laboratory), the work contains separate debatable

provisions, as well as statements and conclusions that require clarification or additional justification in the process of protection. In the process of analysis with the content of the dissertation, some editorial flaws were also revealed.

1. Discussion clauses:

- The work is based on the use of selection samples of sunflowers provided by the National Center for Agricultural Research and Development of Ukraine. Why was breeding material from the People's Republic of China not used in the work?;
- The possibility of using a part of the created samples as a starting material for plant varieties for reclamation use are considered in the chapters of the work and conclusions are considered. At the same time, there is no theoretical justification of the current state and prospects of such selection programs.

2. Provisions requiring additional comments and explanations:

- In the work, namely Chapter 2., Table. .2.2-2.3 a scheme that provides a total of 200 direct and reverse crossings is showed. However, in the text the characteristics of only 73 intervarietal hybrids are presented. What are the characteristics of other hybrids?
- In the methodology and research results, the author uses the indicator of the total amount of cadmium in the substrate and the arable layer of the soil without highlighting its available, water-soluble form. How is this approach justified?;
- Despite the saturation of the dissertation with the results of laboratory studies, the work does not contain indicators of the content of cadmium in the final products of sunflower processing, namely in sunflower oil and sunflower pulp. Have such studies been conducted and if not, why?

3. Remarks on the design of the text

- As a result of converting the text into PDF format (or other operations with the text), pages 2 of section (-1), some tables and figures in other sections were shifted;

- Some parts of the text in figures of Chapters 3 and 4 (3.5-3.8; 4.6-4.11) have a size of less than 10 pt., which makes it difficult to perceive them. Appendix G-J tables do not have row numbers.

General conclusion. The dissertation work of **Yuanzhi FU** “**Selection of sunflower for resistance to cadmium accumulation**”, submitted for defense to the specialized academic council for obtaining the degree of Doctor of Philosophy in the field of knowledge 20 - “Agricultural sciences and food” in the specialty 201 - “Agronomy” in terms of its relevance, scientific and theoretical level, main results of validity, main provisions and results published in professional publications, and novelty of the setting and practical significance meets the requirements of the order of the Ministry of Education and Science of Ukraine No.40 dated January 12, 2017 “On approval of requirements for registration dissertation” and the Decree of the Cabinet of Ministers of Ukraine dated January 12, 2022 No.44 “On approval of the Procedure for awarding the degree of Doctor of Philosophy and cancellation of the decision of the one-time specialized academic council of the higher educational institution, scientific institution on awarding the degree of “Doctor of Philosophy” with amendments made according to the Resolution of the Cabinet of Ministers No.341 dated 03.21.2022. Based on the above, I believe that Yuanzhi FU deserves to be awarded a scientific degree of Doctor of Philosophy in the specialty 201 "Agronomy" of the field of knowledge 20 -Agrarian sciences and food.

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