

R E V I E W

of the official reviewer 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

1. Relevance of the research topic.

Sunflower belongs to plants that accumulate the highly dangerous heavy metal of Cd, the half-life of which from the human body is 25-30 years. In the world, the problem of cadmium is determined by the steady increase in the concentration of this element in soils of agricultural use. The main factor in the growth of the metal concentration in arable soils is the application of phosphorus mineral fertilizers, the content of cadmium in them ranges from 70 to 170 mg/kg. An additional factor in the growth of Cd concentration in the sunflower crop is the expansion of the cultivation zone in areas with an increased share of mobile, water-soluble compounds. The consequence of this is numerous facts of refusal to import sunflower processing products from Ukraine.

The most critical situation regarding the control of cadmium content is the situation with the confectionery sunflower production, the actual concentration of cadmium in this type of sunflower currently exceeds 0.25 - 0.65 mg/kg. Taking into account the focus of domestic agricultural production on the export of ecologically safe food products, research on the possibilities of breeding control of heavy metal accumulation processes in the harvest of major crops is extremely relevant.

2. Connection of thesis with scientific programs, plans, topics.

The studies of Yuanzhi FU were carried out in accordance with the thematic plans of scientific research works 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). Yuanzhi FU is a co-executor and executor of individual tasks of the specified topics.

3. The structure and content of the dissertation.

The dissertation manuscript contains 195 pages of computer text, of which 137 are the main text. The work contains 19 tables and 28 figures. The total volume of work is about nine author's sheets. The manuscript is structured according to a traditional scheme for natural science research. The structure fully corresponds to the goals and objectives of the research. When forming chapters and subchapters, the author followed the rules of proportionality in presenting general and specific issues.

The introduction reveals the main normative indicators of dissertation. The title of the work corresponds to the purpose. Headings and content of chapters correspond to the list of tasks and the general direction of research.

The first chapter reveals the state of study of the issue of breeding control of the resistance of cultivated plant species to the accumulation of certain toxic elements. The material of the chapter is based on the use of more than 200 scientific sources, most of which were published for the last 10 years. The presence of a number of theoretical and practical problems was established, for the solution of which the author developed a scheme of experimental research.

The second chapter contains data on the soil and weather conditions of the research area, and description of the research methods.

The third chapter presents the result evaluation of breeding samples according to the indicator of cadmium content and a set of indicators of their vegetative and generative development. The tabular and illustrative material of the epizeyk presents the progress and results of vegetation (2019) and field (2019-2021) experiments on the implementation of a breeding program for developing sunflower source material with a controlled level of cadmium accumulation. The assessment of selection samples, intervarietal hybrids, the level of relationships

between indicators was carried out using the technique of correlation, regression and cluster analyses.

The fourth chapter deals with the study of physiological and genetic control mechanisms of the resistance trait to cadmium accumulation on the basis of two breeding samples of sunflower.

The fifth chapter presents the results of competitive testing of promising breeding samples. The samples were evaluated both for the cadmium content indicator and for a set of other breeding valuable traits, primarily plant productivity and oil content.

The conclusions are presented in a logical sequence in accordance with the tasks and structure of the work. Proposals for selection practice take into account the current state of sunflower and are quite realistic for implementation

4. Validity and reliability of the scientific provisions of the dissertation.

The validity of the conclusions and the main provisions of the dissertation is ensured by the logical structure of experimental studies performed in accordance with the accepted methods. The correspondence of the methods of vegetation and field experiments is confirmed by acts of experiment acceptance (2019-2022). Laboratory studies were performed in the conditions of a certified laboratory. The selected research methods are modern, highly informative and sufficient for adequate achievement of the set tasks. The reliability and logical justification of the conclusions drawn is based on statistically confirmed dependencies.

5. Scientific novelty of the obtained results.

According to the results of the author's work for the first time

- * A method of indirect assessment of selected sunflower samples for resistance to cadmium accumulation was developed and tested;
- * A working sunflower collection was formed with a range of cadmium content in the aerial 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. There were selected samples with a high level of differentiation before cadmium accumulation;

- * It was determined 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 low cadmium content - 62%, when crossing genotypes with high cadmium content and between group crossing - 85.7 and 66.7%, respectively;
- * Based on the results of the analysis of JB231AC 62\3 samples, it was found 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 gene was identified, which is up-regulated and has a higher level of expression in genotypes with a low level of resistance to cadmium accumulation.

It has been improved the scheme for evaluating collection samples of cross-pollinated plant species based on yield quality indicators.

Scientific states concerning growth the level of adaptability of plants to environmental conditions while narrowing the genetic base of the population have gained further development.

6. The practical significance of research and its implementation in breeding practice.

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. Working collection of intervarietal sunflower hybrids was transferred to the Institute of Agriculture of the Northeast of the National Academy of Sciences of Ukraine for further breeding work, Developed and improved methodical approaches for sunflower breeding were used in scientific and pedagogical work at the Sumy National Agrarian University.

7. Absence (presence) of violation of academic integrity.

There are no signs of academic plagiarism, falsification or other violations that could call into question the independent nature of the author's performance of

the scientific research presented in the peer-reviewed dissertation work. The text is original, all references to primary sources are made correctly.

The provisions of the dissertation submitted for defense are set out in 11 scientific works, 3 articles - in specialized scientific publications recommended by the Ministry of Education and Science of Ukraine, one article in a publication indexed by the scientometric database of Scopus (second Q2 quartile) and 7 theses based on the results of participation in international scientific conferences. Published scientific works fully reflect the content of the dissertation.

I consider it appropriate to note that the chronology of publications in 2019-2022 corresponds to the stages of work on the dissertation declared by the author.

8. Discussion clauses and remarks on the dissertation.

No significant shortcomings were found in the dissertation. The work is designed in accordance with the current requirements, but there are certain comments that need to be paid attention to during the defense:

- In the structure, list and content of the subsections of the first chapter (Chapter 1. Review of the literature), the overview of the physiological and genetic component of plant resistance to the accumulation of toxic elements is dominant. The breeding component is less represented;
- In the text (P.3) it is noted that the study of the collection is carried out in accordance with the previously developed selection program. However, the algorithm of the program itself is absent in the work;
- The dissertation lacks information about the origin and pedigrees of individual selection samples, primarily JB231AC and 62\3, which appear in chapter 3 and are the objects of research in chapter 4;
- The UDC number of the manuscript is too generalized and it does not specify the declared topic;
- In part of tables 2.1; 3.3 and G-J of appendices, the transfer was performed incorrectly.

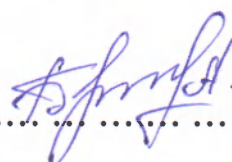
9. General conclusion.

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.

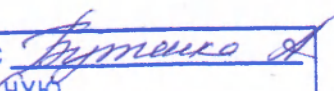
On the basis of the above, I believe that Yuanzhi FU deserves to be awarded the scientific degree of Doctor of Philosophy in specialty 201 "Agronomy".

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..... . **Andriy BUTENKO**



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