

REVIEW

by the official opponent, doctor of agricultural sciences, professor of the department of
crop breeding, genetics and seed production

Poltava State Agrarian University

Mykola Marenych

for Xihuan Zhang's dissertation

**“Effects of long-term biogas slurry application on soil properties and crop yield
in the North China Plain”,**

applied for the degree of Doctor of Philosophy

from the field of knowledge 20 Agricultural sciences and food

in the specialty 201 Agronomy

1. Relevance of the dissertation topic. Processing solid organic waste ought to be an important aspect of environmental management everywhere, but especially in China, a nation with a large population. Environmental pollution and energy scarcity are two major issues that today's civilization is dealing with. Anaerobic digestion is regarded as a crucial method for the treatment and usage of organic solid waste since it efficiently lowers and renders organic solid waste harmless while recovering key energy sources like methane and hydrogen. One major issue is digestate (biogas slurry), which is a by-product of anaerobic digestion. A 500 kW anaerobic digestion facility may produce over 10,000 tons of digestate a year, based on conservative estimations (Kaur et al., 2020). The direct use of such large amounts of digestate without proper treatment can potentially lead to the transmission of pathogens and the spread of disease to animals, humans and the environment, resulting in significant damage. The management of large amounts of digestate with high moisture content is becoming an increasingly serious challenge, so the disposal problem exists. Currently, the main methods of biogas slurry disposal after digestion of organic matter include incineration, composting and landfilling. However, these methods still leave a significant amount of organic matter, nitrogen, phosphorus and other nutrients unused in the biogas slurry. So far, there have been relatively few literature reviews on resource use and sustainable digestate management. In Xihuan Zhang' work, the results of the use of digestate in the form of a suspension as a fertilizer as one of the methods of disposal of waste from biogas plants are presented.

2. Connection of work with scientific programs, topics, plans. The dissertation research was conducted within the framework of the project of Henan Province (212102110388) and by the key scientific research project at Henan Provincial University (20B210004), China. The research also was carried out in accordance with the thematic plans of research works of the department of agrotechnologies and soil science of the Sumy National Agrarian University and within the framework of the topics “Biologization of the farming system through a rational combination of methods of soil cultivation and sideration” 0115u0010055. The work was also supported by a grant from the Development Cooperation of the Czech Republic (Ministry of Foreign Affairs).

3. Scientific novelty and theoretical significance of the thesis. The impacts of applying biogas slurry to winter wheat on lime concretion black soil in Zhoukou were thoroughly investigated and assessed for the first time. The optimal biogas slurry application concentration (BS50) was found, along with the differences between the various concentrations of the biogas slurry. A thorough analysis and evaluation of the effects of applying biogas slurry to winter wheat in calcareous black soil in Zhoukou was conducted. After comparing the application of biogas slurry at various concentrations, it was found that BS50 was the ideal concentration for use.

4. Scientific and practical significance. The research results determined the optimal concentration of biogas slurry used in Zhoukou calcareous black soil and confirmed the effects of biogas slurry on agricultural production (winter wheat yield). In addition, the application of biogas suspension positively effects on soil fertility parameters, stress resistance and production, which can not only achieve the effect of increasing production and quality, but also reduce environmental pollution large-scale aquaculture waste so that people realize the value of biogas slurry in economic benefits, social benefits and environmental protection. In the future, biogas slurry will be increasingly used to promote the organic combination of agriculture and animal husbandry to achieve low-carbon and efficient agriculture.

5. Completeness of presentation of the dissertation material in scientific publications. The results of the dissertation research were published in 11 scientific

papers, in particular, papers in professional journal of Ukraine - 2; papers in journal which included in the Scopus databases - 1 (Q1); in the EU journal – 1, papers in scientific professional publications of China – 3, abstracts of proceedings of conferences – 4. The published works sufficiently reflect and confirm the conducted research.

1. The degree of validity and reliability of scientific statements, conclusions and recommendations. The scientific propositions, conclusions and recommendations presented in the dissertation work are sufficiently substantiated, have a deep scientific meaning and are important for the development of agricultural and ecological science. The purpose of the dissertation corresponds to the research topic, object and subject, scientific and methodological requirements. The methodology of the dissertation work is based on the standard methodic. The content of the dissertation corresponds to its essence. Conclusions to the chapters of the dissertation and general conclusions are logical and are confirmed by the results of testing an international and Ukrainian scientific and practical conferences, publications in scientific specialized publications. All of the above allows us to assert sufficient validity and reliability.

2. The structure and content of the dissertation. The text of the dissertation is written in English logically and consistently. The structure of the dissertation, language and presentation style meet the requirements set for PhD thesis. The scientific terminology used in the work is generally recognized, the style of presenting the results of theoretical and practical research, new scientific provisions, conclusions and proposals ensures the accessibility of their perception and use. In general, the dissertation is a finished scientific work corresponding to the specialty 201 Agronomy.

The dissertation consists of an introduction, five chapters, conclusions, proposals, a list of references, appendixes. The total volume of work is 151 pages. The text of the dissertation contains 13 tables and 32 figures, a bibliography of 172 sources.

In the first chapter, with the goal of practical application and theoretical development, and the experience of international agricultural experience as reference,

this chapter analyzes results the expediency of using biogas slurry, explaining that it is a type of fast-acting organic fertilizer. Biogas plants are used in more than 60 countries, so the waste must be utilized properly and the use in agriculture brings a corresponding profit. The introduction of biogas suspension / digestate affects the physicochemical properties of the soil, and it can partially replace mineral fertilizers. Zhang Xihuan noted from the literature sources that the positive effect of the applied suspension on the activity of soil enzymes, yield and quality of agricultural products.

The second chapter “Conditions, materials and methods of research” describes the location of the research plot, presents the weather conditions of 2020-2022, provides the origin of the biogas suspension and its preparation for application. The scheme of the experiment, the chemical composition of the biogas suspension, the peculiarities of the selection of soil and plant samples, the methods of determining the structural and aggregate composition of the soil, the physical and chemical parameters of the soil, and the yield index are described in detail.

The third chapter of the dissertation “Effects of combined application of biogas slurry and chemical fertilizer on soil physicochemical properties” presents the data for determining the bulk density of the soil, the distribution of particles of mechanically and water-stable soil aggregates, their diameter depending on the type of fertilizer and the percentage of biogas suspension. It was established that the use of biogas suspension increases the pH compared to mineral fertilizers. Biogas suspension reduces soil density, which is good for growing winter wheat. The introduction of biogas suspension increases the content of NPK and organic matter.

The fourth chapter «Effect of combined application of biogas slurry and chemical fertilizer on soil enzyme activity» presents the results of determining the enzymatic activity of the soil from the applied fertilizers. The results of sugar, urease, phosphatase, catalase and their distribution in the soil profile were analyzed. Biogas slurry can improve the soil enzyme activity of winter wheat in 0-40 cm soil layer, especially in 20-40 cm soil layer, which is conducive to delaying the aging process of winter wheat root in the late growth period, promoting the transformation of soil nutrients, improving the ability of soil to supply fertilizer to winter wheat, and meeting

the demand for nutrients during the growth and development of winter wheat, which is beneficial to the improvement of soil fertility and crop yields of winter wheat.

The fifth chapter «The effect of co-application of biogas and chemical fertilizer on the growth and development of winter wheat». It was proved that both biogas slurry and chemical fertilizer application increased the yield of winter wheat, and there was a significant difference compared with control. Biogas slurry 50% is the optimal combination of biogas slurry and chemical fertilizer.

It is worth noting that the conclusions fully correspond to the declared purposes and tasks of the dissertation, have appropriate arguments, are well-founded and reliable.

An analysis of the plagiarism check report for the presence of textual borrowings (Strike plagiarism program) was carried out. The dissertation work of Xihuan Zhang in the topic “Effects of long-term biogas slurry application on soil properties and crop yield in the North China Plain” is the result of the independent research and does not contain elements of borrowing and plagiarism in accordance with the resolution of the CMU dated 12.01.2022 No. 44. Used ideas, texts and results of other authors have a link to the corresponding source.

3. Remarks and wishes for the content. Positively characterizing Xihuan Zhang’s dissertation work, it is necessary to pay attention to separate discussion provisions of the dissertation submitted for review:

1. The dissertation title mentions the long-term use of biogas suspension, but it is not specified in the chapter 2 from which year it was applied in this experimental area.
2. How does the application of biogas slurry affect other crops of the crop rotation? There is no such information in the work, it is only about winter wheat.
3. Soil density was determined after harvesting, although it would be appropriate to analyze it before sowing winter wheat.
4. It would be interesting from a scientific point of view to analyze the content of nitrate and ammonium nitrogen in the soil on fertilized variants. But in the dissertation we see the results only content of total nitrogen.
5. Why such enzymes as urease, sucrase, acid phosphatase and catalase were selected for analysis?

6. What is the economic benefit of applying the biogas suspension instead of applying mineral fertilizers?

7. These remarks do not diminish the scientific value of the dissertation and some of them only reflect the reviewer's scientific position, which can also serve as a reason for discussion.

General conclusion. The dissertation work of Xihuan Zhang entitled «Effects of long-term biogas slurry application on soil properties and crop yield in the North China Plain», which was 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. The content of the dissertation corresponds to the passport of the specialty. The PhD candidate Xihuan Zhang deserves to be awarded the scientific degree of Doctor of Philosophy in specialty 201 – Agronomy.

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