

## REVIEW

of the official opponent Oleksandr Humeniuk, candidate of agricultural sciences, head of the winter wheat breeding laboratory at the V.M. Remeslo Myronivka Institute of Wheat National Academy of Agrarian Science of Ukraine for PhD thesis **Xihuan Zhang “Effects of long-term biogas slurry application on soil properties and crop yield in the North China Plain”**,

submitted for a scientific degree of a Doctor of philosophy

Field of knowledge: 20 – Agricultural sciences and food, specialty: 201 – Agronomy

**Relevance of the dissertation topic.** Biogas production has been rapidly growing in Europe and China for more than a decade. This increase may be further amplified by the current geopolitical context raising questions about countries' gas self-sufficiency. It is also an alternative way to manage farmyard manure and/or industrial organic waste while producing green energy. In addition to biogas production, anaerobic digestion produces digestate – a by-product used as an organic fertilizer. Thus, biogas production contributes to promote circular bioeconomy by closing the nutrient loop, it contributes also to the mitigation of greenhouse gas emissions from farm effluents and increases carbon sequestration in soils.

According to here searcher over the world, the organic matter of digestates may improve the soil structure, its infiltration rate and its water-holding capacity and thus increase productivity while lowering fertilization costs. However, thorough investigations of possible side effects on the soil biota – especially on microorganisms that play important roles in the soil ecosystem – are required to properly assess the sustainability of large-scale land application of digestates in agricultural fields.

**Connection of work with scientific programs, plans, themes.** Xihuan Zhang' research was supported by the science and technology key 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 Suny 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. In 2021 this project “Impact of organic fertilizers from biogas plants on microbiological, physical and chemical properties of soil and crop growth” was supported by minigrant due to participating in the project “Interuniversity cooperation as a tool for enhancement of quality of selected universities in Ukraine” financed within the Development Cooperation of the Czech Republic (Ministry of Foreign Affairs).

**Scientific novelty and theoretical significance of the thesis.** The return of biogas slurry to the field not only solves the digestion and effective utilization of biogas slurry, but also increases the grain yield and quality, and is in line with the concept of sustainable development. The research topic closely follows the urgent problems in the current agricultural development, using the combination of agriculture and animal husbandry as the research entry point.

*First obtained:*

The impacts of applying biogas slurry to winter wheat on lime concretion black soil in Zhoukou were thoroughly investigated and assessed.

The optimal biogas slurry application concentration (BS50) was found, along with the differences between the various concentrations of the biogas slurry.

*Further developed:*

The amount of biogas slurry applied in conjunction with agricultural and animal husbandry was enhanced, wheat yield and quality were raised, and a foundation for the scientific application of biogas slurry was established.

**Practical significance of the obtained results.** This research led to the development of an evaluation system for the application of biogas slurry, the clarification of the relationship between soil and winter wheat measurement indexes, an improvement in soil fertility, the promotion of winter wheat growth and development, and an increase in winter wheat yield and quality. Agriculture and animal husbandry were intimately linked at the same time, and the usage of chemical fertilizers, the expense of agricultural output, and environmental pollution were all decreased. The research has been acknowledged by the Department of Education and the Department of Science and Technology of Henan Province, and it is advantageous to the sustainable growth of agriculture. The experiment's findings are

incorporated into the Sumy National Agrarian University course "Problems of ecological agriculture" which is taught for Master's students in Agronomy.

Using biogas suspension, farmers can solve the environmental problem of waste and replenish the soil with nutrients, thereby increasing the yield and quality of agricultural products.

**The author's personal participation in obtaining the scientific and practical results presented in the dissertation.** Approbation of the scientific and practical results presented in the dissertation was carried out by the applicant personally. In the published works, printed in co-authorship, individual theoretical developments, setting up and conducting of all experimental studies, processing of the obtained results, scientific analysis of research results, formulation of conclusions and proposals belong to the doctoral student.

An analysis of the plagiarism check report for the presence of textual borrowings was carried out (Strike program plagiarism). Used ideas, results and texts of others authors have a link to the corresponding source.

**Complete presentation of the main results of the dissertation.** The main results of the thesis are presented in 1 publication in the Scopus database, 1 quartile, 2 articles in scientific professional journals in Ukraine (category "B"), 3 articles - in scientific professional journals of China (in Chinese), 1 article – in a journal of EU, 4 abstracts of conferences.

**The structure and content of the dissertation, its completeness and compliance with the established requirements for design.** Characterizing the structure and content of the reviewed dissertation, one should note that the work contains an introduction, five chapters, conclusions, a list of references and appendices. A brief description of the work's main content and the research results are presented in the abstract. The text of the work is laid out on 151 pages, which also contains 13 tables and 32 figures, which complement the presentation of the author's text and illustrate the obtained scientific results. Xihuan Zhang used 172 scientific sources, which testifies to the validity and reliability of the obtained results.

The introduction to the dissertation contains an overview of the relevance and main elements of scientific research: goals, tasks, object and subject, and research

methods. The introduction also describes the author's scientific results and their practical significance. In the first section, the author points out the feasibility of using biogas suspension which can partially replace chemical fertilizer. In the process of agricultural use of biogas slurry containing a large amount of organic matter, these organic substances are brought into the farmland. The analyzed studies have shown that biogas irrigation can improve the biomass and metabolic activity of soil microorganisms, enhance the ability of soil to fix organophosphorus. It was noted that biogas slurry is a decomposed water-soluble fertilizer, so watering biogas fermentation liquid can increase wheat yield and influence on the soil fertility.

The second part described the experiment site, that is located in Henan Province, which is an important wheat production base in China. The specific geographical location, meteorological data were presented. The biogas slurry was taken for the experiment from Shangshui Muyuan Agriculture and animal Husbandry, which is mainly engaged in pig breeding and is a China key leading enterprise in agricultural industrialization. The main raw material is the liquid mixture of pig manure and urine, and also includes the washing water of some pig pens. Then this slurry this solution is subject to enzymatic fermentation. Also the sample collection and processing were described.

The third chapter of the dissertation examines the effect of using biogas slurry alone or in combination with chemical fertilizers on the main parameters of soil fertility (content of organic matter, pH, total N, available P and K, bulk density, structural and aggregate composition of the soil). It was found that different fertilization could significantly change the particle size distribution and adjust the mass composition of aggregates with different particle size. The stability of soil aggregates is a very important parameter and Zhang Xihuan proved that the biogas slurry treatment is beneficial to increase mechanical and water stability of aggregates.

In the fourth chapter, the effect of the application of biogas slurry and mineral fertilizers in different proportions on the enzymatic activity of the soil was shown. Different enzymes responded differently to the applying of biogas slurry in combination with mineral fertilizers and without them.

The material of chapter 5 testifies to the effectiveness of the use of biogas slurry in the cultivation of winter wheat, the highest grain yield was obtained using 50% biogas slurry and 50% mineral fertilizers. The use of biogas slurry has a more significant effect on the height of the wheat plant than mineral fertilizers. The harvest index was the highest at BC50.

The conclusions and proposals showed that fertilization by biogas slurry has a great perspective. To stabilize and protect the environment in areas where intensive pig farming is carried out, it is recommended to use biogas suspension together with mineral fertilizers in a ratio of 50:50.

**Evaluation of the language and style of the dissertation.** The dissertation is written in competent English, has meaningful integrity, consistency and completeness. The style of presentation of the material corresponds to that accepted in the scientific literature.

**Remarks and wishes on the dissertation work.** Characterizing the dissertation work of Xihuan Zhang as a whole, it should be noted that it certainly has relevance, scientific and practical significance. However, in my opinion, it is appropriate to note that there are certain debatable points in the work.

1. In the work, it is not entirely clear how nitrogen, phosphorus and potassium mineral fertilizers are applied. It is not specified what type of nitrogen fertilizer was used.
2. How many liters of water were supplied per hectare for application before sowing and for sprinkler irrigation? What specific equipment was used for this? In what period of wheat growth have 30% biogas slurry been applied?
3. What kind of soil tillage is carried out in crop rotation, where biogas slurry is applying?
4. It would be appropriate to investigate the effect of biogas suspension on soil parameters and enzymatic activity. Is it possible that nutrients will be available for the next crop?
5. The paper omits the description of the soil on the experimental site.
6. What type of pH was determined? If it is noted that application of biogas slurry can increase the pH, is it good for all crops in the crop rotation? If you

are working on calcareous black soils, could the increase in alkalinity be even higher?

7. It would be appropriate to conduct a correlation analysis between the parameters of soil fertility and yield on experimental plots.

The above wishes on the dissertation work are not fundamental and do not reduce the overall positive assessment of the work.

**Conclusion on compliance of the dissertation work with the requirements of the procedure for obtaining a scientific degree.** Dissertation work graduate students Xihuan Zhang submitted for obtaining the degree of Doctor of Philosophy in the specialty 201 "Agronomy" according to the signs scientific novelty, theoretical and practical significance of the obtained results in full meets the requirements of the "Procedure for awarding the degree of Doctor of Philosophy and annulment of the decision of the one-time specialized academic council of the institution of higher education, scientific institution on awarding the degree of Doctor of Philosophy", approved by Resolution №44 of the Cabinet of Ministers of Ukraine dated January 12. 2022 and the Requirements for the design of the dissertation, approved by order of the Ministry of Education and Science of Ukraine №40 dated 12.01.2017. The content of the dissertation corresponds to the passport of the specialty. Therefore, the dissertation can be recommended for consideration at a meeting of a one-time specialized academic council, and its author – Xihuan Zhang – for awarding the degree of Doctor of Philosophy in the specialty 201 "Agronomy".

**OFFICIAL OPPONENT:**

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**Oleksandr HUMENIUK**

The signature is certified,  
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**Inna ZAKHARCHENKO**