Dr hab. Patrycja Boguta, prof. IA PAN
Institute of Agrophysics
Polish Academy of Sciences
ul. Doświadczalna 4, 20-290 Lublin

Lublin, dn. 30.07.2026

REVIEW

of the doctoral dissertation of MSc Tianjing Ren

„Factors controlling content and transformations of dissolved organic matter components in agricultural soils at field and global scales" performed in the Institute of Soil Science and Plant Cultivation State Research Institute in Puławy, under the supervision of

supervisor: dr hab. Bożena Smreczak, prof. IUNG-PIB

auxiliary supervisor: dr hab. Aleksandra Ukalska-Jaruga

The basis for the preparation of this review is: a letter from the Deputy Chairman of the Scientific Council, dr hab. Grzegorz Siebielec, prof. IUNG-PIB, dated 22/05/2026 with a request to prepare a review of the doctoral dissertation of MSc Tianjing Ren, resolution no. 18/IUNG-PIB/2026 of the Scientific Council of IUNG-PIB in Puławy dated 20/04/2026 on the appointment of reviewers, as well as a copy of the doctoral dissertation.

The selection and importance of the research topic of the dissertation

In doctoral dissertation, MSc Tianjing Ren focuses on analyzing the factors determining the content and transformation of dissolved organic matter (DOM) in agricultural soils. Despite relatively small contribution of DOM to the total soil organic matter (SOC) pool, this fraction is crucial for many processes occurring in the soil environment. Its high reactivity and mobility govern the cycling of micro- and macronutrients, including their chemical form and bioavailability. DOM is also a crucial soil component affecting the activity and diversity of microorganisms. Furthermore, this fraction shapes the physicochemical properties of soils, such as aggregate structure, surface properties, and the transport of organic carbon within the soil profile.

With the intensification of agricultural production aimed at meeting the growing demand for food, agricultural soils are subjected to increasing pressure from intensive mechanical cultivation and high levels of exploitation of their resources. The consequence of these processes is the progressive loss of organic matter, leading to a deterioration of both the productive and environmental functions of soils. In response to these unfavorable phenomena, agriculture is implementing a variety of management strategies and cultivation practices aimed at reducing soil degradation and improving soil quality. In this context, MSc

Tianjing Ren accurately identifies DOM's potential as a highly sensitive indicator of organic matter changes caused by cultivation methods or fertilization type.

Despite the growing number of studies on DOM properties in agricultural soils, the findings regarding the factors controlling its quantity and composition remain ambiguous. These inconsistencies arise primarily from the wide variation in soils studied, climatic conditions, agricultural practices, and sometimes also from the experimental methodologies. The available results come from experiments conducted in various regions of the world, but individual studies are often limited to local conditions and the specificity of experimental systems. As a result, it remains difficult to clearly identify global patterns and the significance of individual environmental and anthropogenic factors governing the quantity and properties of the DOM fractions. Therefore, undertaking an analysis of this issue should be considered as fully justified from both a research and application perspective.

The topic of MSc Tianjing Ren dissertation addresses the above-mentioned need. The Doctoral Candidate undertakes a time-consuming and extensive research aimed at providing a comprehensive assessment of the influence of a broad spectrum of environmental and agricultural factors that may determine the content and transformations of DOM in soils. Particularly noteworthy is the inclusion of different forms of nitrogen fertilization, climate warming, humid and non-humid regions, as well as the results of a field experiment encompassing both qualitative and quantitative analyses of DOM and its major components, i.e. carbon (DOC), nitrogen (DON), and phosphorus (DOP) within the soil profile.

Considering the above, I believe that the topic addressed in this doctoral dissertation is timely, fully justified, and perfectly reflects current agricultural needs and scientific trends. The broad and comprehensive approach to analyzing DOM changes proposed in this study is highly valuable and can make a significant contribution to a better understanding of the trends in soil organic matter changes under the influence of various factors. Obtained results can also contribute to the development of more effective organic matter management strategies, thus supporting the development of sustainable agricultural production systems.

Assessment of the formal aspects of the dissertation

The doctoral dissertation was submitted in the form of a series of four thematically related scientific publications under the collective title „Factors controlling content and transformations of dissolved organic matter components in agricultural soils at field and global scales". It consists of the following publications:

1. Tianjing Ren, Bożena Smreczak, Aleksandra Ukalska-Jaruga, Xiaojie Li, Waseem Hassan and Andong Cai, Differential impacts of nitrogen addition on soil dissolved organic carbon in humid and non-humid regions: A global meta-analysis. Journal of Environmental Management 337 (2025): 124744.
2. Tianjing Ren, Bożena Smreczak, Aleksandra Ukalska-Jaruga, Waseem Hassan and Andong Cai, Asymmetric responses of soil dissolved organic carbon and dissolved organic nitrogen to warming: A meta-analysis. Catena 252 (2025): 108871.
3. Tianjing Ren, Aleksandra Ukalska-Jaruga, Bożena Smreczak, and Andong Cai, Dissolved organic carbon in cropland soils: A global meta-analysis of management effects. Agriculture, Ecosystems &

Environment 371 (2024): 109080.

4. Tianjing Ren, Guillaume Debaene, Bożena Smreczak, Aleksandra Ukalska-Jaruga, Depth-dependent effects of crop rotation and monoculture on dissolved organic matter quantity and quality. Frontiers in plant science 16 (2025): 1668092.

All above articles were published in reputable international journals. The impact factor for these journals ranges from 5.7 to 8.4. Based on the Ministry of Science and Higher Education's journal list, one paper was published in a 100-point journal, another paper - in a 140-point journal, and two other papers - in 200-point journals, for a total of 640 points. MSc Tianjing Ren served as the first author and corresponding co-author of each article, and her contribution to the individual publications was estimated at 55% to 60%. The PhD Candidate actively participated in the preparation of the papers, from formulating the research problem, through collecting, preparing, and analyzing data, interpreting and visualizing results, to drafting the manuscripts. Such substantial involvement confirms her leading role in conducting the research, as well as her high degree of scientific independence and competence in the planning, conducting, and publication of scientific research.

The rationale for the topic, main assumptions, results, and conclusions from the above four papers are clearly summarized in an 86-page, English-language, authorial paper named "PhD Dissertation". This document is well-structured and contains a number of elements typical of this type of work. It includes a title page, statements of all co-authors specifying their contribution to the manuscripts, a table of contents, list of abbreviations, abstracts, a theoretical background, objectives, hypotheses, methodology, a section with results and discussion, conclusions, as well as a chapter outlining suggestions for future research directions and a bibliography. In accordance with the accepted standards, printed copies of all publications included in the publication cycle have been appended to the doctoral dissertation. The dissertation has been prepared in a coherent manner, forming a logical sequence of research issues and activities that enables the reader to follow the main concept and progression of the study with ease. I consider the proportion of the individual chapters within the overall structure of the dissertation to be appropriate. The title of the dissertation accurately reflects the scope of the research presented in the four scientific articles comprising the publication cycle.

The doctoral candidate made a few editorial errors and minor inaccuracies. For example, the table with objectives and hypotheses should have a number and title. I also suggest to add "clay fraction content" after the word "clay." Figure 1 would benefit from the addition of the word "DOM" or "DOC" next to the words "quantity and quality. The abbreviations used in the dissertation are explained in the form of a list at the beginning of the doctoral thesis and are additionally introduced in the text; however, this is not done consistently in every case. Particular attention should be paid to the abstracts, which often function independently in various types of databases, and therefore it is advisable to ensure that all introduced abbreviations e.g., SUVA, E4/E6, SOC are properly explained. However, I would like to emphasize that

several of the above-mentioned exemplary comments are primarily technical in nature and do not affect the scientific value of the work. They can only serve as a guide for preparing future projects, publications, and studies.

Substantive evaluation of the thesis

Theoretical section

In the introduction, the PhD Candidate presents the definition and key functions of DOM in soil, focusing on its crucial importance in agricultural soils. In subsequent chapters, she synthesizes the issues and potential mechanisms of changes in DOM content and mobility resulting from nitrogen (N) fertilization, global warming, and various agricultural practices. The PhD Candidate also highlights a range of consequences of these processes, including changes in: gas emissions, composition of DOM compounds, microbial activity or soil chemical interactions. This broad perspective demonstrates extensive knowledge and awareness of the complexity of biogeochemical processes occurring in soil, as well as the ability to interpret them in the context of agroecosystem functioning.

Summarizing this section of the thesis, the doctoral student moves to present the concept, key assumptions, and research outline of her doctoral dissertation. She formulates the main goal, which is to identify the factors determining the quality and quantity of dissolved organic matter under conditions of varying nitrogen fertilization, climatic conditions, agricultural practices, and soil depth. Furthermore, in reference to the four articles included in the doctoral dissertation, four specific goals are identified, along with corresponding hypotheses.

- In the chapter on "agricultural management practices," the Candidate notes that understanding the direction and intensity of DOM (DOC) changes is limited. Given the large number of existing publications on this topic, I would like to ask to further clarify this statement. I suspect that most individual studies typically indicate changes, but on a narrow, sometimes only regional scale of study location, climate, soil type, etc. Does the Candidate mean that it is difficult to formulate consistent conclusions on a global scale due to gaps in comprehensive, global, meta-analysis-based studies on DOM variability in agricultural soils?
- I would suggest rewording specific objective 2, for example, to "Study on moisture effect on DOC responses to N", as in its current form it suggests a hypothesis to some extent.

Methodology

The "Materials and Methods" chapter is divided into two parts, one concerning the meta-analysis and the other describing the field experiment. In the first section, the PhD Candidate describes the data selection process, including, among other aspects, the time frame, data sources, and search strategies, separately addressing issues related to nitrogen addition, climate warming, and different agricultural practices. A general framework for the evaluation of research studies considered as potential sources of observations is presented, along with information on the types of data extracted and the procedures used for grouping and standardizing the observations. The PhD Candidate takes great care in data selection, for example, by

excluding data sets that do not meet the inclusion criteria and those for which she did not obtain full access. At the same time, she strives to isolate as much information as possible accompanying individual observations of DOM changes, which further enhances the cognitive value of the conducted analysis.

In the second section, the PhD Candidate describes the main assumptions for the long-term field experiment. The study was conducted on an Albic Luvisol at an experimental site established in 1994. It included the physicochemical and chemical characterization of the soil as well as DOM extraction and the analysis of selected chemical properties of this fraction. In addition, the research involved the quantitative assessment of the major DOM components i.e. dissolved organic carbon (DOC), nitrogen (DON), and phosphorus (DOP), at different depths of the soil profile and under different tillage systems. I consider the overall concept of conducting this type of research to be highly valuable, particularly given that studies simultaneously examining all three DOM components (DOC, DON, and especially DOP) across the vertical soil profile remain relatively scarce. These investigations can substantially complement the meta-analysis conducted by the PhD Candidate by providing additional insights into depth-dependent changes in DOM, as well as into the mechanisms governing the transformation and leaching of organic C, N, and P compounds under different soil tillage systems.

At this point, I would like to raise several questions and comments:

- The PhD Candidate writes that to ensure data consistency, DOC concentrations derived from the physical method were converted to equivalent values. What equivalent values are being referred to, and how the conversions were performed?
- The PhD Candidate indicates that in the meta-analysis, she considered terrestrial systems, including forests. Referring to the title of the dissertation, in what respect could this type of data reflect the situation in agricultural soils?
- The sample size in the meta-analysis of "management practices" was 196 observations for CO_2 emissions, which came from a relatively small number (15) of studies. Could observations from the same publication be considered independent? Could the meta-analysis result be dominated by single publications that provided a large number of observations?

Results and discussion

The first specific objective of the doctoral dissertation was to investigate how nitrogen addition affects DOC content and to identify the factors that modulate this effect. The findings of this study were presented in the form of a meta-analysis in the first article. In this work, the Doctoral Candidate considered humid and non-humid regions, as well as moderators such as precipitation seasonality, soil pH, and baseline SOC content. Among the most interesting observations from this study is the finding that nitrogen addition increased DOC and microbial biomass carbon (MBC) content in non-humid regions and decreased these parameters in humid regions - with the analysis revealing a stronger effect for low-humidity regions. Furthermore, the initial SOC content determined changes in DOC of humid regions, while nitrogen

application rates influenced these changes in non-humid regions. At the same time, the PhD Candidate was able to confirm the hypothesis that changes in DOC due to nitrogen addition are dependent on climatic conditions. Based on the analysis of the obtained results, the Doctoral Candidate also identified the mechanisms and causes of the contrasting effects involving DOC. I consider the inclusion of additional moderators of changes in DOC content, such as pH or soil drying and wetting cycles, particularly valuable. This grouped the results obtained for two very broad groups: humid and non-humid regions. Demonstrating the asymmetric effect of various nitrogen forms on DOC compounds in soils from regions with contrasting conditions of humidity may be helpful in predicting changes in SOC dynamics under various global scenarios.

- The PhD Candidate mentions that the observed effects on DOC depended on soil type and parent material, redirecting the reader to supplementary materials. I noticed this supplementary material is missing from the documentation provided, so I would like to ask about synthetic conclusions from this type of analysis. Is it possible to formulate directions of DOM changes for individual soil types?
- The effects of introducing various soil additives may be visible after different periods of time. Did the PhD Candidate attempt to analyze the duration of the experiments in this research (as in the third article)?

In the second article, the PhD Candidate used a meta-analysis to examine the impact of experimental warming on changes in DOC and DON. She also tested the hypothesis that the DOC:DON ratio was reduced by accelerating DOC turnover. The results showed that warming did not contribute to changes in DOC and MBC levels, nor did it contribute to changes in microbial biomass nitrogen or ammonium nitrogen. However, warming significantly reduced SOC values, increased DON and nitrate nitrogen concentrations, and led to a decrease in C:N and DOC:DON ratios, confirming the loss of correlation between DOC and DON changes. The PhD Candidate clearly emphasizes the potential environmental consequences associated with these phenomena, including limiting the ability of heterotrophic microorganisms to convert ammonium compounds and facilitating the conversion of ammonium to nitrates by autotrophic nitrifying bacteria. This, in turn, may contribute to the accumulation of DON and nitrates, and consequently to pollution and further increases in greenhouse gas emissions. Overall, I consider the subject of presented research, its results, and conclusions to be highly desirable for a more comprehensive understanding of the mechanisms of carbon and nitrogen cycling in soil. Of particular note is the inclusion here of a broad set of indicators e.g., SOC, DOC, DON, TC, MBC, MBN, NH_4^+, NO_3^- and ratios: C:N, DOC:DON, DOC:SOC, which allowed for a more comprehensive interpretation of soil response to warming, as well as the conclusion that the response of different organic matter fractions is not uniform, and changes in one fraction do not necessarily reflect changes in the others.

- The Doctoral Candidate mentions that the data for the analysis of the article comes mainly from China. Can we therefore objectively state that the meta-analysis performed is global in nature?

In the next work, the PhD Candidate focused on the impact of various agricultural practices on DOC

content and transformation. The aim of these analyses was to compare conservation tillage, mineral fertilization, addition of straw, manure, biochar, or mixed nitrogen fertilization with straw or manure in terms of their potential to increase DOC content and reduce CO_2 emissions. Among the most important findings were the increases in DOC content observed under different amendment treatments: by 78.21% with combined manure and nitrogen fertilization, 49.91% with manure alone, 41.02% with combined straw and nitrogen fertilization, 25.68% with straw alone, 18.40% with nitrogen fertilization alone, and 14.89% with biochar application. Interestingly, the largest increase in the DOC:SOC ratio was observed for mixed nitrogen and manure fertilization, while a significant reduction of 25.02% was observed for biochar addition. Experimental duration also had a significant impact on DOC content and the DOC:SOC ratio. In this case, the largest changes were observed for conservation tillage, mineral fertilization, addition of straw and straw with nitrogen fertilizer. The analysis of CO_2 emissions in relation to DOC content was also valuable as it showed that the greatest CO_2 emission potential occurred with biochar addition.

- The Doctoral Candidate emphasized that the results obtained in this work are consistent with the hypothesis presented in the dissertation. I agree, although in my opinion, this hypothesis could be somewhat more precise. Could the type of "disturbance" be specified more precisely? A similar comment applies to the phrase "larger and more beneficial DOC increases." It may be sufficient to use simply "larger DOC increases," unless the intended meaning of "more beneficial" is explicitly defined.

The final part of the doctoral dissertation research consisted of field studies. The main goal of this work was to examine the effect of cultivation system and depth in the soil profile on the qualitative and quantitative characteristics of DOM. In my view, the above-mentioned study represents a valuable contribution to the field and deserves special recognition, particularly given the limited availability of long-term experiments of this type. Special attention should be given to the comprehensive assessment of DOC, DON, and DOP concentrations across several soil layers, including depths of up to 90 cm. The results showed a decrease in the content of these elements with depth, both under monoculture and crop rotation. It is worth noting that the cultivation system did not significantly affect DON and DOP content in any of the studied layers. Only in the case of DOC, a higher DOC content was observed in the monoculture at the lowest layer. Qualitative studies demonstrated a greater effect of depth than cultivation system on the molecular characteristics of DOM. In the lower layers, DOM showed, among other things, an increase in aromaticity, molecular weight, and degree of humification. These conclusions enabled the PhD Candidate to adopt her previously established research hypothesis.

- At this point, I would like to suggest that future studies of this type consider using additional, complementary techniques for DOM analyses, preferably those offering more quantitative assessment, to increase the selectivity of the obtained results. The methods used in this work are characterized by simplicity, relatively low cost, and short analysis time, which are their undoubted advantages. However, it should be noted that, for example, in the case of UV-Vis technique, color derived from certain cations can

affect absorbance, so parameters such as E4/E6 for fractions that are not subjected to purification should be interpreted with great caution.

The discussion of individual articles, together with the synthetic conclusions, is additionally complemented by a brief chapter presenting the limitations of the study and proposed directions for future research. The PhD Candidate highlighted the lack of sufficient input data for some analyses, the heterogeneity of the methodologies used in the analyzed studies, and, in the case of the field experiment, the limitation of observations to specific conditions, such as particular climatic conditions and soil type. These statements do not diminish the value of the doctoral dissertation; on the contrary, they demonstrate scientific rigor, facilitate the proper interpretation of the results by the reader, and enhance the transparency of the publications.

The final chapter of the doctoral dissertation consists of the reference list. It includes approximately 150 references, comprising relatively recent publications from peer-reviewed journals. The cited works are used appropriately throughout the dissertation, in relevant sections and in adequate numbers. The reference list includes thematically relevant international publications, demonstrating the PhD Candidate's very good familiarity with the research area and the latest developments in the field.

Summary and overall conclusion

Despite the minor comments and remarks, which are mainly of a discussion-oriented nature, I evaluate the doctoral dissertation by MSc Tianjing Ren positively. The results obtained are original and valuable, and they should be considered an important contribution to the advancement of knowledge on DOM transformation processes in agricultural soils. The PhD Candidate has successfully achieved the objectives of the study, demonstrated the originality of the research, and presented both constructive conclusions, limitations, and suggestions for future research.

In my view, MSc Tianjing Ren has demonstrated extensive knowledge of the analysis of mechanisms and pathways of DOM transformations in soils, as well as the ability to plan research tasks and solve scientific problems using various laboratory and statistical methods. Considering the above, as well as the relevance and significance of the research topic undertaken, I conclude that the doctoral dissertation submitted for evaluation meets the requirements established for doctoral theses as specified in Act of 20 July 2018 Law on Higher Education and Science (Journal of Laws of 2024, item 1571, as amended). Therefore, I request that the Scientific Council accept this thesis and allow the PhD Candidate to proceed to the next stages of the PhD application process. Furthermore, due to the high quality of the research presented and its significant contribution to the development of the discipline, I request that this doctoral dissertation be awarded a distinction.

Patrycja Boguta

Lublin, 30.07.2026

dr hab. Patrycja Boguta, prof. IA PAN