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dr hab. inż. Magdalena Banach-Szott
Department of Biogeochemistry, Soil Science
and Irrigation and Drainage,
Faculty of Agriculture and Biotechnology
Bydgoszcz University of Science and Technology
Bernardyńska 6 St.
85- 029 Bydgoszcz

Review of the Ph.D. dissertation by mgr Tianjing Ren

Formal basis of the prepared review

This review was prepared in response to a letter from the Deputy Chairman of the Scientific Council of the Agriculture and Horticulture Discipline of the Institute of Soil Science and Plant Cultivation - National Research Institute in Puławy, dr hab. Krzysztof Jończyk (Resolution No. 18/IUNG-PIB/2026).

The dissertation submitted to me for review by mgr Tianjing Ren, titled "*Factors Controlling Content and Transformations of Dissolved Organic Matter Components in Agricultural Soils at Field and Global Scales*," was completed under the supervision of dr. hab Bożena Smreczak, prof. IUNG-PIB – Supervisor and dr hab. Aleksandra Ukalska-Jaruga – Auxiliary supervisor at the Department of Soil Science and Environmental Analyses of the Institute of Soil Science and Plant Cultivation – State Research Institute in Puławy.

The issues of the dissertation

Dissolved organic matter (DOM) – operationally comprising dissolved organic carbon (DOC), nitrogen (DON), and phosphorus (DOP) – is the most mobile and bioactive fraction of soil organic matter (SOM). They are collectively named dissolved organic matter components (DOMC). DOM is a critical and the most dynamic and bioavailable fraction of soil organic matter, despite typically representing less than 5% of total soil organic carbon and nitrogen pools. DOM plays multiple ecological roles: it functions as an immediate source of carbon and energy for soil microorganisms, regulates nutrient cycling and it contributes to stabilization and sequestration of organic carbon. In agricultural systems, DOM is a sensitive indicator of fertility and productivity. Crucially, global change drivers and agricultural management practices jointly

modulate DOMC dynamics: warming and nitrogen inputs can differentially alter DOC and DON through shifts in plant productivity, root exudation, microbial enzyme allocation, and sorption–desorption equilibria, while practices such as tillage and fertilization restructure soil physical and chemical environments that govern production, transport, and retention of dissolved pools. Despite continued progress in DOM research, the patterns of DOMC and their controlling factors under global change remain poorly resolved both at the global and field scales.

Therefore, the research topic chosen by mgr Tianjing Ren, remains highly relevant and well founded. The research question explores how factors such as nitrogen addition, climate warming, agricultural management practices and soil depth is essential for improving ecosystem predictions and guiding sustainable soil carbon management in agricultural soils. It represents a valuable contribution to existing knowledge in the fields of agriculture and horticulture.

Assessment of the formal side of the dissertation

The dissertation submitted for review by mgr Tianjing Ren is a collection of four thematically coherent, peer-reviewed, original scientific articles under the common title *"Factors Controlling Content and Transformations of Dissolved Organic Matter Components in Agricultural Soils at Field and Global Scales"*.

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 377 (2025): 124744. https://doi.org/10.1016/j.jenvman.2025.124744, 200 pkt. MNiSW; IF 8,4
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. https://doi.org/10.1016/j.catena.2025.108871, 140pkt. MNiSW; IF 5,7
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. https://doi.org/10.1016/j.agee.2024.109080, 200pkt. MNiSW; IF 6,0
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 (2025). https://doi.org/10.3389/fpls.2025.1668092 100pkt. MNiSW; IF 5,8

The publications comprising the dissertation were published between 2024 and 2025 (one publication in 2024 and three publications in 2025) in peer-reviewed, international English-language journals listed in the Journal Citation Reports database. The total impact factor (IF) of the submitted publications, according to the year of publication, is 25.9, and the total number of points according to the Ministry of Science and Higher Education's list of journals with ratings is 640. These are very high scientometric indicators for assessing scientific achievement, which is the basis for doctoral proceedings in the discipline of agriculture and horticulture. All publications presented in the series are collaborative works (4-6 authors) and were created in international collaboration. The PhD student is both the first author and the corresponding author of all publications. Furthermore, all articles are co-authored by dr hab. Bożena Smreczak, who served as the dissertation supervisor, and dr hab. Aleksandra Ukalska-Jaruga – co-supervisor. The PhD student's contribution to the publication, as declared and confirmed by her co-authors, was significant and amounted to 55-60%. It should be noted that these publications are the result of research financially supported by The European Joint Project COFUND (EJP SOIL) –"Towards climate – smart sustainable management of agricultural soils" (862695) and the National Science and Technology Fundamental Resources Investigation Project of China (2022FY100500).

Mgr Tianjing Ren supplemented the collection of four scientific publications comprising her scientific achievement with a descriptive study preceded by declarations from all co-authors regarding their participation in preparing the publication. Summaries in Polish and English are located at the beginning of the manuscript and introduce the reader to the most important issues constituting the dissertation's subject matter. The dissertation consists of eight chapters: introduction; objectives and hypotheses; materials and methods; results and discussion; conclusions; limitations and future directions; and references. Chapter 8 (the last) consists of copies of the scientific articles comprising the series of thematically related publications and is preceded by declarations of the author and the supervisors of the dissertation.

Because the dissertation is not in the form of a manuscript, but rather a series of publications that have undergone the publishing process, I consider it unnecessary to conduct a formal evaluation of it, nor to evaluate the attached study. It should be emphasized, however, that the study is very well edited and fully reflects the topics covered in the publications included in the dissertation.

Substantive evaluation of the dissertation

The dissertation, prepared as a single-topic collection of four articles published in renowned scientific journals from Science Direct (3 publications) and Frontiers (1 publication), is a coherent scientific description, demonstrating a high level of substantive merit. The articles

underwent a multi-stage evaluation by competent reviewers and experienced editors from individual publishers. Therefore, it is difficult to find any substantive flaws. Based on the analysis of the publications included in the assessed dissertation, it is worth emphasizing that mgr Tianjing Ren demonstrated excellent technical skills in the preparation of scientific articles.

The aim of the dissertation submitted for evaluation was to investigate the impact of nitrogen addition, climate warming, and agricultural practices on the quantity and quality of DOM, as well as how these are modified by cropping systems and soil depth. Analyses were conducted on a global scale (literature synthesis) and at the field scale (long-term experiment). As part of the main research hypothesis, the author formulated four detailed research aims and hypotheses. It specifies four specific objectives and four testable hypotheses, along with model-relevant parameters emerging from the literature.

- DOC responses to N addition are climate-dependent
- Warming lowers DOC:DON by accelerating DOC turnover
- Practices that synchronize C supply with N and limit disturbance (e.g., NM, manure, CT) produce larger and more beneficial DOC increases.
- Soil depth is a first-order organizer of DOMC, yielding more aromatic, humified dissolved pools with depth.

The research included a global meta-analysis and long-term field experiment. A global database (>6,799 observations from studies published between 1995 and 2022) supported three meta-analyses. Meta-analysis on global scale begins by establishing how added nitrogen alters DOC across contrasting moisture regimes, because humidity sets first-order constraints on microbial activity, leaching, and sorption; this provides the climatic envelope within which other drivers operate (Paper I). Then climate warming influence on DOMC was examined to test the predicted decoupling of C and N in dissolved pools (DOC vs. DON), thereby identifying the proximal biophysical controls most sensitive to temperature and moisture (Paper II). Next evaluations concerned comparison of cropland practices to locate levers that raise DOC while improving yield and lowering CO_2 intensity (Paper III). Finally, because global syntheses are surface-biased and DOP-limited, the field study was designed to fill these gaps by measuring the DOMC (DOC, DON, DOP) at three soil depths (0–30, 30–60, 60–90 cm) under rotation vs. monoculture, thereby validating how cropping system and depth co-structure DOMC quantity and quality (Paper IV).

The proposed hypotheses were verified through carefully selected laboratory analyses and extensive statistical calculations. As part of the long-term field experiment, soil properties were determined, including pH, electrical conductivity, particle-size distribution, total C and total N,

total organic C, etc., as well as the properties of dissolved organic matter (DOM, DON, and DOP). The database for the meta-analysis was compiled using appropriate inclusion criteria, data extraction, and grouping. It is important to emphasize that the PhD student demonstrated excellent knowledge of statistical tests and methods, which she used to interpret the results. Based on a comprehensive discussion of the research results and the discussions, the PhD student answered the proposed hypotheses and demonstrated that N addition reduces dissolved organic carbon (DOC) and microbial biomass carbon (MBC) but increases soil organic carbon in humid regions, whereas it raises DOC and MBC in non-humid regions, with seasonality and pH setting sensitivity (Paper I). Furthermore, warming lowers DOC:DON by accelerating DOC turnover and increasing DON and NO_3^-, with soil moisture as the dominant proxy for control (Paper II). Mgr Tianjing Ren also emphasized the importance of practices that synchronize C supply with N (NM, NS, N + straw), which outperform others on DOC-for-yield gains and CO_2 mitigation (Paper III). The global meta-analysis was complemented by results from long-term experience, based on which the author concluded that depth is the first-order organizer of DOM (declining DOC/DON/DOP; lower E4/E6, higher SUVA with depth). Management signals are subdued except at depth, where monoculture retains more DOC; DOC tracks TN/TC/DOP, DON follows DOC/depth/available P, and DOP aligns with humus/total P/available P.

The fact that mgr Tianjing Ren has taken up such a complex issue concerning factors controlling content and transformations of dissolved organic matter components in agricultural soils at field and global scales, as well as the proper interpretation of the results, accurately supported by the literature, constitute valuable advantages of the dissertation, which determine its positive assessment.

Comments of a debatable nature

Although all the articles included in the dissertation were peer-reviewed during the publication process and each constituted a separate chapter, after reviewing the dissertation I received, the following comments came to my mind as a reviewer:

- The dissertation contains minor editorial inaccuracies. In the caption for Figure 5, “significance levels” should be written “***P<0.001.” In Section 3.1, while discussing the effect of nitrogen addition on soil carbon content in humid and non-humid regions, the doctoral candidate stated that “in humid regions, DOC responses were shaped by precipitation seasonality and rose with higher SOC.” (She attributes DOC responses in humid regions to precipitation seasonality and an increase in SOC.) In my opinion, it would be worth to include a reference here to the figure presenting these results. Additionally, the figure numbering in Section 3.4 is inconsistent.

- In Section 3.3 (Effects of agricultural management practices on soil DOC), the discussion of Figure 11 omitted the statement that the addition of straw also markedly elevated CO_2 emissions. Furthermore, the doctoral student used the phrase: All management interventions significantly enhanced crop yields (Figure 11), with nitrogen fertilizer + manure (NM) producing the greatest yield improvement (145.07%) and conventional tillage (CT) showing the smallest gain (8.11%). The effect size of DOC demonstrated a robust positive linear association with both CO_2 emissions and crop yields. However, the efficiency with which DOC influenced these outcomes varied across management practices (Figure 11)". I believe that such a direct statement would require a somewhat broader approach, especially since the cited relationships and values are found only in the supplement to Article III.
- The dissertation focuses on the most mobile fraction of organic matter, operationally defined as DOMC. In Chapter 2.1.4, "Standardization and Effect Sizes," the doctoral candidate demonstrated that, in the database, DOC was determined using a variety of methods, categorized as physical and chemical methods. The chemical methods utilized different extraction solvents (e.g., distilled water, potassium chloride (KCl), or potassium sulfate (K_2SO_4)). It is well known that the type of extraction method used (different extractants and their concentrations, e.g., KCl, $CaCl_2$, K_2SO_4, borate buffer; different temperatures) often leads to divergent results. Therefore, the question arises: how did the Ph.D. student standardize the results obtained for the studies included in her dissertation? Furthermore, after analyzing the dissertation and the attached publications, I would like to hear the Author's opinion on the following: why was the DOM extraction (Article IV) performed using cold water rather than another extractant? I would like to emphasize that dissolved organic matter is often extracted, for example, with a calcium chloride solution ($CaCl_2$) rather than distilled water, as this provides more reliable and reproducible results and better reflects soil conditions – including maintaining an ionic strength similar to that of a soil solution, stabilizing soil structure, and ensuring better reproducibility of results.

I would like to emphasize that the comments mentioned above are intended to stimulate discussion and do not call into question the scientific value of mgr Tianjing Ren's dissertation as a whole. Based on an analysis of all the articles and the scientific description, I can conclude that the dissertation is complete and contains extensive material of high scientific value. The scientific description under review represents a creative and original contribution by the doctoral candidate to knowledge in the field of agriculture and horticulture.

Final Conclusion

In summary, I conclude that the dissertation submitted for review by mgr Tianjing Ren titled "Factors Controlling Content and Transformations of Dissolved Organic Matter Components in Agricultural Soils at Field and Global Scales," is of very high scientific, cognitive, and practical value, and that the substantive scope of the dissertation falls within the discipline of agriculture and horticulture. I conclude that the doctoral candidate demonstrates extensive knowledge in the scientific discipline of "Agriculture and Horticulture," as evidenced by her ability to independently conduct scientific research. This is confirmed by the very well-planned and executed analyses that form the basis of the aforementioned dissertation, as well as her co-authorship of numerous articles and presentations at conferences. I unequivocally conclude that **the dissertation meets the formal and substantive requirements for dissertations**, as specified in Article 187, paragraphs 1 and 2, of the Act of July 20, 2018, on Higher Education and Science (Journal of Laws of 2024, item 1571).

Accordingly, I request that the Scientific Council of the "Agriculture and Horticulture" Discipline at the Institute of Soil Science and Plant Cultivation – State Research Institute in Puławy accept the dissertation of mgr Tianjing Ren, and admit the doctoral candidate to the subsequent stages of the dissertation.

Furthermore, based on the review conducted, I conclude that the dissertation under evaluation is characterized by a very high level of academic merit. The quality of the publications – including the doctoral candidate's role as first author on key articles – along with the excellent description in the manuscript submitted for evaluation, further confirms her significant contribution and commitment to the research. The coherence of the series of articles and their high scientific value constitute a strong argument for giving this thesis special recognition.

In light of the above, I recommend that the reviewed dissertation be awarded an honor.

dr hab. inż. Magdalena Banach-Szott

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MAGDALENA
BANACH-SZOTT
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