

Biogeosciences Discuss., author comment AC1
<https://doi.org/10.5194/bg-2021-53-AC1>, 2021
© Author(s) 2021. This work is distributed under
the Creative Commons Attribution 4.0 License.



Reply on RC1

Heleen Deroo et al.

Author comment on "Effect of organic carbon addition on paddy soil organic carbon decomposition under different irrigation regimes" by Heleen Deroo et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-53-AC1>, 2021

Reviewer 1

This manuscript investigates how the addition of exogenous OC influences dissolution and mineralization of native SOC in paddy soils in function of water management, with particular attention to the role of the co-release of Fe-bound SOC. The present data are interesting and novel, and the experiments are well designed to provide the useful insights in the complex priming effect in soil.

Response: Thank you very much for your appreciation and very valuable suggestions to improve the manuscript!

Please find some more detailed comments below.

- **Lines 17, 87, the full name of "Feox" is inconsistent. I recommend that the "oxalate-extractable Fe" is more accurate than "reducible-Fe".**

Response: We agree that there is no one-on-one match between oxalate extractable Fe and reducible Fe: We therefore would replace "reducible" by "oxalate-extractable" in Line 17.

- **Lines 81-83, it is suggested to add the Fe reduction derived production of hydroxyl radicals in the Discussion section. During this process, the production of hydroxyl radicals is certainly essential in the priming effect of native OC mineralization.**

Response: Thank you for this very interesting addition. Although we have not measured levels of hydrogen peroxide (H₂O₂) or hydroxyl radicals, the production of hydroxyl radicals may certainly contribute to anaerobic decomposition. However, we doubt that Fenton chemistry would have functioned as major mechanism leading to positively primed emissions upon enhanced Fe reduction. In the first place, observed priming effect coefficients for gaseous C emissions were lower than for dissolution (and were in fact often negative) (Fig. 8). This suggests that the potential contribution of the mentioned mechanism (which would mainly impact gaseous emissions, in particular CO₂ emissions) is

rather low as compared to other avenues by which maize addition could have stimulated native SOC mineralisation. In addition, the larger share of C emitted as CH₄ from maize-amended pots than from control pots (Fig. 4) rather contradicts the idea that the production of hydroxyl radicals would be considerably higher in amended pots than in controls without amendment – as these would lead to relatively higher CO₂ emissions (not CH₄).

Nevertheless, we agree that it is certainly relevant to mention Fenton chemistry in Section 4.2, and we propose to add the following after Line 418.

“Lastly, enhanced Fe reduction might also abiotically mediate positive priming of native SOC mineralisation through Fenton reactions that lead to the production of reactive hydroxyl radicals (Yu & Kuzyakov, 2021). However, as priming effect coefficients for gaseous C emissions were low as compared to those for dissolution (Fig. 8), and since the relative contribution of CO₂ to gaseous C emissions in maize-amended pots was lower than in control pots (Fig. 4), it seems unlikely that the potentially enhanced production of hydroxyl radicals would have played a considerable role in stimulating SOC decomposition in maize-amended pots.”

- **Line 96, I think that the total Fe and dissolved Fe are critical and should be provided here.**

Response: Thank you for your suggestion. However, we tend to disagree concerning the relevance of total Fe, as the redox-active fraction of total Fe is more important than the total amount of Fe to support our objectives, so that we considered oxalate-extractable Fe the most relevant measure for Fe here (van Bodegom et al., 2003). Equivalent of dissolved Fe, furthermore, are in fact illustrated in function of time in Figure 2 (controls without maize). The Fe forms of the two soils used in this study were previously analysed by Mössbauer analysis, yielding the proportion of Fe³⁺ versus Fe²⁺ in various Fe-bearing minerals (Akter et al., 2018). We think that this (quite scarce) information would provide sufficient insight into potential pools of reducible Fe³⁺ in the studied soils.

- **Lines 156-158, why the authors did not use the typical CBD method to estimate the content of Fe-bound OC?**

Response: We could not use the citrate bicarbonate dithionite (CBD) method because this extractant contains C (in both bicarbonate and citrate). Moreover, crystalline pedogenic Fe, which is included in CBD extracts, is not very reducible (van Bodegom et al., 2003). Poorly crystalline Fe forms the most likely source of reducible Fe and is typically quantified by means of ammonium oxalate extraction. However, since oxalate again contains C, we used hydroxylamine instead, which approximately targets the same Fe forms. We are thus convinced that hydroxylamine is a better extractant than CBD for reducible Fe in flooded soils, including for the C associated with this poorly crystalline Fe fraction. Any C that is associated with CBD-extractable crystalline Fe (if quantifiable) is also less likely to potentially contribute to enhanced dissolution of SOC, precisely because little crystalline Fe is subjected to reductive dissolution.

- **Lines 366-376, root exudates can disrupt the mineral-organic associations directly or indirectly by driven redox-active bacterial communities, which are the predominant control over soil C dissolution. In the Discussion, this point should be considered.**

Response: Thank you for this pertinent remark. We propose to make the following

addition in Line 373: "Next to the direct contribution of rhizodeposition, some root photosynthates (e.g. oxalate and citric acid) can also indirectly increase DOC levels by promoting the release of Fe-bound SOC in the rhizosphere through their strong metal-complexing capacity (Keiluweit et al., 2015; Yu et al., 2017). This mechanism was, however, likewise restricted here considering its local impact and the juvenile age of the rice plants."

- **Line 63, 505, "Fe hydroxides"; Line 74, 88, "Fe³⁺ oxides"; Line 88, "Fe oxides"; Line 364, "Fe oxyhydroxides". The names of Fe minerals are very complexed. In fact, "Fe (oxyhydr)oxides" is more common than the above names.**

Response: We totally agree that our naming of Fe³⁺ was inconsistent. Since the term "Fe oxides" encompasses both Fe oxides (e.g. hematite), Fe hydroxides (e.g. ferrihydrite) and Fe oxyhydroxides (e.g. goethite), we propose to use the term "(pedogenic) Fe oxides" throughout the manuscript, and we would clearly introduce its interpretation/definition throughout the manuscript in Line 63, where the term "Fe hydroxides" would be replaced by "Pedogenic Fe³⁺ oxides, hydroxides and oxyhydroxides (hereafter collectively referred to with "Fe oxides")". We would then replace any further reference to Fe oxides in the manuscript with the term "Fe oxides".

References

Akter, M., Deroo, H., De Grave, E., Van Alboom, T., Kader, M. A., Pierreux, S., Begum, M. A., Boeckx, P. & Sleutel, S. (2018). Link between paddy soil mineral nitrogen release and iron and manganese reduction examined in a rice pot growth experiment. *Geoderma*, 326, 9-21.

Keiluweit, M., Bougoure, J. J., Nico, P. S., Pett-Ridge, J., Weber, P. K. & Kleber, M. (2015). Mineral protection of soil carbon counteracted by root exudates. *Nature Climate Change*, 5(6), 588-595.

van Bodegom, P. M., van Reeve, J. & Denier van der Gon, H. A. C. (2003). Prediction of reducible soil iron content from iron extraction data. *Biogeochemistry*, 64(2), 231-245.

Yu, G. & Kuzyakov, Y. (2021). Fenton chemistry and reactive oxygen species in soil: Abiotic mechanisms of biotic processes, controls and consequences for carbon and nutrient cycling. *Earth-Science Reviews*, 214, 103525.

Yu, G., Xiao, J., Hu, S., Polizzotto, M. L., Zhao, F., McGrath, S. P., Li, H., Ran, W. & Shen, Q. (2017). Mineral availability as a key regulator of soil carbon storage. *Environmental Science & Technology*, 51(9), 4960-4969.