Authors' response to the review comments

Title: Differences in organic carbon fractions and stability explain limited accumulation in loam and sandy loam under greenhouse conditions

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Dear Prof. Luisella Celi,

We sincerely thank you for the time and effort you devoted to evaluating our manuscript, as well as for your constructive comments and suggestions. Your valuable feedback has helped us further improve the clarity and overall quality of the manuscript.

Following your suggestions, we carefully revised the manuscript to improve its clarity and readability. In particular, abbreviations and acronyms throughout the manuscript were systematically checked and standardized to ensure consistency and clarity. In addition, all comments raised by the reviewers have been carefully addressed and revised accordingly.

The issue regarding the discussion section was also raised by the second anonymous reviewer (Comment 15). In response, we have rewritten the discussion section to make it more concise and more closely focused on the data presented in the manuscript.

All revisions are highlighted in red font in the revised manuscript. A detailed point-by-point response to all comments and suggestions is provided below. We hope that the revised version now meets the requirements for publication in ***SOIL***.

Reviewer: Yi Cheng

Overall comments:

Greenhouses are characterized by enclosed spaces, high nutrient inputs, and frequent irrigation, which likely result in mechanisms of SOC accumulation and stabilization that differ from those in open-field systems. Therefore, the long-term evolution and dominant mechanisms of SOC under greenhouse conditions remain to be further explored. This manuscript addresses this issue by systematically analyzing the molecular structure of SOC, the distribution of different organic carbon fractions, and their relative contributions to carbon pool stability across varying durations of manure application in greenhouse soils. Overall, the research question is well defined, the experimental design is generally sound, and the data provide solid support. The study offers valuable insights into understanding long-term SOC dynamics and optimizing organic fertilizer management in intensive greenhouse systems. However, improvements are still needed in the rigor of argumentation and the precision of academic writing. Minor revision is recommended. Specific comments are as follows:

Response:

We sincerely thank Reviewer Yi Cheng for the time and effort spent reviewing our manuscript, which has greatly improved the overall quality of our work. We have carefully considered all comments and made the necessary revisions accordingly. Detailed responses to each comment are provided below.

Comment 1:

The manuscript points out that organic manure inputs are high under greenhouse conditions, but SOC accumulation remains below expectations. It is suggested to briefly explain the possible reasons why high inputs have not resulted in corresponding SOC increases, or to clearly state that the underlying mechanisms remain unclear, so as to better introduce the research gap and objectives of this study.

Response:

We sincerely appreciate this valuable suggestion. In the revised manuscript (Lines 86–89), we have added a clear explanation to address why high manure inputs in greenhouse soils do not necessarily lead to proportional SOC accumulation. Specifically, we now emphasize that elevated temperature and moisture, frequent irrigation, and intensive tillage under greenhouse conditions collectively accelerate organic matter decomposition and carbon mineralization.

Comment 2:

The statement that 'most greenhouse studies last only 1–10 years, and short-term stability does not represent the final stage' requires supporting references.

Response:

A supporting reference has been added. Das et al. (2023b) has been cited after Line 92. This long-term manure experiment demonstrates that SOC stabilization occurs over much longer timescales than the typical 1–10-year greenhouse trials, supporting our statement that short-term SOC stability does not represent the final stage.

Comment 3 (Section 3.1):

This section provides numerous numerical values describing SOC content and stock changes in loam and sandy loam. While detailed, it appears somewhat lengthy and may obscure the main findings. Consider summarizing or emphasizing key patterns.

Response:

Section 3.1 has been revised to streamline numerical descriptions and to emphasize the major patterns. The revised text now highlights: (i) the stabilization of SOC content and stock in the loam after approximately 20 years, (ii) the substantially lower SOC accumulation in the sandy loam despite similar manure inputs, and (iii) the consistent decline in SOC sequestration efficiency in both soils as application years increase. These revisions improve readability while retaining the essential quantitative information.

Comment 4 (Line 362):

The study did not include microbial community sequencing or functional analysis. Therefore, this discussion point is only indirectly supported and may weaken the focus of the argument. It is suggested that the authors narrow the discussion scope or explicitly clarify that the explanation is speculative and based on previous studies, to avoid logical inconsistency with the present data.

Response:

We agree that the present study did not include microbial community sequencing or functional analyses, and therefore the previous discussion regarding microbial mechanisms was not directly supported by the experimental data.

To avoid potential overinterpretation and to maintain consistency with the available evidence, we have removed the speculative statements related to microbial mechanisms and narrowed the scope of the discussion to focus on the results directly supported by the data. The revised text has been modified accordingly in the manuscript.

Comment 5:

The sentence describing how lower clay and silt contents in the sandy loam reduce SOC protection is grammatically and logically awkward. The relationship between particle-size composition and SOC protection is not clearly conveyed. Please revise for smoother and more precise expression.

Response:

The original sentence describing the relationship between particle-size composition and SOC protection was indeed unclear. In the revised manuscript, we have rewritten this section to improve both grammatical clarity and logical explanation. Specifically, we clarified how the lower clay and silt contents in sandy loam weaken mineral-associated and physical protection mechanisms for SOC, which helps explain the observed differences in SOC chemical composition between the two soil textures. The revised text can be found in Lines 391–393 of the manuscript.

Comment 6 (Section 2.2):

The sampling description lacks clarity. The authors mention 6–8 samples per group (totaling 90), but later indicate that only 42 samples were retained after screening. Although selection criteria are mentioned, the numerical transition appears abrupt, requiring careful reading to understand. Consider improving logical continuity.

Response:

The sampling description in Section 2.2 has been revised to improve logical continuity and clarity. The updated text now explicitly explains the initial collection of 90 samples and the subsequent screening process based on soil texture consistency within each region and pH constraints. This clarification makes the numerical transition from 90 to 42 samples more transparent.

Comment 7:

The manuscript acknowledges several limitations but should additionally recognize that the space-for-time substitution (chronosequence) approach may introduce uncertainty, as initial soil differences among greenhouses can affect the SOC baseline. This assumption should be explicitly acknowledged.

Response:

This section has been revised to explicitly acknowledge the uncertainty associated with the chronosequence (space-for-time substitution) approach. We now note that, although unified management conditions and sample-screening procedures were applied, initial soil differences and microenvironmental variability among greenhouses may still influence the SOC baseline and confound the interpretation of long-term patterns. In our study region, all greenhouses belong to the same village collective and were gradually expanded over time into a coherent production system. This developmental pattern provides a higher degree of comparability across sites and helps reduce confounding effects related to disparate management histories, while our screening procedures further excluded individual outlier greenhouses with inconsistent practices. In addition, the limitations related to the absence of controlled experiments on manure type or dosage, the lack of submicron-scale structural characterization of mineral–organic complexes, and the absence of microbial community or functional data have been integrated into a unified and clearer paragraph. The revised text has been added to Lines 459–475 of the manuscript.

Comment 8:

The discussion alternates between the mechanisms of physical protection and chemical recalcitrance, but it does not clearly identify which mechanism predominates under greenhouse conditions.

Response:

The discussion has been revised to clarify the predominant mechanisms of SOC stabilization under greenhouse conditions. A summary statement has been added to the concluding part of the Discussion indicating that mineral-associated physical protection predominates in loam soils, whereas chemical recalcitrance plays a relatively greater role in sandy loam soils with limited mineral binding capacity (Lines 455–458).

Comment 9:

The manuscript frequently cites general conclusions from open-field studies; however, greenhouse soils exhibit distinct hydrothermal characteristics. It is recommended to further emphasize the mechanistic differences identified in this study compared with open-field systems.

Response:

This section has been revised to explicitly highlight the mechanistic differences between greenhouse and open-field soils. We now clarify that, although both systems receive organic inputs, their contrasting hydrothermal conditions fundamentally alter SOC decomposition dynamics and stabilization pathways. The revised text emphasizes that open-field soils experience lower temperature and moisture, which slow organic matter decomposition and promote MAOC as the dominant long-term stabilization mechanism. In contrast, greenhouse soils are exposed to elevated hydrothermal conditions that enhance microbial activity, accelerate the turnover of labile carbon, and shorten the residence time of POC, thereby reshaping both the sequence and efficiency of precursor–product transformations. These revisions strengthen the conceptual distinction between the two systems and better articulate the novel mechanistic insights provided by our study. The revised paragraph appears in Lines 372–376.

Reviewer #1

Overall comments:

The manuscript of Tan et al. investigates how soil organic carbon fractions and chemical forms vary with manure application duration in greenhouse soils with diverging textures. The conditions in greenhouses are warmer, and management is intensive, which may result in carbon accumulation patterns that differ from those in the field. The data presented are comprehensive, and the interpretation considers different pathways of C stabilization. In addition, combining physical and chemical measures of soil carbon is a valuable approach. There is still some room for improvement regarding clarity. In particular, many abbreviations are used; some are commonly known, but some of them should be introduced more clearly in the introduction (full name and meaning), and the meaning could again be more directly connected in the discussion (e.g., for the stability indexes, for them also Figure 5cd was not entirely clear) to help the reader. In general, the result and discussion could be slightly shortened by checking for repetition of result descriptions in the discussion and in the argumentation. If needed, some of the figures could also be moved to the SI (e.g. correlation figures).

Response:

We sincerely thank the reviewer for the careful and constructive evaluation of our manuscript. The comments and suggestions have been extremely helpful in improving the clarity, rigor, and overall presentation of the study. We have carefully considered each comment and revised the manuscript accordingly. All changes have been implemented in the revised version, and detailed point-by-point responses are provided below.

Comment 1: L.29 and L.63

A/OA description is missing. First occurrence of the abbreviations (A/OA, ARM) in the main manuscript, please add the description/meaning.

Response

The descriptions of the abbreviations A/OA and ARM have been added at their first occurrence in the manuscript (Lines 29 and 64). In addition, the definition of AI (aromaticity index) has also been clarified in the revised text.

Comment 2: L.66

How does this example (tropics) relate to the study? I suggest removing examples that do not directly support the arguments.

Response

We agree with the reviewer that the regional example was not directly relevant to the focus of this study. Therefore, we have removed the comparison between tropical and non-tropical regions and revised the sentence to emphasize the role of hydrothermal conditions in regulating the effectiveness of long-term manure application on SOC accumulation, which is more consistent with the environmental context of greenhouse systems investigated in this study.

Comment 3: L.74

How does this example (rice cultivation) relate to the study? I suggest removing examples that do not directly support the arguments.

Response

We agree with the reviewer that the example related to rice cultivation was not sufficiently relevant to the present study. Accordingly, we have removed the rice-related example from the revised manuscript to keep the Introduction focused on mechanisms directly applicable to greenhouse soils under manure application.

Comment 4: L.117–120

This is a repetition, please remove.

Response

We have removed the repeated text as suggested.

Comment 5: L.142

Word “aged” is unspecific, state more directly that you refer to the duration for which manure was applied in these greenhouses.

Response

We agree that the term “aged” was ambiguous. The sentence has been revised to explicitly indicate the duration of manure application, replacing “aged” with “years of continuous manure application” to improve clarity (Line 147).

Comment 6: L.194

Acquisition time?

Response

The acquisition parameters of the 13C CPMAS solid-state NMR measurements have been clarified and fully specified in the revised Methods section. In CPMAS experiments, the contact time refers specifically to the duration of magnetization transfer during the cross-polarization process and is therefore conceptually distinct from acquisition time. In the present study, the acquisition conditions are defined by the recycle delay and the total number of scans, which determine the effective signal accumulation and signal-to-noise ratio. Accordingly, we have added detailed information on the magic angle spinning rate (5 kHz), contact time (1 ms), recycle delay (0.8 s), and the total number of scans (140,000 scans per sample) (Lines 203–205). These parameters together ensure reliable spectral quality and reproducibility for SOC chemical structure characterization.

Comment 7: L.198:

With which NMR regions were the indices calculated?

Response

We agree with the reviewer's comment. The Methods section has been revised to clarify that the relative contribution of each SOC functional group was determined by integrating the corresponding ^{13}C NMR spectral regions. Specifically, the chemical shift regions were defined as follows: alkyl C (0–45 ppm), O-alkyl C (45–110 ppm), aromatic C (110–160 ppm), and carbonyl C (160–220 ppm) (Lines 205–207).

Based on these relative intensities, three SOC stability indicators were explicitly defined and calculated as follows:

The aromaticity index (AI) was calculated as:

AI = Aromatic C / (Alkyl C + O-alkyl C + Aromatic C)

The hydrophobicity index (HI) was calculated as:

HI = (Alkyl C + Aromatic C) / (O-alkyl C + Carbonyl C)

The ratio of alkyl C to O-alkyl C (A/OA) was calculated as:

A/OA = Alkyl C / O-alkyl C

These formulas have now been explicitly provided in the Methods section as Eqs. (5)–(7) (Lines 207–213) to improve clarity and avoid ambiguity.

Comment 8: L. 226-229:

The use of SOCs as an abbreviation for sequestration here is confusing. For the other variables (SOC content and SOC stock), you use the full term, which is easier to understand. So, I advise also using the full term for SOC sequestration and dropping this additional abbreviation from the manuscript. Also, the sequestration is shown in Figure 1c, currently missing after the first mention of SOCs.

Response

The manuscript has been revised to improve clarity and consistency in terminology. The abbreviation "SOCs" has been removed throughout the manuscript and replaced with "SOC sequestration." In addition, Figure 1c is now cited at the first occurrence of SOC sequestration. To ensure clarity, Section 3.1 has been substantially rewritten.

Comment 9: L. 278–286

Can you add literature references for the NMR functional group description?

Response

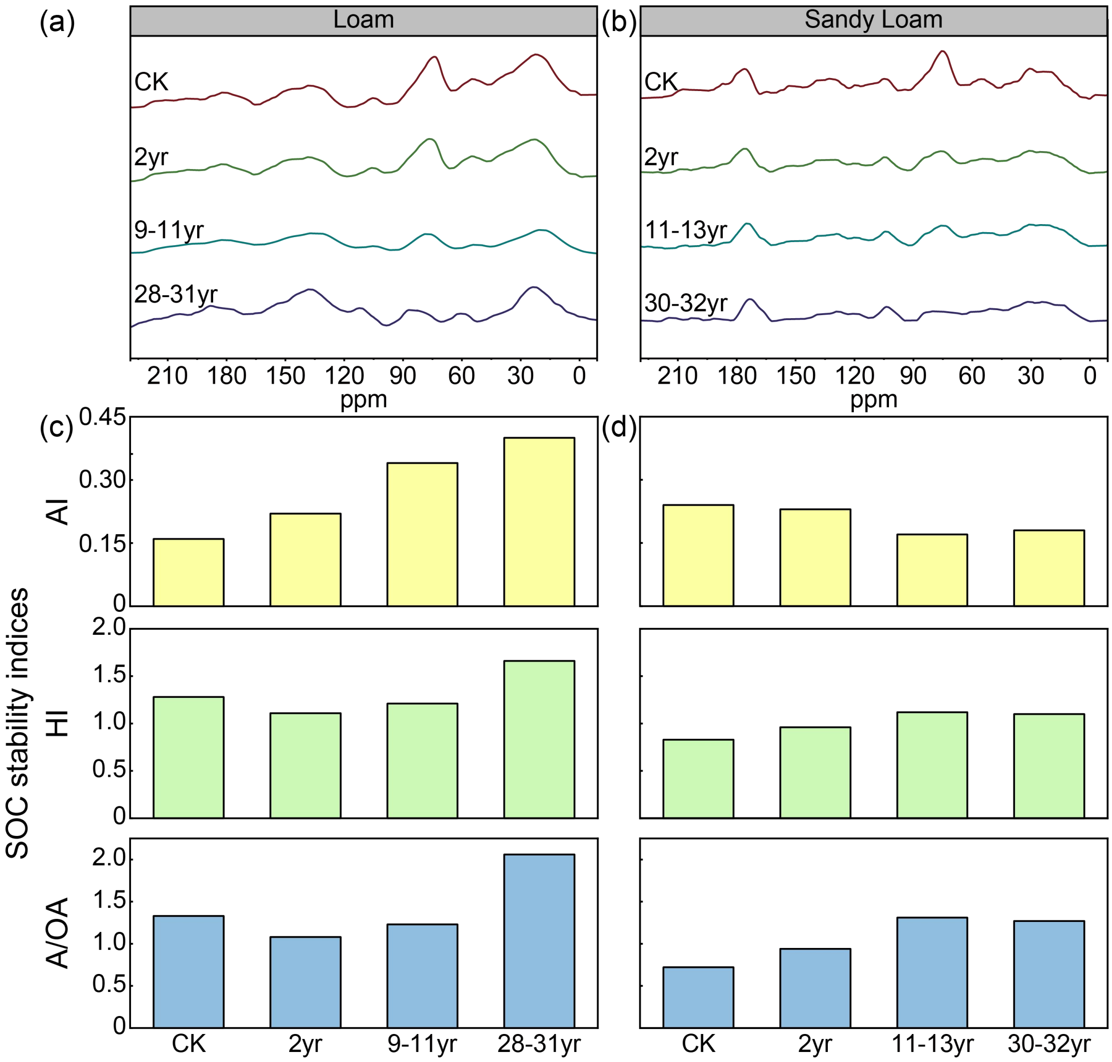
We agree with the reviewer's suggestion. Relevant references have now been added to support the interpretation and description of the ^{13}C NMR functional groups in this section (Line 297).

Comment 10: Fig. 5c and 5d

The visualization of the different ratios as stacked boxes is unclear. The ratios don't add up to a total, and this visualization makes it difficult to get the actual information about the ratios. Also, the additional proportional change is adding complexity. Maybe you can visualize the different ratios as different points (plus standard error) per treatment (no boxes)? Then, the change should be visible without additionally plotting it.

Response

We thank the reviewer for this constructive suggestion and agree that the previous visualization (stacked boxplots) could be confusing because these ratios are not additive quantities. We have therefore revised Fig. 5c and 5d to improve interpretability. Specifically, we now present each ratio index (e.g., A/OA, HI, and AI) as one value per treatment (individual data points), rather than as stacked boxplots.



Comment 11: L. 308

This paragraph is now discussing correlations between physical fractions and chemical composition. Could it be a new section itself?

Response

Following this suggestion, the paragraph has been reorganized into a separate subsection entitled "3.5 Correlations between SOC fractions and chemical composition." This subsection presents the relationships between SOC fractions and the ^{13}C NMR functional groups as well as the stability indices (AI, HI, and A/OA), which improves the clarity and logical structure of the Results section. The revised text now appears in Lines 319–334 of the revised manuscript.

Comment 12: L. 348

Literature references?

Response

The sentence has been revised and appropriate literature references have been added to support this statement. The revised sentence now reads:

"Manure application significantly increased all SOC fractions, with MAOC emerging as the dominant stable pool (Figs. 2, 3), consistent with previous findings highlighting MAOC's central role in long-term carbon sequestration (Mustafa et al., 2022; Zhou et al., 2024)."

The revised text appears in Lines 356–358 of the revised manuscript.

Comment 13: L. 382-384

Literature references?

Response

The sentence has been revised and appropriate literature references have been added to support the description of the transformation and stability of different 13C NMR functional groups. The revised sentence now reads:

"O-alkyl C and alkyl C are more readily biodegraded than aromatic and carbonyl C and can be transformed into more stable carbonyl- and aromatic-enriched structures via microbial oxidation and free-radical reactions (Panettieri et al., 2014; Kubar et al., 2018; Lan et al., 2022)."

The revised text appears in Lines 380–383 of the revised manuscript.

Comment 14: L. 395

This last sentence of the paragraph is stating the opposite of the discussion before (e.g. L.380)? Please clarify.

Response

The reviewer is correct that the previous version could create confusion regarding the trends of SOC functional groups. To address this issue, the paragraph has been substantially revised and reorganized. The revised discussion clarifies that SOC stabilization followed texture-dependent pathways. Specifically, in the loam, SOC stability increased mainly with higher proportions of aromatic C and carbonyl C, whereas in the sandy loam SOC stabilization was more closely associated with the increased contribution of alkyl C and enhanced hydrophobicity. This revision resolves the potential inconsistency and aligns the discussion with the results presented in Fig. 5 and Table 2. The revised text now appears in Section 4.2 of the revised manuscript.

Comment 15:

Is the correlation of the fractions based on the fraction concentrations or proportions? Please clarify the units in the Figure description (also in the other correlation Figure 4).

Response

The correlations were calculated using both the concentrations of SOC fractions (g kg^{-1}) and their relative proportions to SOC. SOC fractions (SOC, EOC, DOC, MBC, cPOC, fPOC, and MAOC) represent concentrations, whereas EOC/SOC, DOC/SOC, MBC/SOC, cPOC/SOC, fPOC/SOC, and MAOC/SOC represent their relative proportions to SOC. To clarify this point, the captions of Figure 4 and Figure 6 have been revised to explicitly distinguish between concentrations and proportions and to specify the corresponding units.

Reviewer #2

Overall comments:

This paper investigates the characteristics of SOC fractions (contents, chemistry and stability) under greenhouse conditions with various durations of manure addition (2 to 50 years) in two contrasted soil textures. This article is interesting as such long timespans are quite rare; it uses many sites and combines both physical fractions (POC and MAOC) and stability-defined fractions.

The differences between the two soils are rather marked, as the new equilibrium in loam reaches high SOC levels and takes at least 20 years to establish, versus only 2 years in the sandy loam soil with smaller SOC accumulation. The chemical composition of the SOC also varies between the soils.

Overall, the article is nice and well written, although indices could be made more accessible to the reader for better understanding; physical vs other fractions should also be separated more carefully. Please find below a few suggestions.

Response:

We thank the reviewer for the positive and constructive assessment of our manuscript. We appreciate the helpful suggestions regarding the clarity of SOC indices and the presentation of different SOC fractions. In response, we have revised the manuscript to improve the definition and interpretation of the indices used and to more clearly distinguish physical SOC fractions from other property-based carbon pools. These changes were made to enhance clarity and readability. The detailed responses to the specific comments are provided below.

Comment 1:

L.29: what is A/OA?

Response:

We have revised the text at Line 29 to explicitly define A/OA as the ratio of alkyl C to O-alkyl C. The sentence now reads: in sandy loam, alkyl C increased, elevating alkyl C to O-alkyl C (A/OA) and the hydrophobicity index (HI).

Comment 2:

L.32: you introduced POC but not fPOC: fine? free?

Response:

In this study, fPOC refers to fine particulate organic carbon. To avoid potential confusion, the text has been revised to clearly define fPOC (fine particulate organic carbon) at its first occurrence in Line 32. In addition, cPOC (coarse particulate organic carbon) has also been defined at its first occurrence in Line 34 of the revised manuscript.

Comment 3:

L.33: Aromatic molecules are usually less labile, I am surprised it ‘stimulates’ EOC. Could you clarify? Also, I understand you mean that POC will later adsorb on the mineral phase and form MAOC so it ‘enhances’ MAOC, but you can state it more clearly.

Response:

We agree with the reviewer’s concern and have revised the sentence to avoid implying that aromatic molecules directly stimulate labile carbon pools. In the revised text, increases in SOC aromaticity (AI) and hydrophobicity (HI) are described as occurring concurrently with changes in DOC, EOC, and POC, rather than as direct causal effects. This wording is consistent with the structural equation model, which indicates that these carbon pools collectively contribute to MAOC formation in loam through integrated pathways, while in sandy loam MAOC formation is mainly associated with EOC and cPOC contributes to SOC independently without a significant pathway to MAOC. The sentence has been revised accordingly (Lines 32–36).

Comment 4:

L.63: again, define A/OA here.

Response:

The abbreviations A/OA and AI have now been defined at their first occurrence in the main text by adding their full names (alkyl C to O-alkyl C ratio and aromaticity index, respectively) at Line 64. The text has been revised accordingly

Comment 5:

L.121: ‘22–36 °C’ is not an average temperature, except if you are presenting the result under the form 'Wujianfang–Yangshibao'. Same for nighttime.

Response:

The temperature description has been revised to avoid using 'average' for a temperature range. The text now states that daytime and nighttime temperatures ranged from 22 to 36 °C and from 15 to 18 °C, respectively (Line 121). The text has been revised accordingly.

Comment 6:

L.134: you can add the durations here, so we know how many groups were studied (although it is in the Table 1).

Response:

The manure application durations and the number of experimental groups at each site have now been explicitly added to the main text at Line 135 to clarify the study design. Although this information was previously provided in Table 1, it is now stated in the text to improve clarity and readability. The text has been revised accordingly.

Comment 7:

L.141: if I get it well, more than half of the samples do not match your criteria of soil texture and pH. While having these criteria is interesting to keep homogeneity in the soil properties, how do you ensure the results you present after can be applied to greenhouse soils if half of them are not covered by the conditions of your experiments?

Response:

Thank you for raising this important point. The 90 samples were initially collected to ensure adequate replication given the high spatial heterogeneity of greenhouse soils. Because this study adopts a chronosequence (space-for-time substitution) approach, it is essential that sites are comparable in inherent soil properties. Therefore, screening based on particle-size distribution and soil pH was applied to minimize confounding effects from large variations in soil texture or extreme pH conditions.

After screening, 42 samples (3–4 replicates per duration group) remained and were used for SOC fractionation and 13C NMR analyses. We have revised the

Methods section to clarify that the conclusions of this study primarily apply to greenhouse soils with loam or sandy loam texture and near-neutral pH conditions (Lines 137–151).

Upon re-examination of the particle-size data, we also identified that the silt and clay fractions were inadvertently interchanged in the original manuscript, which caused an apparent inconsistency with the predefined texture criteria. This was a reporting error only; the particle-size measurements themselves are correct. The soil texture classification has now been recalculated using the correct values according to the USDA soil texture triangle, and the tables have been revised accordingly. Importantly, this correction does not affect the analyses or the main conclusions of the study.

Comment 8:

L.159: I think it would be useful to clarify which fractions are complementary (POC and MAOC), and which are just corresponding to properties (EOC, DOC, MBC). Having them all presented together can be confusing.

Response:

We agree that POC and MAOC represent complementary physical SOC pools, whereas EOC, DOC, and MBC correspond to carbon lability and microbial activity rather than discrete or mutually exclusive SOC pools.

To avoid potential conceptual ambiguity, we have revised the Methods section to explicitly distinguish between these two categories and to clarify their different analytical roles. Specifically, the Methods section now states:

'We quantified (i) complementary physical SOC pools obtained by physical fractionation—POC (coarse particulate organic carbon, cPOC, and fine particulate organic carbon, fPOC) and MAOC—which together represent SOC stored in particulate versus mineral-associated forms, and (ii) labile C indicators—EOC, DOC, and MBC—which reflect short-term bioavailable and microbially mediated C dynamics rather than mutually exclusive SOC pools. These two categories were jointly analyzed to evaluate how long-term manure application influences both SOC accumulation and turnover in greenhouse soils.'

This clarification ensures that physically defined SOC pools and labile carbon indicators are conceptually separated, while also explaining why they are presented together in the analysis. These revisions have been incorporated in the Methods section (Lines 166–172) of the revised manuscript.

Comment 9:

L.160: from this, I guess cPOC and fPOC stand for coarse and fine, but you should add it.

Response:

We agree with the reviewer. The abbreviations cPOC and fPOC have now been explicitly defined as coarse particulate organic carbon and fine particulate organic carbon, respectively, at their first occurrence in the Methods section (Line 167) of the revised manuscript.

Comment 10:

L.164: you could add what the fumigation agent is.

Response:

The Methods section has been revised to specify that ethanol-free chloroform vapor was used as the fumigation agent in the fumigation–extraction procedure (Vance et al., 1987). This information has been added in the Line 173 of the revised manuscript.

Comment 11:

L.198: you can add more information about these indices: in particular, formula, extreme values and their interpretation.

Response:

We agree with the reviewer's comment. The Methods section has been revised to clarify that the relative contribution of each SOC functional group was determined by integrating the corresponding ^{13}C NMR spectral regions. Based on these relative intensities, three SOC stability indicators were explicitly defined and calculated as follows:

The aromaticity index (AI) was calculated as:

AI = Aromatic C / (Alkyl C + O-alkyl C + Aromatic C)

The hydrophobicity index (HI) was calculated as:

HI = (Alkyl C + Aromatic C) / (O-alkyl C + Carbonyl C)

The ratio of alkyl C to O-alkyl C (A/OA) was calculated as:

A/OA = Alkyl C / O-alkyl C

These formulas have now been explicitly provided in the Methods section as Eqs. (5)–(7) (Lines 207–209) to improve clarity and avoid ambiguity.

Comment 12:

L.230: while this is correct, it feels a bit strange to compare the result at 20 years in loam vs at 2 years in sandy loam – even though the value doesn't change much after 2 years. Either compare similar durations, or state clearly that you do it this way because the equilibrium has been reached.

Response:

We agree that directly comparing SOC values at different application durations may be confusing. In the revised manuscript, we have therefore removed the explicit comparison between sandy loam and loam at mismatched durations. The Results section now describes SOC content and stock in the sandy loam independently, focusing on their temporal pattern within this soil type. This approach is explicitly justified in the main text by stating that SOC in the sandy loam reached an apparent equilibrium after approximately 2 years of manure application, whereas SOC in the loam continued to increase and approached equilibrium only after around 20 years. The text has been revised accordingly. To clarify this point, we have added a sentence explaining the rapid stabilization of SOC in the sandy loam in the revised manuscript (Line 244).

Comment 13:

L.250: I don't understand well Fig.2 a and b. It is the 'content and variations of SLOCF and POC, MAOC' for loam and sandy loam soils: content at which duration? Also, you talk about 'reductions' in sandy loam 'relative to loam': to me, reduction means it was higher and decreased. Here, it seems you mean it is smaller, does it? Apologies if I am misunderstanding this.

Response:

In Fig. 2a and b, the values do not represent a specific manure application year. Instead, they show the overall distributions of SOC fractions using all available application durations for each soil type. We have revised the Results text to state this more clearly.

In addition, we replaced the term 'reduction' with 'lower than' to avoid confusion, because the intention was to indicate smaller contents in sandy loam than in loam, rather than a temporal decrease. These revisions were made to improve clarity and consistency with Fig. 2 (Lines 263–265).

Comment 14:

L.253: I am not comfortable with comparing fractions that are not complementary. POC and MAOC belong together, as complementary physical fractions, but not the others as they are not extracted and measured the same way.

Response:

The sentence that ranked SOC fractions across different fractionation schemes has been removed to avoid inappropriate comparisons between non-complementary fractions. The paragraph has been revised accordingly, and the results are now described within their respective fractionation frameworks.

Comment 15:

Discussion: the whole part is a bit too long, the reader ends quite lost after some time, especially when discussing the chemical composition of SOC. I think this can be made clearer, maybe shorter.

Response:

We agree with the reviewer that the original Discussion section was overly long and that the interpretation of SOC chemical composition could be difficult to follow. To address this concern, we have substantially revised and streamlined the Discussion to improve clarity and logical structure.

In the revised version, the discussion of SOC chemical composition (Section 4.2) is more concise and mechanism-focused, emphasizing only the key transformations relevant to SOC stabilization. Interpretation of texture-related differences is now mainly integrated into the correlation analysis (Section 4.3) and the pathway synthesis (Section 4.4), rather than being repeatedly stated across sections.

Specifically, we reorganized the Discussion into four clearly defined subsections (Sections 4.1–4.4).

Section 4.1: Effects of manure application on SOC fractions in greenhouse

The former Section 4.1, which combined SOC fractions and chemical structure, was refocused exclusively on SOC fractions (POC, MAOC, EOC, DOC, and MBC). The key observation that SOC reached an apparent equilibrium after approximately 20 years in loam but after about 2 years in sandy loam was retained and explicitly framed as a texture-dependent equilibration pattern, thereby avoiding confusing comparisons across mismatched durations. Examples not directly supported by the present dataset (e.g., microbial functional gene case studies) were removed, while DOC and MBC were retained as process-related indicators with limited contribution to total SOC.

Section 4.2: Effects of manure application on SOC chemical composition in greenhouse

The discussion of SOC chemical composition based on ^{13}C NMR was separated from the former Section 4.1 and consolidated into an independent subsection. This section was shortened and streamlined by removing repetitive descriptions and merging overlapping explanations of functional-group changes. The revised text focuses on the main texture-dependent trends in SOC functional groups, thereby improving readability and reducing potential confusion.

Section 4.3: Relationships between SOC fractions and stability-related indices

The former Section 4.2 was refined to focus on the relationships between SOC fractions and stability-related indices (AI, HI, and A/OA). Repetitive mechanistic descriptions were shortened, and the discussion was refocused on how mineral protection modulates the contribution of different SOC fractions to stability in loam versus sandy loam. Interpretations related to priming effects were condensed and presented cautiously, without extending beyond the observational scope of the data.

Section 4.4: Sequestration pathways of SOC in greenhouse

The synthesis of SOC sequestration pathways, previously embedded in correlation analyses, was extracted into a separate subsection to provide a clearer integrative summary.

Overall, these revisions shorten the Discussion and improve its readability by removing redundancy and clarifying the organization, particularly for the section on SOC chemical composition.

Comment 16 and 17:

L.97 and L.99: 'durations' instead of 'years'?

Response:

The term 'years' has been replaced with 'durations' at Line 97 and Line 99 to more accurately describe the length of manure application history rather than calendar time.

Once again, we thank you for your valuable comments and thoughtful suggestions. Hopefully, our answers are clear and with our best regards to you!

Yours sincerely,

All authors