RESPONSE TO REVIEWERS: Manuscript: “Soil health approaches to assess the impacts of no-tillage with agricultural terraces in southern Brazil”

All reviewer and editor comments have been addressed in the final accepted version of the manuscript. No further changes were required after the final revision.

REVISOR 1

We sincerely appreciate the detailed and constructive feedback provided by the reviewer. Below, we present the point-by-point responses, indicating how each suggestion was incorporated into the revised version.

GENERAL COMMENTS

In response, we have revised the Introduction to:
Clarify the scientific gap, explicitly stating that previous studies have not directly compared the sensitivity of different soil health assessment methods to detect short-term effects of conservation practices such as terracing in tropical no-till systems.
Emphasize the conceptual contribution of the study, highlighting that the novelty lies in the comparative evaluation of the diagnostic capacity of these approaches in a highly relevant tropical agroecosystem.

SPECIFIC COMMENTS

Novelty: The introduction should more clearly state the specific knowledge gap: a direct, comparative evaluation of the sensitivity of these established methods for detecting short-term impacts of conservation practices like terracing.

The comment has been fully accepted. We have revised the end of the Introduction to explicitly include the suggestion.

L76-L82: “Although terracing in no-till systems is widely recognized for reducing erosion and improving water infiltration (Fuentes-Guevara et al., 2024; Lal, 2020; Panagos et al., 2015), their effects on soil health under subtropical field conditions remain poorly understood, despite the availability of multiple assessment methods. Moreover, no study has directly

compared the sensitivity of different soil health approaches in detecting short-term impacts of terracing in subtropical no-till systems. Therefore, this study aims to comparatively evaluate the performance and sensitivity of four integrative soil health assessment approaches in detecting short-term changes, using agricultural terracing under no-till management as a field-based case study in southern Brazil, and to identify the most responsive soil health indicators for monitoring these systems."

Methods Clarification – Expert Opinion (EO): The description of the Expert Opinion (EO) method requires clarification. Specify if the initial indicator selection was purely based on expertise, while only the weighting was data-derived, to avoid a circular argument.
We reformulad

L31-34:"In the EO, indicator selection was guided solely by prior technical expertise and evidence from the scientific literature concerning the sensitivity and functional relevance of physical, chemical, and biological soil indicators. No data-driven criteria were applied in this selection step. This selection prioritizes the indicators that are most sensitive to variations in soil behavior and those that are easiest to determine in the field or laboratory and to interpret."

L61-64: "The SHI_EO was integrated using the covariance matrix weights, in a manner based on that described in Manly (2008) and Jolliffe (2002) applied to different multivariate analysis methods. The SHI_EO integration method consisted of an analysis of the proportional contribution of variables to a composite index, ensuring that the integration step reflects the variability observed in the dataset while keeping the selection step independent of the data."

Conclusions

We completely agree. The conclusion has been reformulated to:

L349-350: "Among the approaches tested, SHI_EO and SHI_FERTBIO demonstrated greater sensitivity in detecting short-term changes in soil health. This effect is mainly associated with biological indicators of soil health."

TECHNICAL CORRECTIONS L77:

Correction made: "their effects on soil health".

L252 – Figure 5:

The word “Haverst” was corrected to “harvest”.

REVISOR 2

We sincerely thank the reviewer for the careful reading and constructive suggestions. We fully agree that the manuscript required a clearer and more cohesive narrative regarding its primary objective.

Following the reviewer's recommendation, we have now explicitly defined the main objective of the study as the comparative evaluation of the sensitivity and performance of four soil health assessment approaches, using agricultural terracing under no-till as an application case.

Accordingly, we revised the title, introduction, discussion, and conclusions to consistently reflect this focus. The discussion was expanded to address (i) the physical, chemical, and biological drivers underlying the temporal variability between NT and NT+T, and (ii) the practical applicability, scalability, and potential transferability of these approaches to other soil types and regions.

We believe these changes substantially improved the clarity, coherence, and impact of the manuscript.

SPECIFIC COMMENTS

P2, L49: Please define 'FERTBIO'. Is this an acronym or a specific program? Please cite the developer or governing body.

L53-L66: In the Introduction, we added the definition of FERTBIO as the Soil Fertility and Biology sampling concept, embedded within Embrapa's Soil Bioanalysis Technology (SoilBio) framework. The developing and governing institution (Embrapa), as well as the key references associated with the development and application of this approach, are now explicitly indicated in the manuscript (Mendes et al., 2021a, 2021b; 2024).

P2, L60: Please specify the crop rotation or specific crops used in the no-till system.

L98-100: This information has been added to the beginning of the Materials and Methods section:

"Annual cycle species were cultivated according to the most common management practices and crop sequence in the region: soybean (Glycine max) and maize (Zea mays) in the

summer, and wheat (Triticum aestivum) and black oat (Avena strigosa) in the winter."

P3, L65: Please clarify the term "tropical agriculture."

We thank the reviewer for this important observation. The expression "tropical agriculture" has been removed from the manuscript, and the text was revised to provide a more precise geographic and environmental context, now referring to agricultural systems of southern Brazil and to subtropical field conditions, thereby eliminating any climatic ambiguity.

L70-82: "Given Brazil's leadership in agriculture and the widespread adoption of no- tillage, which is applied to 33 million hectares of the country's cropland (Fuentes-Llanillo et al., 2021), but which alone is not sufficient to control soil loss on sloping soils (Merten et al. 2015), soil erosion remain an ongoing challenge, especially in areas with rugged terrain. Conservation techniques such as no-till and terracing have been essential strategies to mitigate soil degradation and improve agricultural sustainability in the region (Merten et al., 2015).

Although terracing in no-till systems is widely recognized for reducing erosion and improving water infiltration (Fuentes-Guevara et al., 2024; Lal, 2020; Panagos et al., 2015), its effects on soil health under subtropical field conditions remain poorly understood, despite the availability of multiple assessment methods. Moreover, no study has directly compared the sensitivity of different soil health approaches in detecting short- term impacts of terracing in tropical no-till systems. Therefore, this study aims to comparatively evaluate the performance and sensitivity of four integrative soil health assessment approaches in detecting short-term changes, using agricultural terracing under no-till management as a field-based case study in southern Brazil, and to identify the most responsive soil health indicators for monitoring these systems."

P3, L71: Define the SHI abbreviation at its first mention (e.g., Soil Health Indicators).
The information was added at its first occurrence in the introduction.

L43: "...generate integrated soil health indices (SHIs), allowing for a holistic..."

P4, L95: Please state whether any irrigation was implemented or if the study was strictly rain-fed.

We added:
L87-88: "The experiment was conducted entirely under rainfed conditions throughout the entire study period."

P4, L99: Clarify if "field capacity" refers specifically to volumetric water content at field capacity.

L112: This has now been clarified in the Materials and Methods section: "…volumetric water content at field capacity)"

P5, L105: I note SHI is defined here as "Soil Health Indices." As mentioned above, please ensure this is defined at the first usage in Line 71.

This has now been corrected. The abbreviation SHIs (soil health indices) is now defined at its first occurrence in the Introduction, and the redundant definition has been adjusted accordingly.

P5, L120: Please correct the citation formatting: "...proposed by Andrews et al. (2004), Stott et al. (2010), and Wienhold et al. (2009) were selected."

We reformuled
L135-136: "[...] proposed by Andrews et al. (2004), Stott et al. (2010), and Wienhold et al. (2009) were selected."

P7, L134: In the table, please define what "A" represents in the context of your data categories.

L150-151: This information has been corrected. The manuscript now explicitly defines A as arylsulfatase activity in the Table 2 legend.

Dear Luis Merino-Martín,

Thank you for your constructive feedback on our revised manuscript. We appreciate the careful evaluation and the opportunity to further improve the methodological coherence and discussion. Below, we address each of your suggestions point by point. All modifications in the revised manuscript are highlighted in **bold** for ease of identification.

Comment 1: Define FERTBIO in the abstract

Editor's comment: *"Please define FERTBIO (Soil Fertility and Biology) in the abstract as it is for the other methods."*

Response: We have revised the abstract to include a clear definition of the FERTBIO approach, consistent with the definitions provided for the other methods. The revised sentence now reads:

"...Soil Fertility and Biology approach (FERTBIO), based on the Soil Bioanalysis framework..."

This definition was already incorporated in the previous revision and remains in the current version of the abstract.

Comment 2: Align Discussion conclusions with the experimental design

Editor's comment: *"The Discussion should more explicitly align its conclusions with the study's experimental design. Each treatment (NT and NT+T) is represented by a single mega-plot and comparisons between them must be interpreted as site-specific observations rather than replicated treatment effects. Thus, reducing causal treatment inference (terraces vs. no-till) and framing the results as patterns observed in this particular field comparison will ensure that the interpretations remain consistent with the level of replication."*

Response: We fully agree with this important observation. We have carefully revised the Discussion and Conclusions sections to ensure that interpretations are framed as site-specific observations rather than replicated treatment effects. The specific changes are detailed below:

(a) Throughout the Discussion, we replaced references to "treatments" with "management conditions" or "field management conditions" to avoid implying experimental replication. For example:

- "the biological index was the most sensitive in detecting differences **between the two field management conditions**" (Discussion, sensitivity paragraph)

- "The only index that consistently captured differences between **the two management conditions**" (Discussion, SHI performance paragraph)
- "the biological indicators had already shown greater sensitivity in differentiating **the management conditions**" (Discussion, sensitivity paragraph)

(b) We replaced causal language with associative framing throughout the Discussion:

- "" was replaced by "**being associated with higher soil health values for the no- till with terraces plot**"
- "" was replaced by "**in this field comparison**"
- " soil health crop performance" was replaced by "the **association between** soil health **and** crop performance **in this field comparison**"

(c) We replaced "system" with "plot" or "field comparison" where appropriate to reinforce the site-specific nature of the observations:

- "maize productivity (...) were higher **under** the no-till with terraces **plot**" (Discussion, productivity paragraph)

(d) In the Conclusions section, similar adjustments were made:

- "Four soil health approaches were evaluated **in a field comparison of** no-till systems with and without agricultural terraces"
- "the no-till with terraces **plot was associated with** higher maize productivity"
- "showing gradual **alignment** over the years **under these management conditions**"

(e) We strengthened the existing acknowledgement paragraph by adding an explicit statement:

"Accordingly, the patterns described should be interpreted as observations from this particular field comparison rather than as generalizable treatment effects."

We believe these revisions ensure that the interpretations remain consistent with the level of replication, while preserving the important insights regarding temporal trends and the relative sensitivity of the different soil health indices.

(f) In addition, Figure 6 was replaced with a revised version to improve visual clarity and enhance color contrast, thereby facilitating the interpretation of the results.

Comment 3: Consistent structure in reviewer responses

Editor's comment: *"For future submissions, I recommend maintaining a fully consistent structure when replying to reviewers; in the current response, some reviewer comments are quoted explicitly while others are not, and including each comment (or a concise summary of it) before the corresponding response would greatly enhance clarity."*

Response: We sincerely appreciate this recommendation. We have taken note of this guidance and will ensure that all future responses to reviewers follow a fully consistent structure, with each reviewer comment (or a concise summary) explicitly quoted before the corresponding response, as exemplified in the present letter.

We hope that these revisions satisfactorily address all of the Editor's suggestions. We are grateful for the constructive feedback, which has strengthened the manuscript. We remain available for any further revisions that may be needed. In addition, we have addressed the techinal requirements raised during the submission process, including revising the short summary to remove abreviations and adding a dedicated “Code and data availability” section.

Sincerely,

Ariane Lentice de Paula, on behalf of all authors

Dear Luis Merino-Martín,

We thank the reviewer for the positive evaluation of our revised manuscript and for acknowledging the improvements achieved. Below, we address your suggestion. The modifications in the revised manuscript are highlighted in bold for ease of identification.

Comment 1:

Editor's comment: *"[ ]. At this stage, only one issue remains, Figure 6 is still difficult to interpret because the labels are overlapped. Once the authors improve the clarity of this figure, the manuscript will be suitable for acceptance."*

Response: Regarding Figure 6, we have carefully revised the figure to enhance its clarity. The labels were repositioned to eliminate overlap, including adjustments to their placement and spacing. In addition, we refined font sizes and optimized the graphical layout to improve readability.

These changes significantly improved the visualization, and we believe the figure is now clear and easy to interpret.

Sincerely,

Ariane Lentice de Paula, on behalf of all authors