

Dear Editor

We thank the reviewer 2 for their feedback on the manuscript. Our response to reviewer comments is in green font. The line numbers correspond to the manuscript file with track changes.

General comments

This study aims to evaluate the impact of agricultural management and environmental variables on soil C indicators, including indicators from thermal analysis. Based on the analysis of 1490 samples, they concluded that soil textured classes and cropping systems had the strongest influence on both quality and stability of soil C indicators, and evidenced interactive effects between cropping systems and tillage intensity. The aim of the subject is very relevant because based on a large dataset at the landscape scale. The experimental approach seems appropriate for answering the scientific questions. I recommend moderate revisions for this paper.

Authors: Thank you.

More information should be given about the delimitation of the geographical area. In general, several results warrant further explanation and discussion. The authors should further elaborate on the limitations of the approaches and adopt a more critical perspective towards them. The part concerning the PCA interpretation should be improved.

Authors: Thank you. We have addressed all the reviewer comments and believe that these revisions have significantly improved the manuscript.

Detailed comments

Introduction

Line 32-36: “Soil C” à do the authors mean soil C dynamic or turnover or stability or ...? Soil C alone is not a parameter. The parameter or process meant in this paragraph should be specified.

Authors: Agreed and clarified at line 33 by adding soil C dynamics.

Line 34: “Soil organic C (SOC)” content

Authors: We have added “content or concentration” at line 36. Both the terms SOC content or SOC concentration are accepted in the literature, and we used both the terms here to be consistent with published research and to avoid confusion.

Line 81-82: I am not sure to understand if the research gap is due to the difficulty to observe any effect of the previously cited factors on C stability, or if it is due to the difficulty to identify the main factors affecting C stability. I suggest reformulating this sentence.

Authors: Agreed. Sentence revised at line 83 “Yet, it remains uncertain which management or environmental variables exert the strongest influence on soil C stability under the complexity of agricultural fields.”

Line 91: again: “soil C “ storage and stability?

Authors: Agreed and edit made at line 94.

Material and method

Line 97: Since the study highlights that the experiment was done at a landscape scale, the authors should specify the geographical area of the project. It may be important to have an idea if the scale of the area (regional, national or multi-national scale?) and if the studied parameters (e.g. cropping systems, tillage intensity, use of organic amendment) are representative of this geographical area.

Authors: We have clarified this comment at line 100 “The soil samples for this project were collected from multiple locations throughout southern Ontario.”

Line 112 “The agricultural management factors identified in our study were consistent with the commonly adopted practices by the growers and were representative of the geographical area.”

Line 129: the authors should precise what “QA/QC analysis” refers to.

Authors: We have clarified this at line 137 “After quality assurance and quality control (QA/QC) analysis”

Line 159: Were the CO emissions also included in the S3?

Authors: Yes. We did not add this edit to the manuscript to avoid potential confusion.

Line 163: I understand that T50 corresponds to 50% of C emissions under all S1, S2 and S3 signals. If not, this should be specified.

Authors: We have clarified this comment at line 176 “ It is important to note that T50 is measured under S1 and S2 only.”

Line 167: if “variance component analysis” are made, the data should follow normal distributions. It would be relevant to precise here if the normality and homoskedasticity were tested for the data. Unless the authors consider that the sample sizes are large enough to override the normality of the data...

Authors: We have clarified this at line 180 “Prior to conducting the variance component analysis, the assumptions of normality were assessed. Given the relatively large sample sizes for most of the variables studied, variance component estimates were considered robust to minor deviations from normality.”

Results and discussion

Line 190: it is not clear what “75.2%” refers to.

Authors: We have reorganized this sentence for clarity. Line 214” Soil texture also explained a large amount of variance (75.2%) in the thermal-based parameters of soil C (Table 1).”

Table 1: it is surprising that the carbon inputs, such as cover crops (if plant residues remain on the field) and organic amendments, have so low effects on SOC and on the indicators of C stability, when compared to cropping system and soil texture. Indeed, organic matters amendment is expected to increase labile C content and hence, decrease the overall stability of C. These results are, at least to me, very surprising and therefore interesting. I suggest developing a bit more a critical discussion about these results and the approach, and eventually present hypothesis of explanation. An idea to complete this approach, could be to make a partitioning of the variances within each textural class.

Authors: We have added some discussion based on this and reviewer 1 comments. The results and discussion section was thoroughly revised to address both reviewer comments. This reviewer comment was addressed at line 223 “The least amount of variance in soil C indicators was explained by MAT, use of cover crops, and organic amendments (Table 1), suggesting a minor influence of these factors on soil C variability in our study. One possible explanation for this result could be that cover crop and organic amendment effects varies with soil type, climatic conditions, and baseline fertility which might have potentially masked their overall impact on soil C indicators in our multi-site study.”

We, however, do not agree with the reviewer regarding partitioning of variances within each textural class. We believe that the current analyses adequately address the study results. Given the structure of our data, further partitioning of variances by soil textural class might result in misleading interpretations of our dataset and would not provide any additional information. We have, however, focused on providing the potential mechanisms based on the study results and have revised the results and discussion throughout the manuscript.

Table 2: is there any reason why annual temperature and mean precipitation are not tested in this table? Furthermore, the results evidence statistical differences but ignore tendencies that may also be interesting to investigate.

Authors: Thank you for your comment. Annual temperature and mean precipitation were not tested in Table 2 because the focus was on the agronomic management factors and their interactions. Nevertheless, we have acknowledged that environmental variables like annual precipitation and temperature are important predictors of soil C dynamics and have thoroughly discussed this in the manuscript. While tendencies might be interesting to investigate, our analysis focused on statistically supported differences to ensure the reliability of conclusions. We did not add discussion on trends and tendencies to avoid overinterpretation of study results.

Table 3: in the legend, the authors should remind which statistical differences are represented by the letters. As for tables 1 & 2, the authors should add what T50 refers to.

Authors: Agreed and done.

Line 210: “the lowest soil C” content? Stability? Please precise which indicator are referred to.

Authors: Sentence revised for clarity at line 255.

Lines 210-211: I guess that many types of management exist to produce vegetable and annual grain systems. They are maybe not always intensively managed. I guess that this could be a critical point you

could add to the discussion. It would be interesting to have a bit more information about how the fields of the project were managed and if they were all managed the same way within each cropping system.

Authors: We agree with the reviewer's comment that there are nuances within each of the cropping systems used in the analysis of the data, and that management is not consistent across all farms within each cropping system. In fact, this is the reason additional parameters were included in the analysis (i.e., tillage, cover crops, organic amendments). The statement in question is meant as a general statement to reflect the fact that annual cropping systems and vegetable production systems, when compared to perennial cropping systems, are in general more intensive, as supported by the cited literature. Therefore, we did not add any more details about the management within each cropping system.

Line 219: Forage doesn't have the lowest T50 across all soil textures in table 3; vegetable and perennial have lower values than forage for medium-textured soils, and orchard has lower values for fine-textured soils.

Authors: We have revised this sentence. We have removed Table 3 from this sentence for clarity. This result was based on average values across all soil textures. Line 269 "While T50 was not statistically different due to cropping system and tillage practices in all soil textures (Table 2), annual grain had the highest whereas forage had the lowest T50 when averaged across all soil textures (Figure 1a)."

Lines 226-228: This result is interesting, and therefore it would be relevant to develop the discussion about the influence of the texture on thermal stability. There may be a link to do with the higher organo-mineral associations in clay than in sandy soils. It would also be relevant to precise if other studies also found this same result.

Authors: Thank you. We have added a discussion to address the reviewer comment at line 279 "It is likely related to the greater organo-mineral associations in clay rich fine textured soils than the coarse textured soils, which contributed to the protection of soil organic matter from microbial decomposition and increase its thermal stability. Previous studies by Simkovic et al. (2025) and Stoner et al. (2023) have also confirmed a positive relationship between clay content and stabilization of soil organic matter."

Figure 2: In the legend, the authors wrote that the data from the other cropping systems are not shown because of the insufficient number observations. If these number of observations were not a problem for the other tables and figures, why should they be a problem for this figure? It should especially not be a problem when presented as boxplots.

Authors: The reason for not including the data from other cropping systems in Figure 2 is that the number of observations for the other cropping systems was low and unevenly distributed, which could make the boxplots difficult to interpret and misleading. In the other tables and figures, the data were presented as summary statistics or treatment means which are less sensitive to uneven sample size. Boxplots visually help to understand the distribution of observations and including cropping systems with very few observations would have given a false impression of variability. Therefore, we only used cropping systems with sufficient number of observations for meaningful comparisons.

Line 251: I guess you mean "Table 2" instead of "Figure 2".

Authors: Yes. Thank you. It was a typo and fixed in the manuscript text.

Lines 247-264: in this paragraph, there are several mentions of the Table S1. It could be relevant to add this table in the main tables.

Authors: Thanks for your suggestion. While we understand that information in Table S1 supports the main text, we did not include it in the main manuscript tables. We believe that including Table S1 as main table would disrupt the flow and clarity of the manuscript. We have therefore kept it as a supplementary table while ensuring that all the relevant information is appropriately referenced and discussed in the main manuscript text.

Line 269: The HI of vegetable systems doesn't seem different than those of orchard systems and thus, this figure doesn't show that the organic matter of vegetable systems mainly consists

Authors: To address this comment and for clarity, we have inserted a sentence at line 332 "While the visual representation of HI vs OI between both systems (i.e. vegetable and orchards) may appear similar due to variability and sample size, the underlying data distribution supports our interpretation (Figure 3)."

Lines 274-287: This paragraph, as well as figures 4 and 5 should be transferred in material and method. In the discussion should only appear how this distribution may affect the results. Figures 4 and 5 could as well be transferred as supplementary materials.

Authors: We thank the reviewer for their suggestion. However, we believe that this paragraph and Figures 4 and 5 are essential components of the results and discussion section. This paragraph and Figures provide core results and key contextual information that directly supports the interpretation of our study findings and explains the variability observed. One possible explanation of the observed results is related to the frequency distribution of the data, which is presented in Figures 4 and 5. Moving this paragraph and figures to methods or supplementary section would limit the understanding of the study results. Therefore, we prefer not to move them to methods or supplementary section of the manuscript.

Line 289: The authors should introduce in the main text how the PCA was done and with which indicators and parameters.

Authors: Agreed. We have provided details about this comment in the main text at line 192 ". In addition to the site characteristics and pedoclimatic conditions, the variables included in the PCA were SOC concentration, POXC, $C_{min-24h}$, Solvita CO₂-burst, ACE, HI, OI, and T50. The first two PCs were selected based on scree plots and the eigenvalues of the soil C indicators were used to create the biplots to better understand the interdependence among the soil C indicators and how they interacted with the site characteristics and pedoclimatic conditions."

Line 290: did the other studies used also the same parameters and indicators? If yes, on which type of data did they use it? It is a bit tricky to compare variances from different datasets...

Authors: We have deleted the "which is consistent with variance explained in other studies (Liptzin et al., 2022)." from the sentence for clarity.

Lines 294-296: It would be interesting to have an explanation of why the different approaches of variance analysis and PCA do not show the same results concerning the influence of weather (temperature and humidity) on C indicators.

Authors: Thank you for this comment. We have clarified this comment at line 363 “It is important to note that PCA and variance component analysis differ in both the statistical structure and objectives, which perhaps led to differences in the results between both approaches. For instance, variance analysis evaluates the independent effect of each predictor variable on soil C indicators, whereas PCA simultaneously assesses the covariance among the multiple soil C indicators.”

Lines 307-314: In the PCA, the arrows from the soil texture are orthogonal to the arrows from the soil C indicators, thereby showing no correlations. Therefore, I disagree with the results presented in this paragraph.

Authors: We have significantly revised this paragraph to address reviewer comments and for clarity. Lines 378 “Furthermore, silt and clay content were clustered together in PCA on one side of the second axis whereas sand content was positioned on the opposite side of the second axis (Figure 6). This result was consistent with the well-established associations between soil C dynamics and soil texture where soils rich in clay content have higher C retention capacity than coarse textured soil (von Lutzow et al., 2006). Accordingly, the positive loading displayed by the clay and silt rich soils on the second axis corresponds to greater values of soil C indicators observed in our study. Although important, the relationship between soil texture and soil C indicators (particularly POXC and respiration) has not been explored enough in the literature (Nunes et al., 2020; Sinsabaugh et al., 2008).”

Line 315: idem, HI and the C indicators are orthogonal to the cover crops and thus, the PCA does not show any correlation between them. In addition, the cover crop reflects a very low contribution in the PCA analysis (small arrow size).

Authors: To avoid confusion and for clarity, we have removed “cover crops” from this sentence. We have only focused and discussed the results of tillage intensity and how it impacts soil C dynamics in this paragraph.