The manuscript “High capacity of integrated crop-pasture systems to preserve old stable carbon evaluated in a 60-year-old experiment” is an interesting study of how different crop management practices can influence the carbon cycling in soils. The long-term nature of the study is unique and provides nice insight into these processes.

We are very grateful for the valuable comments raised by the reviewer. Below, we present the answers to each of the points made. In many cases, these responses led to modifications in the original manuscript, so we outline the lines (corresponding to a new version of the manuscript) where these modifications were introduced.

General comments:

The term "stable" is pretty loaded, I suggest the authors use a different term. Stability is being interchanged with decreased decomposition and with MAOM, which I don’t think is always true. From the model, the observed differences in 14C and C stock of bulk soil are likely due to higher decomposition rates in the CC system, which doesn’t necessarily indicate higher stability at the RR sites. I don’t think the authors have shown that the RR system C is more stable, just that the RR system increases C stocks by reducing losses. If the RR site were to be tilled in a similar manner to the CC system, would you expect the C stock value to persist, or would it decrease similar to the CC sites? If the latter, I don’t think it’s fair to say the C is stable, just that the land management decreases losses. The authors sort of get at this in lines 464-465.

Following this, I think it would be more appropriate to refer to the modeled pools as something like “fast cycling” and “slower cycling”, rather than calling them “POM/labile” and “MAOM/stable”. We know that some MAOM doesn’t persist for very long, so it is misleading to interchange the terms. Modifying word choice does not impact the conclusions of the model, which are quite interesting and provide nice perspective on SOC cycling rates in the two pools. (As an aside, it would be interesting to see the 14C of the POM and MAOM that the authors physically separated and how this matched up to the modeled pools, though I realize this may be outside the scope of this project).

The reviewer is correct regarding this point. It is not possible to draw conclusions about the inherent stability of the MAOM in both agricultural systems, as the dynamics of this pool in CC and R emerge as a consequence of each of the agronomic managements performed. Therefore, the term "stability" would not be correct in this context. Based on the reviewer's suggestion, the terms "fast cycling" and "slow cycling pool" were adopted to refer to each of the compartments throughout the manuscript.

Regarding the 14C data in fractions, they are indeed interesting data but beyond the scope of this manuscript. It is expected that this information will be available later, and will contribute then to deepen the understanding of these systems in future work.

Interpretation of the incubation data: I disagree with the statement that the incubation CO2 from the CC system is “more modern” than that of the R system (Lines 289-293). In the 0-10 cm, the CC system incubation CO2 is -6.5 permil and the R is 9.13 permil, making the R system CO2 more modern. All of the other results are 14C modern (positive numbers falling on the bomb curve). You can’t distinguish which side of the curve they are on and therefore can’t claim one is more modern than the other.

The reviewer is correct; this statement is clearly incorrect. Given the results of the modeling work and reconsidering the 14C data, the slightly lower isotopic signature in the CO_2 output from the CC system incubations is probably due to a greater contribution from the MAOM pool in the output flow, which leverages the average delta14C towards lower values.

The text was modified at L. 317 to eliminate the comparison of the "ages" of C that was mistakenly made when preliminarily analyzing the 14C results in the incubations.

“CO_2 radiocarbon measured in soil incubation experiments from 2021 samples showed significant differences between systems at all depths (Table 3), with values of 6.87± 3.09 ‰ in the CC system (0-20 cm) and 27.1 ± 4.82 in the R system. In both cases, these were much more modern (closer to the atmospheric signature of the year of measurement) than the bulk soil.”

Title: I suggest rewording this a bit following the above comments on wording

Based on the reviewer's suggestion, the manuscript title was changed to:

“High capacity of integrated crop-pasture systems to preserve old soil carbon evaluated in a 60-year-old experiment”, deleting the word “stable”.

Technical/minor edits:

-Lines 31: Using the phrase “on the one hand” makes it sounds like the two perspectives are in opposition, but I don’t think these are.

Text changed according to reviewer suggestion.

-Line 117: should be “acidic”

Text changed according to reviewer suggestion.

-Line 146: clarify if fertilizer application was using in the crop-pasture rotation system

Yes, the R system is also fertilized. Text was added at L.162 to clarify this point:

“In both systems, fertilization (N and P) of crops and pastures is carried out according to recommendations based on soil and plant analysis.”

-Line 172: how many is “a large number”?

This internal laboratory validation process was conducted with over 2000 soil samples.

-Line 185: what was the actual temperature? (> 500 C)

The actual temperature was 550°C. The text was modified to address this suggestion from the reviewer.

-Line 229: The “a” in “Fa” should be subscript

Modification made.

-Lines 499 and 501: “Ancient” is a bit of a stretch for this age of carbon

This word was replaced by “old” where the reviewer mentions.

-Lines 503-505: This sentence is speculative and not actually tested in the study.

To correct the speculative statement made about the influence of C inputs on the dynamics of Cslow (~ MAOM) formation, the text was changed where the reviewer suggests (at line L. 566):

“This process occurs to a greater extent in the integrated system due to higher carbon inputs, which result in a larger stock of labile C and a consequently greater microbial activity. No differences were observed between treatments in the model parameters (k_1 and α) that determine the C flow to the C_{slow} pool per unit of C entering the system. However, it was not possible to establish a mechanistic connection between the quality of the C input and the dynamics of the C_{stable} pool (~MAOM), given that the former factor was not explicitly modeled.”