Answer to Referee 1

Dear referee,
Thank you for taking the time to review the manuscript and for your relevant suggestions. You will find below the answers to your comments.

The manuscript by Hulin et al compares C inputs of 12 cover crops with a labelling approach. SOC new as a pool consisting of fine root C and rhizodeposition is determined. With this the paper provides new data and complements the existing literature on C inputs. The scientific methods are valid and reported nicely. The analysis and conclusions are sound and clear. However, the presentation of the results in the figures was not that clear (see comments below). I recommend publication after incorporating these comments.

Thank you for you positive comments.

L35: C instead of Carbon

We changed it in the text.

L37: what processes? How much does it vary over time?

We specified (L 38-45): "**Their release in the soil is governed by a large range of processes: among the most well-documented, we can mention passive diffusion and active transport through the root cell membrane for exudates; secretion through exocytosis for mucilage or enzymes; detachment or lysis of root cells related to root growth or senescence (Jones et al., 2009). Besides, these processes predominate at different times in the plant's life cycle: C allocation to gross rhizodeposition as a whole declines with plant age, as does allocation to roots (Nguyen, 2003). Indeed, C allocation to these two pools is maximal during the first two months of growth for annual crops (Pausch and Kuzyakov, 2018). On the other side, the senescence-related release of C shows an opposite trend by increasing with plant age (Hirte et al., 2018)**".

L43: what did Huang et al find? Change 'not confirmed' to contradicted?

They did not found any significant differences between families. This was most likely due to their limited number of species. We detailed in the text some of their results showing results contradicting previous results from Henneron et al (2020) (L48-52): "**For instance, Henneron et al. (2020a) showed for grassland species that legumes yielded more SOC_{new} than other forbs or grasses, which was contradicted by another study by Huang et al. (2021), who did not found significant differences between families, and who found high a SOC_{new} production for *Artemisia frigida* and *Cleistogenes squarrosa*, a forb and a grass repectively, against a low production for *Medicago ruthenica*, a legume.**"

L44: sentence seems off

We changed it (L 52-53): "**It is therefore necessary to conduct more comparative studies between different plants under the same conditions.**"

L54: reference?

It is in fact not easy to find the right original paper that states that the residence time of carbon is relevant to consider in order to achieve additional SOC sequestration for a climate goal, especially if we want to recognise pioneering work. A lot of work has been done on SOC persistence, already decades ago or even more, without clearly mentioning that it was to assess the possibility to store additional carbon. We propose to mention Minasny et al., 2017, which is a clear paper explaining the 4 per mil basis and which stipulates the following: "*Ideally, it is desired to convert input organic matter into passive pools with longer residence time*".

L55 remove C?

We agree and changed it to "**The SOC_{new} pool, along with roots, are the main contributor to SOC in the mid-term, even when shoots are not harvested**" (L 64).

L132: how many plants were grown in one mesocosm?

We included the following precision in section 2.2 (L 129-132): **"We sowed twice the amount of seeds recommended by French technical institutes for a pure intermediate crop (Table S2) (ARVALIS, 2022). In the first two weeks, some seedlings have been removed if the seed germination rate exceeded 50 %. The number of seeds ranged from 2 for faba bean to 64 for Alfalfa. The number of plants that have been maintained is available in Table 1.**"

L148: SOC

We changed it in the text.

L234: unclear. What is compared to a greenhouse?

Indeed it is unclear. Our results were compared to the greenhouse experiment. We simply suppressed "A comparison to" (L 308).

239: hard to understand to what the literature refers, maybe you can report it like the barley

We changed to report it like the barley (L 319-320): "**we noted deviations from the literature: Bolinder et al. (1997) found a ratio of 0.4 for oat, against 0.2 in our case, and Bolinder et al. (2002) found a ratio of 0.7 for alfalfa, against 1.5 in our case.**"

Fig 1: upper panel letters are not in the centre of the bar as in the lower panel, why no statistics for the middle panel? Statistics for lower panel confusing. Please consider displaying the SOCnew:Belowground C inputs ratio to match the statistics.

We did not introduce statistics in the second panel for several reasons: 1) This would add 36 letters, which would be a lot of informations and alter the reading of the figure; 2) these statistics are not mentioned in the text; 3) we believe that they are complicated to interpret as they would represent a fraction that would depend on two other fractions. For instance, for mustard, 71 % of the C is retrieved in shoots, 14 % in roots and 15% in SOC. The fraction allocated to roots is relatively small compared to other species. Nevertheless, it depends on the Root:Shoot ratio that is relatively low, but also on the SOC_{new}:Belowground C inputs ratio, which is high for *Brassicaceae*. We do not want readers to focus too much on this percentage, but rather to gain an overall view of the distribution between the pools.

We displayed the SOCnew:Belowground C inputs ratio as you suggested. Please see the new figure below.

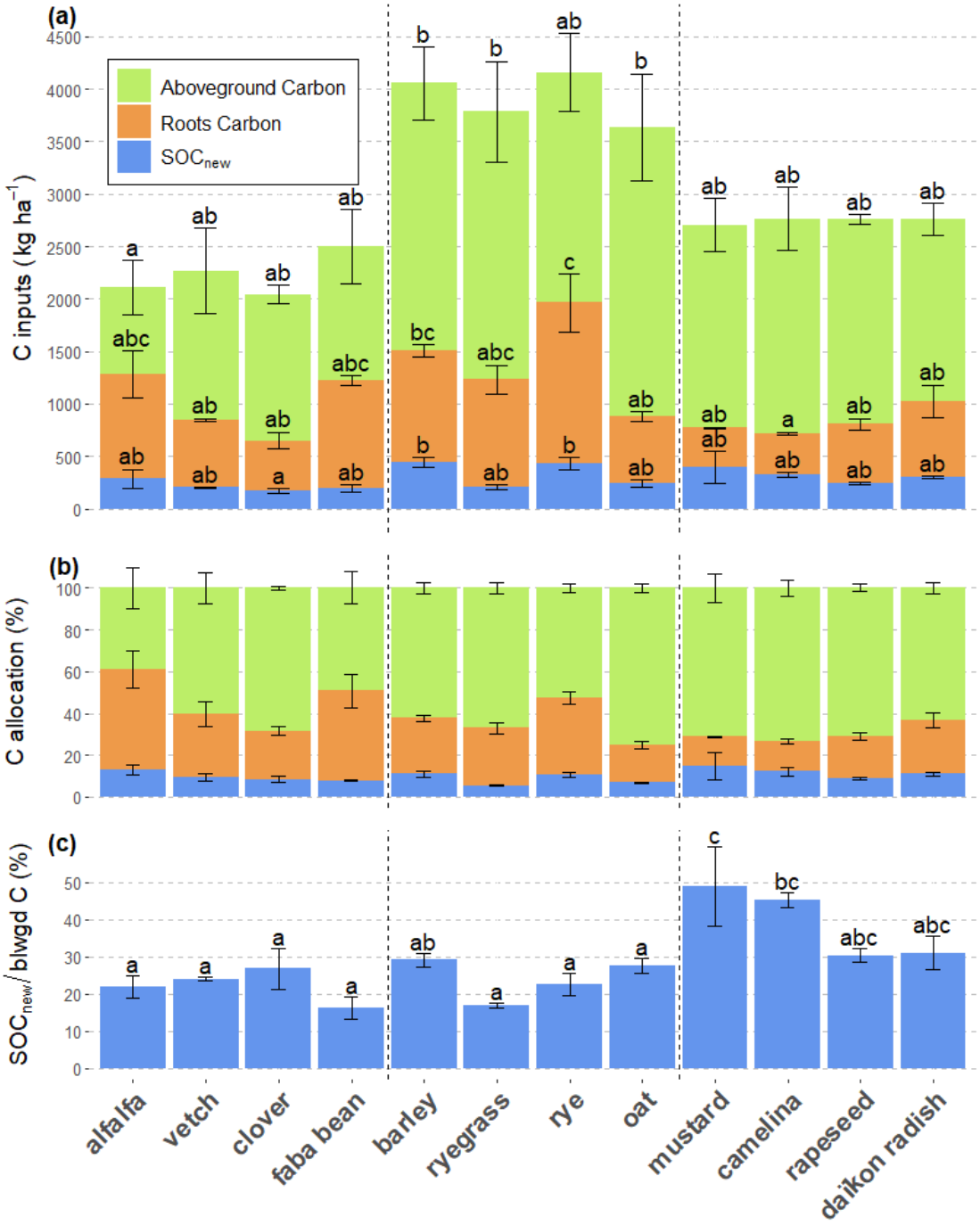

Figure 1: C allocation to different pools for 12 plant species: (a) net primary production, scaled to the hectare with the mesocosm's surfaces; (b) relative C allocation to SOCnew , roots and shoots; (c) share of belowground C (blwgd C) inputs allocated to SOCnew . Values are average values for species and error bars equal 2 standard errors (n=3 mesocosms). Lowercase letters represent significant differences ($p < 0.05$) between species for the total net primary production (upper panel) and for the SOC_{new} :Belowground C inputs ratio (lower panel).Vertical dashed lines separate plant families displayed in the following order from left to right : Fabaceae; Poaceae; Brassicaceae

Fig 2: Visually irritating. It looks like the whole 0-20cm horizon is missing with statistics and error bars. The orange and blue "background bars" don't add any information. I assume that the horizon 0-20cm is the percentage that is not framed and striped. Please add a proper bar for this horizon.

Your comment goes hand in hand with the comment by the second referee, who suggested to suppress the background bars. We suppressed them. Please see below the new figure.

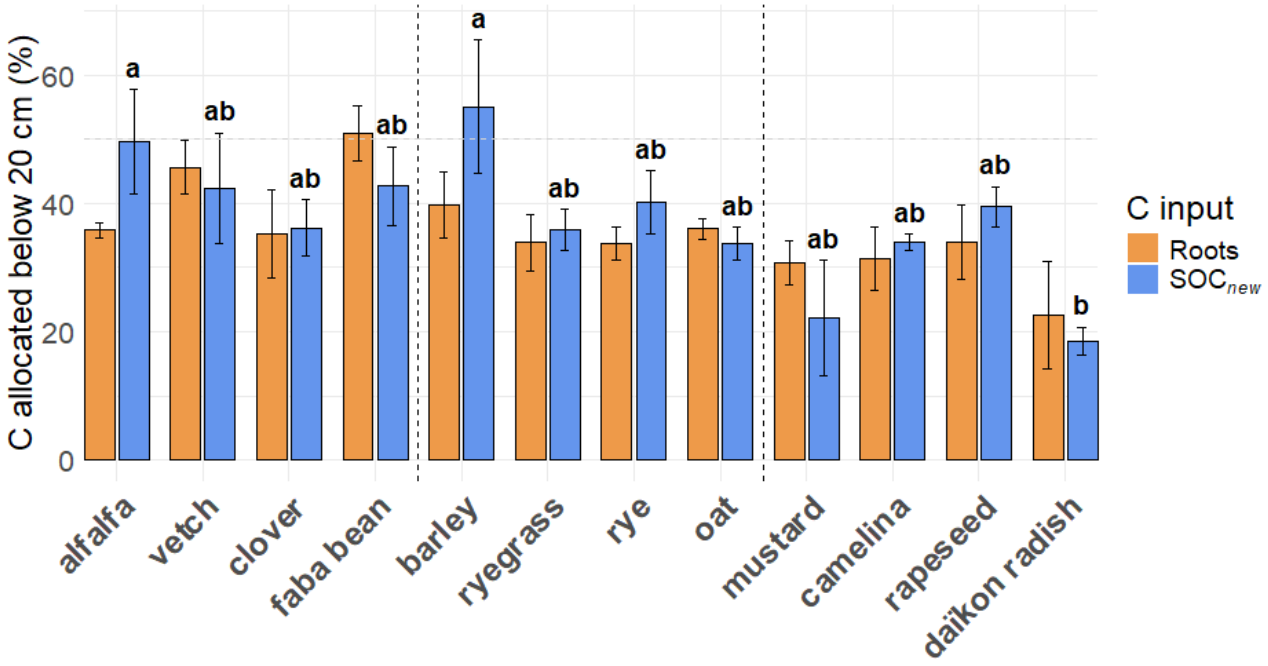

Figure 2: Root C and SOC$_{new}$ retrieved in the soil horizon below 20 cm (20 -45 cm). The bar heights are the mean for each species and error bars equal 2 standard errors. The significant letters are only reported for SOC$_{new}$ as no significant differences were observed for roots.

L308: was it expected that the Poaceae had the highest rhizosheath values? Report the mean value in the text so the reader can directly compare it to the mean across species.

We reported the value for *Poaceae* in the text: 4.3 ± 2.9 % of the soil mass (L 282-281): "**The highest rhizosheath values were retrieved for *Poaceae*, which retained the most soil with their arbuscular root system: 4.3 ± 2.9 % of the soil mass".**
There is little literature to compare to in order to know whether this result was expected. McBride-Serrano et al. (2025) found that rye led to a higher amount of rhizosheath formation compared to a *Fabaceae* and a *Brassicaceae*, which is in line with our results. We believe that root entanglement, that was high for the arbuscular root systems of *Poaceae*, helped to maintain the soil around the roots while shaking.

L315: "our results" and then you cite a different paper. Confusing in the way it is done now.

We agree and we reformulated (L 375-378): "**This invites us to consider most of the planted soil as the rhizosphere and it suggests that soil processes inherent to the rhizosphere are not constrained to the vicinity of the roots. For instance, an enhancement of native SOC cycling that would be associated to rhizodeposition release (Huo et al., 2017) may affect most of the soil volume above the maximal rooting depth.**"

Fig 3: Confusing with the big difference between axis and hard to read. Consider to plot it separately in two panels. Report statistics for the linear correlation in the plot and not only in the text. The inset is very small.

We have decided to separate the three components of the figure into three panels. We also included a fourth panel to support the following point: "Whereas the amount of SOC_{new} in the rhizosheath is closely linked to the rhizosheath mass, the latter is not correlated to the total amount of SOC_{new} retrieved in the mesocosm."
Please see the new figure below.

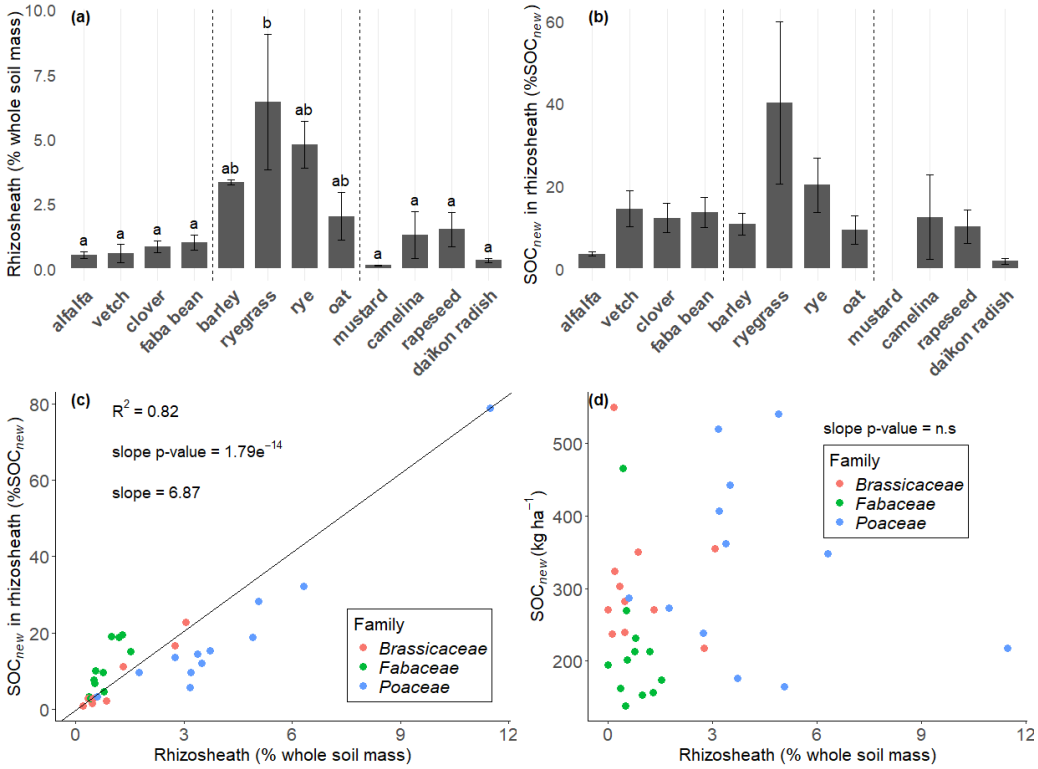

Figure 3: (a) Mass fraction of the soil comprised in the rhizosheath, calculated with Eq. 1. (b) Mass fraction of SOC_{new} comprised in the rhizosheath. The bar heights of the two barplots are the mean for each species and error bars equal two standard errors. The significant letters are only reported for the rhizosheath mass fraction as no significant differences were observed for SOC_{new} mass fraction. (c) Relationship between both mass fractions (SOC_{new} mass fraction and rhizosheath mass fraction). (d) Relationship between total SOC_{new} in the mesocosm and rhizosheath mass fraction. Each point stands for one mecosom. The slope was obtained with a mixed-effects model with species as a random effect, to let the intercept vary. The R^2 is the marginal R^2.

L322: C loss, please check for consistency throughout the manuscript

Thank you. We replaced all the words “carbon” that were spelled, except those in the abstract or in sections titles.

L326: reference?

The references were mentioned in the previous sentence, but we moved it to the sentence you mentioned so that the readers can refer directly to the specific study (L389-392): “**We compared our results on root decomposition with data from literature reviews from which we recalculated a percentage of dry mass presumed to be remaining at day 524 (Table S1). Our decomposition rates for graminoids are in line with literature values reporting 12 to 17 % of the C remaining at day 524 (Silver and Miya, 2001; Zhang and Wang, 2015; See et al., 2019) against 17 % in our case (Rye and Oat).**”

L344: fresh OC = SOCnew right? Stick with one term.

We have replaced the term as you suggested.

L373: sentence is off

We reformulated (L 430-431): “**However, including SOC_{new} in C assessments requires estimating it from crop traits or other C pools, as its direct quantification is costly.**”

L375: the conclusions of the review article you cited are not valid without restrictions: https://doi.org/10.1111/ejss.70077

We agree and we have nuanced the sentence (L 433-434): “**Crop selection favouring high root inputs to the soil seems to be a promising practice to sequester additional C in certain pedoclimatic contexts without being at the expense of the yield (Heinemann et al., 2023).**”

Figure S5: consider making this figure part of the manuscript instead of only using the inset in Fig 3.

We indeed included it in the manuscript

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