Response to Reviewer comments (Manuscript No. EGUSPHERE-2024-3602)

This is a revised manuscript of **No. EGUSPHERE-2024-3602_R1.** The manuscript has been revised, and the responses to the comments have been addressed as below.

Dear Editor and Reviewers,

We are very grateful to the Editor and reviewers for taking the time again to review our manuscript. We deeply appreciate the reviewer's valuable comments, suggestions, and questions to improve our manuscript. Please find below our itemized responses to these suggestive questions. We have revised our manuscript according to the Editor and reviewers suggestions and hope our responses will be satisfactory and the manuscript has been improved significantly. We hope the revised manuscript will fully meet publication standards in your journal after this revision.

Comments from the Editor and Reviewers:

Dear authors, both reviewers have recommended a number of things that need to be improved before your article can be published. Please take special note to improve the MS following the comments of reviewer 3 about the insufficient description of statistical methods.

Additionally, please note that the figure captions lack detail. All panels (e.g., a), b) c) etc.) need to be mentioned in the caption. Also, the caption needs to be detailed enough so that the figure can be understood even without reading the main text of your article. This means that all abbreviations (including treatments) need to be clarified, and a quick description of what was compared/tested is necessary, including how you display statistical significance.

Response: We sincerely appreciate the time and effort taken by the Editor and the esteemed reviewers to evaluate our manuscript. Their insightful comments and constructive suggestions have greatly helped us improve the quality of our work.

In response to Reviewer: 3 comments, we have provided a point-by-point reply addressing each concern and suggestion in detail below. Additionally, we have completely updated all figure captions to ensure they are self-explanatory: each panel (a, b, c, etc.) is now clearly described, all abbreviations and treatments are defined, and statistical comparisons (e.g., ANOVA, t-tests, post-hoc corrections) are specified.

Response to the comments of Reviewer # 1

L43: Could you please add the implications of this finding and suggest directions for further research?

Response: Thank you very much for your suggestion. We have added the implications of this finding. Please see line number # in the revised manuscript.

"Rubber plant root traits enhance soil aggregate stability and mitigate land degradation risk in tropical regions, offering practical soil restoration strategies through targeted root trait selection to strengthen soil cohesion, ensure long-term agricultural productivity, and preserve environmental quality, highlighting the need for further research across diverse ecological zones and forest types."

Besides, the minor mistakes in unit format and other typo mistakes were corrected throughout the manuscript. Please see the revised manuscript.

Response to the comments of Reviewer # 3

General Comments:

This is an interesting study with a strong dataset and sound experimental design. The discussion is thorough and connects findings in a compelling way, helping advance our understanding of how root traits influence SOM stabilization. That said, there are several areas that need more clarity and detail, especially around the statistical methods and terminology used to describe key metrics. I've also noted some issues with inconsistent terms and missing information that should be addressed to improve readability and reproducibility.

Introduction:

• L51: The sentence suggests that land degradation is driven by a high proportion of microaggregates. Isn't it the other way around? High microaggregate proportion is more likely a result of degradation, not a cause.

Response: Thank you for your valuable comment. You are correct that a high proportion of microaggregates is generally a consequence of land degradation rather than its initial cause. Our intention was not to suggest a unidirectional causality but rather to highlight the role of microaggregate dominance as both an indicator and facilitator of continued degradation. When macroaggregates break down due to factors such as erosion, reduced organic matter input, and biological disturbance, microaggregates increase in proportion. This shift leads to decreased soil structural stability, reduced porosity, impaired water infiltration, and limited organic matter protection, all of which can hinder soil recovery and promote further degradation. To clarify this point, we have revised the sentence. Please see the revise manuscript line Number #

"Land degradation in tropical regions, such as Hainan Island, southern China, is driven by unfavorable soil conditions, including a high proportion of microaggregates (<0.25 mm) often observed in degraded soils due to macroaggregate breakdown which reduces structural stability, water infiltration, and low soil organic matter (SOM) content, which further weakens soil structure."

• L70: Please write out "RLD" when it is first introduced.

Response: Thank you very for your correction, revised as suggested, and added the full form of root length density (RLD) in the revised file.

• L73: Missing period after the word "cohesion."

Response: Thanks, added the missing period "cohesive force"

• L83: Change "slope" to "sloped" for grammatical accuracy.

Response: Corrected as suggested

Methods:

• Please state what the land use was prior to rubber planting—this context is helpful.

Response: Thank you for your comment. Prior to rubber planting, the land was covered by tropical rainforest. We have now added this information to the materials and methods section in the revised file to clearly indicate the original land use before rubber planting. Please see line No: in the revised file.

• L205–206: MWD and GMD are introduced in reverse order relative to Equations 2 and 3. Please match the order of terms with their definitions.

Response: Thank you very much for your correction. Corrected the MWD and GMD information according to equations

"Equations 2 and 3 were used to compute the mean weight diameter (MWD, mm and geometric mean diameter (GMD) and mean weight diameter (MWD, mm), respectively"

• L213: The structure of the statistical models isn't clearly described. What metrics were used to assess fit and variance (e.g., F statistic, Wald Chi-square)? You mention Tukey's test, but this is a post-hoc comparison, not the main analysis. Your response to Reviewer 2 on this point was insufficient—please clarify what models were used, how they were structured, and what was tested.

Response: We sincerely appreciate the reviewer valuable feedback and constructive suggestions, which have significantly improved the rigor and clarity of our statistical analysis. We have revised the statistical model please see line number # in the revised file

"Prior to conducting one-way ANOVA, data were tested for normality using the Shapiro–Wilk test and for homogeneity of variance using Levene's test. All datasets satisfied the assumptions required for ANOVA. Each treatment was replicated three times ($n = 3$), and results are presented as mean ± standard deviation. We revised the analysis and used a post-hoc (Tukey's) test for significance. All the graphs have been revised, and letters that show a significant difference between the treatments were added.

• Section 2.4: The distinction between RFCF and root–soil composite cohesive force is not clear. The full term "root–soil composite cohesive force" first appears in the results section. Earlier in methods, it's mentioned once as "root-soil composite core," which made it unclear that these were different. Also, the acronym "RSCCF" is introduced late (L314); it would help to introduce and define this in the methods.

Response: Thanks for your correction. We apologize for not mentioning the soil root-free cohesion force (RFCF and root soil composite cohesive force (RSCCF). We have added this information in the materials and methods also corrected it in the results and discussion parts. Please see line number : in the revised file.

• L220: The construction of the random forest (RF) model needs more explanation. What metric was used to assess variable importance (e.g., Gini importance, permutation accuracy)? Please also describe how the path analysis was structured and how model fit was evaluated. Typically, this would include Chi-square ($p > 0.05$), CFI > 0.90, RMSEA < 0.08, and SRMR < 0.08. Were these used?

Response: We sincerely appreciate the reviewer insightful questions regarding our modeling approaches.

"The MSE and R^2 were calculated to assess the predictive performance of the RF model, with results presented in Figure 7. These metrics were derived by comparing predicted versus observed values on a hold-out test set after model tuning. Variable importance was assessed using Gini importance. The RF model was tuned using a grid search to optimize hyperparameters, and model validation was performed using cross-validation to ensure robust performance, with MSE and R^2 reported as key metrics in Figure 7."

"We appreciate your questions regarding the Partial Least Squares Path Modeling (PLS-PM) analysis presented in Figure 8. The PLS-PM analysis was conducted using the *plspm* package in R to elucidate the pathways through which plant root traits. Direct and indirect effects were specified based on theoretical hypotheses. Model fit for the PLS-PM was assessed using standard metrics for PLS-based models, as traditional SEM fit indices (e.g., Chi-square, CFI, RMSEA, SRMR) are less applicable due to the non-parametric nature of PLS-PM. We evaluated the following: significance of path coefficients was determined using bootstrapping (5,000 resamples), with $p < 0.05$ and R2 indicating significant paths."

Results:

• The results text and figures refer only to p-values. Please report the test statistics used (e.g., F-values, degrees of freedom). These can be added to the text or provided in a summary table of ANOVA results.

Response: Thank you very much for your suggestion. Revised all figures and added the statistical information in the results where necessary.

• Figure descriptions: Clarify the variance metrics shown in error bars—are these standard errors or standard deviations?

Response: Thank you very much for your suggestion. Each treatment was replicated three times (n = 3), and results are presented as mean ± standard deviation.

• Figure 4B: Minor typo—y-axis should be labeled "force" (currently reads "force" again).

Response: Revised as suggested

• L291–292: Subsection header is not properly separated with a line break.

Response: Thank you so much for your correction. Correct the subsection header, please check it revised file.

• L306–308: Try to avoid interpretation of findings in the results section—save that for the discussion.

Response: Thank you very much for your correction. Removed the interpretation finding from results section and added it to the discussion in the appropriate place

Conclusion:

• L437: The section on practical implications refers to differences in rubber tree varieties, but only stand age was measured. Consider rephrasing this to reflect what the data support—what can we infer about management or best practices across different stand ages?

Response: We appreciate this constructive comment. The revised text now clarifies that our recommendations are based on stand age (a measured variable) rather than unverified varietal differences. The updated section read in the revised file line No:

"These findings offer practical implications for managing rubber plantations across different stand ages to restore soil quality in degraded tropical regions of Hainan Island. For instance, younger stands may benefit from targeted organic amendments or intercropping to accelerate SOM accumulation, while older stands might require interventions to mitigate aggregate breakdown through root properties. The study underscores the role of root systems in soil stability, suggesting that management practices promoting robust root development regardless of variety could enhance aggregate cohesion and long-term productivity."