SOIL Discuss.,
https://doi.org/10.5194/soil-2019-59-AC2, 2019

Interactive comment on "Variation of soil organic carbon, stable isotopes and soil quality indicators across an eroding-deposition catena in an historical Spanish olive orchard" *by* José A. Gómez et al.

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Received and published: 20 December 2019

We appreciate the contribution of the reviewer to improve the quality of our work through a careful assessment of the manuscript and helpful suggestions.

We detail below each of the reviewer's comments and how we plan to address those suggestions in a revised version of the manuscript that we have not uploaded by the time of closing the period for posting comments due to the lack of time to prepare a convenient review. For the shake of clarity, the original comments by R2 are between

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quotation marks.

“General comments: This paper focuses on the impact of long-term erosion and deposition processes on different soil parameters, especially bulk soil organic carbon and its fractions, within an historical olive orchard in Andalusia, Spain. The purpose of this study is worthy giving the importance of olive orchards and intense erosion processes in Mediterranean region. The soil parameters used to illustrate the impact of land use and erosion-deposition processes on soil quality have been well chosen. However, I have many concerns about the methodology, the data analysis, and the structuration of the manuscript. Different points of the ‘materials and methods’ section should be completed and more detailed as the sampling method and the method used to calculate the Corg stocks. Also, how the samples of the reference site were used in the data analysis is fuzzy to me. You’ll find my related questions/requests in the specific comments below. Whereas the authors chose well the parameters to study here and gather an interesting dataset, this latter seems insufficiently analyzed. I agree with referee #1, the authors should dig a bit further and try to better synthetized the results via fewer but more synthetic figures. Moreover, I have some serious concern about the way the Corg stocks and saturation capacity have been computed and treated. The authors could review the ‘results’ and ‘discussion’ sections accordingly to new data analysis and figures. Please, could you better structures these sections and add sub-titles? Please, find some specific comments and technical corrections below.” We will expand the details on methodology and sampling, e.g. giving more details on the sampling equipment, calculation of the Corg stocks, etc., and improve the clarity of the data analysis following the recommendations of the three reviewers. Additionally, we will re-check the calculations on the Corg stocks and saturation capacity and structure the results and discussion sections also including subtitles to facilitate the reading.

“Comment §2.1 ‘Description of the area’: As the study focuses on an erosion-deposition soil catena, an elevation map of the olive orchard or a topographic profile of the sampled transect locating the soil profiles could be appreciated.” We will provide in

the supplementary material a transect showing the elevation of the sampled areas and an elevation map including the orchard and the reference area.

“Comment §2.2 ‘Soil sampling’: The authors specified in the text that the reference site was sampled per 5 cm increments whereas the olive orchard was sampled per 10 cm increments. How did the authors compute values of soil parameters in reference site for the 10 cm increments? All the results presented in the results section concerned the 40 first cm of soil. The reference site was sampled ‘until bedrock was reached (i.e., 0-5, 5-10, 10-15, 15-20cm). ‘(l.119-120). Does it mean that the number of sample by 10cm increment in reference site is not constant? If the bedrock can be reached at 20cm within the reference site, what are the implications for the olive orchard especially in eroded areas? What are the implications on the rock fragment content in the samples and the computation of the Corg stocks?” The sampling in the reference area was done manually at 5 cm depth intervals (e.g. 0-5 and 5-10 cm) and the samples were integrated to perform the analysis at 10 cm intervals (e.g. integrating 0-5 and 5-10 cm into one for 0-10 cm). We found a mistake in lines 119-120; the reference area was sampled until reaching bedrock which was located at least at 40 cm in all cases. The carbon, δ13C and δ15N analysis comes from samples from four of these pits, while the 137Cs analysis comes from the 13 pits. In all these pits bedrock was below 40 cm depth. Carbon stock calculations were made for the fine soil fraction (< 2 mm) after discounting rock or stone fragments larger than 2 mm and considering soil bulk density measured using the hand cylindrical core sampler with a volume of 100 cm3.

“Comment 3: Could you specify somewhere what are the final numbers of values analysed by 10cm increments in the reference site and in the olive orchard please?” Yes. In the revised version of the text we will include the information requested by the reviewer. The number of soil samples for each 10 cm increments was 4 and 8 from the reference area and olive orchard, respectively.

“Comment 4: The sampling was performed by a mechanical soil core. Was it a percussion drilling machine? Was there any soil deflection/compaction of the samples due to

the mechanical drilling, i.e. was there any consequence on the depths of the soil increments?" The mechanical soil sampling was made with a hydraulic core sample which gently rotates and push the core, and with the soil at a moisture content between 40 to 80 WHC, and therefore we did no need to hard drilling the soil, minimizing the compression of the soil samples. The sampling was made properly, insuring that the whole sample was taken for each given depth, abandoning the point and starting a new one if some problem arose (like a sample being only partially taken). A better explanation of this and the model of core equipment used will be included in a revised version of the manuscript.

"Comment 5: The Corg stocks were calculated in the study. How exactly? Did you assess the soil bulk density based on the volume and mass of the soil increments? What about the rock fragments¿' Soil carbon stock were calculated for the fine soil fraction after discounting rock or stone fragments larger than 2 mm, and considering bulk density which was measured following using the hand cylindrical core sampler with a volume of 100 cm3

"Comment §2.3 'Physico-chemical analysis': Corg concentration were determined according to Walkley and Black method. Did you apply a coefficient of correction to the raw data in order to take into account for the incomplete oxidation? This correction factor may vary from 1 to 1.6 depending on land use, soil texture, organic matter quality, sampling depth or climate. You compare two sites with different land uses, texture and organic matter quality (as highlighted by the fractionation results), and different depths." We thanks to the reviewers for this comment, as we have detected a mistake in the reference we used regarding the method for SOC determination. In all cases, SOC fractions and in the bulk soil, organic carbon concentrations were determined by using the wet oxidation sulfuric acid and potassium dichromate method of Anderson and Ingram (1993). We have corrected this in the revised version of the manuscript.

"Comment: You determined the theoretical values of stable carbon saturation based on the soil particle analysis. Could you specify exactly which model you used, with the

values of the parameters, please? (See my comments below concerning the results section)." See answer to concerns in result section.

"Comment §3 'Results': l. 197-199: A more correct way to compare soil Corg stocks between different land uses is on equivalent soil mass." We will compare the reference area and the olive orchard in equivalent soil mass following the procedure describe in Wend and Hauser, 2013. An equivalent soil mass procedure for monitoring soil organic carbon in multiple soil layers. European Journal of Soil Science doi: 10.1111/ejss.12002 , 2013

"Comment. 200-204: did you invert in the values of texture distribution between the reference and olive orchard sites? If you have estimated the theoretical values of stable carbon saturation based on the content of particles <2μm (l. 205), the olive orchard should have a higher potential than the reference site according to the clay contents proposed here, i.e. 41 and 30% in the orchard and reference site respectively. Concerning the values of theoretical stable carbon saturation, could you precise the model used to compute them please? The values you proposed (i.e., 1.94 and 1.15%C; l.205) can't be achieved based on the model a proposed by Hassink & Whitmore (1997) in the Table 4." We thank the reviewer for his comments on this topic as we have detected errors on our calculations regarding the theoretical values of stable carbon saturation. As reviewer has detected, the olive orchard soils have a higher potential than reference site. We have applied the model of Hassink & Whitmore (1997). According to this model, the theoretical value of protected SOC (g C kg soil-1) = 21,1 + (clay content (g kg-1 soil) x 0,0375. Considering that there were not significant differences in the soil clay content along the catena in the olive grove soils, the average theoretical protected SOC (%) is 3,63ïĆś0,19, where in the reference site averaged 3,24ïĆś0,11. According to these new values, protected soil Corg in the reference site and orchard soils accounted for 20.5ïĆś5.2 % and 49.8ïĆś11.5 % of the maximum soil stable Corg, respectively at the topsoil. After this amended, conclusions have not changed respect to the first submitted version of the manuscript. In the revised version of the manuscript

we have corrected the data: Texture distribution of the topsoil (0–10 cm) along the catena in the olive orchard presents an average clay, silt and sand content of 41, 37 and 22% and low variability, respectively (average coefficient of variation of 17%) without significant changes between the erosion and deposition areas. In the reference area, the soil has an average clay, silt and sand content of 30, 31 and 39% respectively, also with a homogeneous distribution across the sampling area (coefficient of variation of 10%). According to the Hassink and Whitmore (1997) model, the percentages of organic carbon of maximum soil stable Corg are of 3.63ïĆś0.19 and 3.24ïĆś0.11 % in the reference site and olive orchard, respectively. So, protected Corg in the reference and olive orchard areas account for 20.5ïĆś5.2 % and 49.8ïĆś11.5 % of the maximum soil stable Corg, respectively at the topsoil.

“Comment §4 ‘Discussion’: l. 276: the value is 1.19 or 1.15%C as proposed line 205?” Reviewer is right in his/her concern on this issue, and we are deeply sorry on our errors on the calculations. The correct value is (3.64ïĆś0.23 %) and we have amended in the revised version of the manuscript: In fact, the protected Corg concentration in the topsoil of the olive orchard in the eroded area is about the 18.6ïĆś3.9 % of the upper limit of protected Corg (3.64ïĆś0.23 %) according to the model of Hassink and Whitmore (1997)

“Comment l. 278-280: here, the authors affirmed that the land degradation reduced the soil capacity for Corg stabilization. If the authors well used the model fitted by Hassink and Whitmore in 1997 (‘As proposed by Hassink and Whitmore (1997), theoretical values of carbon saturation were established from the soil particle analysis’ l. 158-159), they know that basically the model is in the form : X = a * clay content + b with X the soil capacity for Corg stabilization, a and b some constants. As the soils in the reference and in the olive orchard have different clay content, they have different capacity for Corg stabilization! Here, it is like the authors were affirming that the land degradation has changed soil texture... I need more explanation and proof, please.” Reviewer is right. We will delete this sentence in the revised version of the manuscript.

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“Technical corrections Figure 1: Please, could you add bar scales or precise the olive orchard size in the part §2.1?” Yes we will include a scale bar for this Figure.

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