SOIL Discuss., author comment AC1
https://doi.org/10.5194/soil-2022-13-AC1, 2022

Reply on RC1

Sastrika Anindita et al.

Author comment on "Tropical Andosol organic carbon quality and degradability in relation to soil geochemistry as affected by land use" by Sastrika Anindita et al., SOIL Discuss., https://doi.org/10.5194/soil-2022-13-AC1, 2022

Thank you for the comments and suggestions. Our responses are listed below in the same order as the referee's comments.

- **Line 51:** We have checked the article by Gerzabek et al. (2019) and indeed a comparison of SOC stock, pedogenic Al and Fe was made between native forest and agriculture after 5 and 15 years of conversion. We propose to revise the sentence accordingly to: *"A recent study on the Galapagos island demonstrated that even 15 years conversion of native forest to cultivated land strikingly accelerated soil weathering (Gerzabek et al., 2019)"*

- **Regarding the small climatic differences between sites:** all the sites have a strong leaching regime (between 1850 – 2600 mm $year^{-1}$) and a similar slope and exposition. For this reason, we do not expect differences in weathering and leaching between the sites, even though there are some differences in climate.

- **Regarding the OC stock:** we agree to include OC stocks of each soil carbon pool per sampled layer as per the referee's advice. The outcome of a statistical comparison of OC stocks between the land-use groups yielded the same result as that obtained for SOC contents (as bulk densities were in fact highly comparable between the soils). Accordingly, reporting SOC stocks would not bring about major changes to the discussion section or to the conclusions.

- **Figures:** We will increase the font size in all figures

- **Line 253:** Will be revised accordingly

- **Ad 4.2, Regarding our interpretation about the mineralisation process that could show up in the smallest fraction when the situation is less favorable for microbes:** we agree that for the soil incubation experiment, a comparison of the entrance of the exogenous OM-C (untransformed or microbially processed) into the various separated soil fractions (MAOM, POM, occluded POM)) could provide extra insight into whether or not potentially contrasting governing SOM-protection mechanisms predominate between the studied soils. However, the contrast in ^{13}C-content of the used plant material ($\delta^{13}C$ +50‰) and native SOC ($\delta^{13}C$ -13 to -27‰) is probably too small for proper tracking of ryegrass-C entrance into soil fractions, particularly given the large SOC background concentration of most of the included soils. This would most likely obstruct robust statistical comparison of ryegrass C preservation in function of land use (forest and agricultural land use), particularly as the soil respiration assays already revealed wide variation in % ryegrass mineralized between the forest soils. Moreover, even if we were to dispose of a substrate with more strongly contrasting $\delta^{13}C$ vs. SOC than the one used here, we still think that the primary conclusion of this study - long-term formation of pedogenic Al and amorphous materials and accumulation of Ca by liming stimulated occlusion of POC into microaggregates – would not have been well testable by a simple lab incubation experiment such as the one performed here. The formation of soil aggregates depends on plant, soil microbial and soil faunal activity as well as on fluctuations in environmental conditions (like moisture content). In addition, the diminution of the added OM into smaller-sized particles that may more readily end up inside microaggregates could be of importance. The simplistic approach used here: short-term incubation of small soil cores at constant moisture level without plants and no inoculation is likely unfit to realistically reproducible actual aggregate occlusion as it were to occur on the longer time scale in the field. We are therefore reluctant to also fractionate soil cores at the end of the performed soil respiration assays and measure $\delta^{13}C$ levels of soil fractions – as this would involve a substantial extra amount of work with probably limited added value to support or disprove the current interpretations.

- **Conclusions, net-input OC, the overall SOC stock under forest and agricultural land, and comparison with sites receiving e.g. only mineral fertilizers:** We acknowledge that data on OC inputs would have been very useful to more strongly ascertain that differential pedogenesis indeed caused observed differences in aggregate occluded SOC and other fractions between the two investigated land-uses. At all three agricultural sites farmers indeed apply substantial quantities of manure. This is the default practice in the Mt. Tangkuban Perahu and Mt. Burangrang areas. We in fact did not find any field where only mineral fertilizer is used, and hence comparison with sites that do receive manure would not be possible. Obviously, one can expect such large manure amendments (please see the below table) to non-negligible contribute to the SOC balance. We propose to clearly list organic fertilizer C inputs and balance these vs. plant-C inputs in the revised version. Unfortunately, measuring plant-C inputs would require a huge amount of extra work and is also methodologically extremely challenging, especially measurement of below-ground C inputs from the considered tropical native forest and secondary pine forest seems out of reach for this study.

As an alternative, we propose to introduce estimates of vegetation C inputs for the included land uses into our discussion. When estimating C-inputs for the arable sites, we could base these on known residue C-inputs for the crop rotations and the known use of exogenous OM. For the forested sites, ranges of vegetation C-input estimates could be taken over from the literature. For this, we only used literature references on comparable native forest and secondary pine forests in Indonesia. The below table presents estimated plant and manure C inputs to the soil for each site (next to SOC stocks). We propose to add these C-input estimates to Table 1 and three new literature references.

Site	land use	Plant C -input	Organic fertilizer C –input	Total SOC stock (0-20 cm)	Total SOC stock (0-80cm) (Mg $ha^{-1}yr^{-1}$)
		(Mg ha^{-1} yr^{-1})			
			(Mg ha^{-1} yr^{-1})	(Mg ha^{-1} yr^{-1})	

NF	natural forest	6.7 – 12.2[(1)]	-	56.9	134.8
PF1	pine forest	3.6 – 9.1[(2)]	-	30.4	54.4
PF2	pine forest	3.6 – 9.1[(2)]	-	33.0	72.1
AG1	agriculture	1.8	11.50	40.3	72.0
AG2	agriculture	1.6	6.4	71.4	139.1
AG3	agriculture	1.0	6.8	61.1	105.8

[(1)]Guillame et al. (2018), https://doi.org/10.1038/s41467-018-04755-y and Hertel et al. (2009), https://doi.org/10.1016/j.foreco.2009.07.019

[(2)]Bruijnzeel (1985), http://www.jstor.org/stable/2559453

Although the estimated ranges in C-inputs are forcefully very wide they do readily reveal that C inputs to the agricultural plots are probably similar to or even above those in the forest soils. Thus, we recognize that it was not possible to conclude that the higher OC stock in agricultural compared to pine forest soils was solely due to the observed enhanced soil weathering as a result of conversion from forest to agricultural land use. We propose to change L405-409 of the conclusion into, *"Based on the present study, we postulate that the enhanced formation of amorphous minerals and Al_o under agriculture with high OM inputs promoted the development of stable soil aggregates and OC occlusion therein and this would in part counter otherwise expected losses of SOC compared to secondary forest. However, the contribution of large OM input vs. land-use conversion per sé could not be elucidated here and this will require study of other tropical Andosol forest-agricultural land use pairs with detailed inventory of OC inputs".*