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Reply on RC4

Elisa Bruni et al.

Author comment on "Additional carbon inputs to reach a 4 per 1000 objective in Europe: feasibility and projected impacts of climate change based on Century simulations of long-term arable experiments" by Elisa Bruni et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2020-489-AC4, 2021

We thank the reviewer for the comment and we tackle the limitations raised by changing several parts of the manuscript. Please find below the details, separated into three main points.

1.

In the introduction (now rephrased to clear out our objectives) we stated that we estimated if a 4‰ SOC increase is attainable with currently implemented soil practices:

"Our work was set up in this context with the objectives to: 1) estimate the amount of C inputs needed to increase SOC stocks by 4‰ per year; 2) investigate if this amount is attainable with currently implemented soil practices (i.e. organic amendments and different crop rotations) and 3) study how the required C inputs are going to evolve in a future driven by climate change."

Also, in the discussion (L.554 – 556) we said:

"In terms of C sequestration, organic fertilizers coming from animal manure are usually being applied to the soil at some location, hence they cannot account for additional climate mitigation potential (Poulton et al., 2018)."

We add the following sentence:

"Rather, they are considered as a business as usual situation that can unlikely be significantly expanded."

However, some treatments considered in this study were sewage sludge and household waste, which are currently not a business as usual scenario. We discussed this in Subsection 4.2.4:

"In our study, we also considered treatments with other types of EOM addition, such as sewage sludge and household waste. In many countries, a significant proportion of food and urban waste is currently left on disposal areas, where C is lost to the atmosphere as CO_2 or methane (CH_4) emissions (Bijaya et al. 2006). Pellegrini et al. (2016) reported the amounts of sewage sludge disposed on landfill in Europe (EU26) from Eurostat (2014b). In

2010, this was 0.914 TgDM. Using the Van Bemmelen factor (1.724) to convert OM to OC (McBratney and Minasny, 2010; Rovira et al., 2015), we estimated that the sewage sludge disposed on landfill in Europe was around 0.004 MgC ha^{-1} per year in 2010. If applied to cropland, this could potentially increase C inputs to the soil and decrease GHG emissions associated to landfilled waste. However, in some countries social acceptability of spreading EOM such as sewage sludge is very low, limiting its actual potential. In Europe, landfilled municipal waste was 0.3 MgC ha^{-1} in 2019 (estimated from Eurostat (2020) considering a C content in household waste of 71% (Larsen et al., 2013)). This is higher than the amount of municipal waste currently composted in Europe (i.e. 0.22 MgC ha^{-1} in 2019, according to Eurostat (2020)), showing that additional efforts to improve the reutilization of municipal waste could help to increase C inputs in agriculture."

2.

We agree that sourcing EOM from another field does not account as additional C sequestration. Hence, we remove the following sentence from the discussion: "First of all, the amount of organic fertilizers is limited at site scale and farmers may have difficulties in producing or buying high quantities of EOMs (Poulton et al., 2018). "

Instead, we add the following:

"However, a full C cycle assessment should be considered to make sure that GHG emissions associated to such treatments do not exceed additional C storage (Guenet et al., 2020)."

Also, we add the following sentence to the end of subsection 4.2.1:

"Moreover, producing additional animal manure implies larger GHG emissions through animal digestion and manure decomposition. Consequently, even if more manure is returned to the soil, it will not necessarily result in climate change mitigation."

And to subsection 4.2.4:

"In this study, we did not include other potentially beneficial management practices, such as cover crops, reduced tillage, biochar application, improved soil pH, landscape differentiation and mineral amendments. Further research should investigate if long-term experiments with these management practices would be able to increase SOC stocks by 4p1000, following Century predictions."

3.

In the conclusion, we add the following sentence:

"In this study, we did not take into account the whole life cycle of C at the farm. However, compensating CO_2 emissions from human activities through SOC sequestration should also comprehend GHG emissions related to the management of additional EOM."