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LETTER TO THE EDITOR

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Cover crops do increase soil organic carbon stocks—A critical comment on Chaplot and Smith (2023)

Recently, Chaplot and Smith (2023) challenged the notion, that cover crops constitute an effective option to increase soil organic carbon (SOC) stocks. As much as we agree with the authors' position on the need for analytical rigour, we strongly question the validity of their study.

1. There is a wealth of solid, published experimental data showing clear positive effects of cover crops on SOC stocks, which were ignored by the authors. It is extremely surprising that the authors identified only 31 publications (37 experiments) on the topic, indicating a great deficiency in their search for references. Qin et al. (2023) summarized three meta-analyses at global scale and one in the temperate zone, using hundreds of paired observations each, and reported average SOC accrual rates of 0.32–0.56 and 0.21 $Mg\,C\,ha^{-1}\,year^{-1}$, respectively. Beillouin et al. (2023) performed a second-order global meta-analysis and identified five cover crop meta-analyses, showing a significant positive mean effect of cover crops on SOC (+11.6%). Obviously, international standards to carry out systematic reviews and meta-analyses (Gurevitch et al., 2018) were not followed by Chaplot and Smith (2023), which is a major shortcoming of this paper.
2. Most of the exclusion criteria are not justified.
   (i) Sampling depth: Growth and incorporation of cover crops mostly affect the plough layer (or the A horizon). Subsoil effects are typically limited in magnitude and depth (~50 cm) and in the same direction as topsoil effects (Skadell et al., 2023). A minimum required sampling depth of 1 m is over-ambitious, unrealistic, and leads to disregarding many studies of interest without good reason.
   (ii) We agree that reporting only SOC contents is a weakness because bulk density and stone content then need to be estimated for stock calculation. However, in mono-layer assessments, and when tillage is homogenous across treatments, the relative change in SOC content equals the relative change in mass-corrected SOC stocks. Given the large variability across sites, studies reporting SOC contents are a valuable source of information that should be considered.
   (iii) Comparing SOC stocks without mass-correction is another weakness, but since bulk density is almost always negatively correlated with SOC, the cover crop treatment is often the one with the lower soil mass to a fixed depth. A correction would thus lead to an even larger effect of cover cropping on SOC.
   (iv) Too little data points per treatment due to pooling or the experimental design might be a statistical short-coming at the site level, which can and should be accounted for in a meta-analysis. However, the exclusion of such studies is not necessary.
3. The analysis of the results is terse and questionable as there is no true quantitative analysis. The authors carry out an analysis similar to "cherry picking" after choosing not to consider votes for most candidates. This is scientifically questionable (Haddaway et al., 2020), just as generating a final global average value from three remaining case studies.
4. All three remaining studies were misinterpreted. Instead of negative, Thomsen and Christensen (2004) reported positive effects of cover cropping on SOC across a range of different straw incorporation treatments. From their numbers, we have calculated SOC accumulation rates of 0.27–0.39 $t\,C\,ha^{-1}\,year^{-1}$ thanks to cover cropping. Constantin et al. (2010) found increases in SOC not only in one but in all three sites (Figure 2 in their paper). SOC stock change was proportional to the C inputs derived from cover crops. Finally, the third study (Balkcom et al., 2015) did not even mention SOC and was completely off-topic, which once again reveals the deficient literature search and completely invalid conclusions of the authors.
5. There is no plausible hypothesis, why cover crops should not significantly enhance SOC. The regular addition of significant amounts of high-quality biomass (including roots and rhizodeposition) must be beneficial for SOC storage. Cover crops have a much narrower C:N ratio than straw, with a maximum C:N ratio of 30 (De Notaris et al., 2020), so that the build-up of stabilized SOC is hardly limited by N. It is surprising to find a putative and unproven argument using results of (Constantin et al., 2010) to support the hypothesis that the addition of manure in the system explains the efficiency of cover crops to enhance SOC storage, which was not demonstrated by these authors. Indeed, cover crops may not strongly enhance SOC in some regions due to low biomass production or priming effects (Liang et al., 2023). Given the wide variability in cover crop management, mixtures and site conditions it can be expected that their success to build up SOC

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is highly variable, depending on the level of cover crop growth which determines the C inputs in the soil. However, a general questioning of an average positive effect of bare soil replacement with vegetation used as green manure has no foundation.

We conclude that the doubts on the positive effects of cover crops on SOC are unjustified. Moreover, their opinion on the relevance of policies and the use of public subsidies is a political point of view that is expressed without any nuance and is very debatable given the obvious weaknesses of their study. Finally, it is alarming that this manuscript even passed the review process of such a high impact journal.

AUTHOR CONTRIBUTIONS

Christopher Poeplau: Conceptualization; writing – original draft. **Zhi Liang:** Conceptualization; writing – review and editing. **Axel Don:** Conceptualization; writing – review and editing. **Daria Seitz:** Writing – review and editing. **Chiara De Notaris:** Writing – review and editing. **Denis Angers:** Writing – review and editing. **Pierre Barré:** Writing – review and editing. **Damien Beillouin:** Writing – review and editing. **Rémi Cardinael:** Writing – review and editing. **Eric Ceschia:** Writing – review and editing. **Claire Chenu:** Writing – review and editing. **Julie Constantin:** Writing – review and editing. **Julien Demenois:** Writing – review and editing. **Bruno Mary:** Writing – review and editing. **Sylvain Pellerin:** Writing – review and editing. **Daniel Plaza-Bonilla:** Writing – review and editing. **Miguel Quemada:** Writing – review and editing. **Eric Justes:** Conceptualization; writing – original draft.

CONFLICT OF INTEREST STATEMENT

We do not have a conflict of interest to declare.

DATA AVAILABILITY STATEMENT

There is no data involved in this letter.

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