We thank the anonymous reviewer for the very valuable and constructive comments, which greatly helped improve the clarity, structure, and overall focus of the manuscript. In response, we clarified the scope of the paper as a perspective article, explained the criteria used to select the literature, reorganized the manuscript to strengthen the argument, clarified key concepts related to fertilization strategies and soil carbon dynamics, and developed a clearer agenda for future research.

With best regards

Vincent Chaplot and Pardon Muchaonyerwa

General comments:

The submitted article discusses the topic of crop fertilization as a requirement for building soil carbon stocks. It is a timely topic and surely deserves attention. However, the research question/objective, methods used and scope of the article are unclear.

> We thank the reviewer for this important comment. We have clarified the nature of the manuscript as a perspective paper synthesizing existing evidence rather than a systematic review. We have added a paragraph in the introduction explaining the criteria used to select the cited literature (long-term experiments, meta-analyses, and studies comparing fertilization regimes). We have also clarified the main standpoint of the paper, namely that soil organic matter dynamics in croplands are strongly regulated by nutrient stoichiometry and fertilization strategy, and we have improved the logical flow of the argument throughout the manuscript.

While some literature on the topic has been reviewed, it is unclear how this selection was made. If the authors intend not to write a review but a perspective, it is unclear what the main standpoint is and how the argumentation evolves.

A new rationale section was added as follow:

*"**1. Rationale***

This article is a perspective paper that synthesizes existing evidence to argue that balanced fertilization, including adequate nutrient supply, is a key determinant of soil organic matter dynamics in croplands. The literature reviewed here was selected to illustrate findings from long-term field experiments, meta-analyses, and paired-site studies that quantify SOC changes under different fertilization regimes. Priority was given to studies comparing fertilized and unfertilized systems, as well as to large-scale syntheses documenting soil carbon responses to nutrient management."

The paper structure was edited from :

- Section 1: SOC declines after conversion
- Section 2: Fertilization reduces losses

- Section 3: Over-fertilization increases SOC
- Section 4: Residue decomposition and priming
- Section 5: Way forward

To

1. Global evidence of SOC loss after conversion
2. Role of nutrient depletion (nutrient mining)
3. Evidence that balanced fertilization reduces losses
4. Evidence that high/combined fertilization increases SOC
5. Conceptual framework (stoichiometry + priming)
6. Implications for policy (including 4 per 1000)

A conclusion was finally added to clarify the main standpoint of the paper:

*"**Conclusion***

Evidence from long-term experiments suggests that soil organic matter dynamics in croplands are controlled not only by carbon inputs but also by nutrient stoichiometry and fertilization strategy, making balanced nutrient management an essential component of reliable soil carbon modeling and sustainable carbon sequestration. Balanced fertilization, when aligned with crop demand and residue decomposition requirements, can reduce nutrient mining and limit excessive SOC mineralization, and should therefore be promoted alongside practices aimed at increasing carbon inputs to soils. This calls for further studies on crop fertilisation for soil C sequestration.

Balanced fertilization may generate positive outcomes at agronomic, environmental, and climatic levels. Based on the estimates of Kirkby et al. (2014), the CO_2 emissions associated with the additional fertilization required to support crop residue decomposition—including fertilizer production, transport, field application, and potential volatilization—would remain below 20% of the CO_2 potentially sequestered in soils. Furthermore, when nutrients are applied after harvest on relatively dry soils—that further rewet slowly—they are likely to be rapidly taken up or immobilized by soil microorganisms, thereby reducing the risk of leaching and limiting transfers to freshwater systems

Finally, from a long-term sustainability perspective, the availability of essential nutrients must also be considered. Phosphorus solubilizing microorganisms may be fostered in soils. Although several key mineral resources such as phosphorus are finite on land, large oceanic reservoirs exist, estimated to be several thousand times larger than current annual mine production, which could potentially be accessed through biological pathways such as algae-based recovery systems. Developing such *approaches could help sustain nutrient supply while supporting the long-term rebuilding of soil organic matter and soil fertility in global agriculture.*

In addition, while 'recommended rates' are a central theme, they are not defined and it is unclear if 'recommended rates' in the experiments cited are always calculated in a similar manner (e.g. using an offtake model or based on environmental/economic optima) and have the same meaning.

- We agree. In many cases fertilizer recommendations are based on yield targets that optimize profits rather than strict nutrient replacement. The manuscript was edited accordingly. Please see the detailed comments were addressed below and the version of the manuscript showing the alterations made from the previous draft.

At the end of the article the authors highlight research and knowledge gaps. Perhaps, the article could be structured around identifying a research agenda on crop fertilization for soil carbon sequestration.

> We thank the reviewer for this suggestion. We have identified several issues we included in a new conclusion section:

"However, major knowledge gaps remain. Future research should aim to quantify the amount, timing, and stoichiometry of nutrient inputs required to prevent prevent priming during the decomposition of crop residues. This includes determining optimal fertilization regimes—covering macro- and micronutrients—across crop rotations, soil types, and climatic conditions worldwide. Particular attention should be given to identifying fertilization thresholds and nutrient ratios that promote SOC recovery, as recent studies suggest that the response of SOM to fertilization depends on initial SOM levels and other site-specific factors.
Such efforts will require coordinated long-term experiments, global meta-analyses, and improved process-based models capable of representing interactions among plant productivity, microbial processes, nutrient availability, and residue decomposition. Integrating these mechanisms into Earth system and agricultural carbon models would improve predictions of SOM sequestration potential under different fertilization strategies.

Further, a summary sentence was added to the rationale as follows:
"This also calls for SOM dynamics studies and models to jointly consider nutrient availability and carbon inputs."

Specific comments:

The authors mention that fertilization to meet crop needs compensates for exports by agricultural products (Line 82), but it is unclear if all the following studies cited also used this definition of 'recommended rates'. Some 'recommended rates' might refer to economic or environmental optimal application rates, not to nutrient offtake compensation. This will influence the findings and interpretations. If 'recommended rates' are based on environmental optima, increasing NPK applications might have more negative effects than benefits while if 'recommended rates' are based on offtake models there might still be scope to improve the rates, also for the environment. Often, 'recommended rates' in experiments are economic optima which differ widely across regions, which will make interpretation complicated.

- Thank you for this comment. In many cases fertilizer recommendations are based on yield targets that are economically attainable, reflecting optimization of expected profit rather than strict nutrient replacement. Unfortunately, most publications do not explicitly describe how the reported "recommended rates" were derived. However, based on the magnitude of the application rates and the way they relate to expected yields, it is reasonable to infer that many of them reflect yield-target or economic optimization approaches rather than strict nutrient replacement.

  The sentence line 82: "*that fertilization to meet crop needs compensates for exports by agricultural products*"
  Was replaced by :
  "Fertilization to meet yield targets that are economically attainable (i.e. optimizing expected profit) significantly lessens the rate of SOM decrease consecutive to cropping"

As a consequence of the unclarity on 'recommended rates', it is unclear when cited numbers of soil C increase are due to increased biomass and carbon inputs or due to avoided priming or avoided nutrient mining. In some cases, crop yields increased with rates higher than 'recommended' (e.g. Line 99), pointing at the potential benefit of increased biomass and C inputs to the soil and one can question the 'recommendations'. Also at application rates higher than offtake, crop yields can still increase. Such numbers do not give any evidence for priming at the recommended rates, while in the discussion section all the experimental data seems to be used as evidence for soil nutrient mining. For a meaningful interpretation of the data, the two mechanisms should be clearly distinguished.

- We fully agree and the expression "recommended rate" was removed from the manuscript and replaced it by "*Fertilization to meet yield targets that are economically attainable (i.e. optimizing expected profit)***"**
- In addition, we also agree that increases in soil C can result from multiple mechanisms, including (i) increased biomass and carbon inputs due to higher crop yields at rates above the recommended levels, and (ii) avoided nutrient mining or priming effects at recommended rates. However, identifying the relative contribution of these mechanisms was not the aim of our study. Our goal was to report observed increases in soil C under fertilization, while explaining why they occur is a perspective for future research. To avoid confusion, we have revised the Discussion to explicitly note that the mechanisms behind soil C changes were not distinguished and that both mechanisms could contribute depending on crop and soil conditions.
- It is true that the SOC stock decrease at low fertilization rates may also be caused by lower biomass and carbon inputs to soils. However, although croplands typically receive lower carbon inputs than native ecosystems, increasing residue returns (Poulton et al., 2018) or adding cover crops (Chaplot and Smith, 2023) frequently results in little change in SOM stocks. In contrast, greater nutrient availability can increase SOM, indicating that the efficiency with which carbon inputs are converted into stable SOM depends on the availability of nutrients required for microbial processing. This implies that SOM dynamics are jointly controlled by carbon inputs and nutrient availability. This was added to the text from line 166

- We thus added the following sentence to the discussion part: "*The SOC stock decrease at low fertilization rates may also be caused by lower biomass and carbon inputs to soils. However, the fact that the years following conversion of natural vegetation to cropland often exhibit high biomass production and yields, while soil carbon stocks nevertheless decline the most, indicates that SOC losses cannot be attributed solely to reduced biomass inputs.*"
- The following sentencing was added from line 166: "*The SOC stock decrease at low fertilization rates may also be caused by lower biomass and carbon inputs to soils. However, although croplands typically receive lower carbon inputs than native ecosystems, increasing residue returns (Poulton et al., 2018) or adding cover crops (Chaplot and Smith, 2023) frequently results in little change in SOM stocks. In contrast, greater nutrient availability can increase SOM, indicating that the efficiency with which carbon inputs are converted into stable SOM depends on the availability of nutrients required for microbial processing. This implies that SOM dynamics are jointly controlled by carbon inputs and nutrient availability.*"

Technical corrections:

Abstract and short abstract:

Lines 14-17: this is not in contradiction

Lines 14-17: "tone of soil health, agricultural productivity and ecosystem functioning. While virgin lands (forest or grassland) exhibit the highest SOM stocks, their cultivation leads to their sharp decrease and that of crop yields in the first decade(s), even when zero tillage and cover crops are promoted."

We agree that this sentence had to be edited.

- We thus edited as follows: "while virgin lands (forest or grassland) have the highest SOM stocks, cultivation leads to a sharp decrease in SOM and crop yields in the first decade(s), even with zero tillage and cover crops".

Line 25: 'staggering' seems subjective

>We replaced by « substantial » : « **Virgin lands converted to croplands lose substantial amounts of soil organic carbon**

Line 29: soils -> soil

- OK

Section 1:

Line 33: soil organic matter

  - > Thank you

Line 33: Instead of talking about 'intrinsic capacity' it might be more useful to relate the capacity of soils to store carbon to soil texture, soil pH and climates

- > We did so: "*The level of soil organic matter (SOM) depends on soil characteristics (e.g. texture and pH), climate and the balance between carbon inflows and outflows.*"

Lines 36-58 and Lines 59-79: The numbers on SOM decline in practice and field experiments could be summarized in a table to improve readability, with the text referring to the main trends and findings.

Table 1. SOC changes following land conversion from pristine vegetation to cropland and impact of crop fertilization from selected experiments.

Authors	Context/fertilization	Duration	SOC Change
	-------------------------------Land conversion effect------------------------------		
Guo & Gifford (2002); World	Conversion forests/grasslands → fertilized cropland	30 years	-42 % (forests), -59 % (grasslands) (n= 134)
Deng et al. (2016) ; China	Forest/grassland → fertilized cropland	20 years	-1.74 Mg C ha-1 yr-1 (forests), -0.89 Mg C ha-1 yr-1 (grasslands)
Swanson & Latshaw (1919); ; USA	Grassland → fertilized cropland	NA	-30% (0-20 cm), -6% (20-50 cm) (n=37)
Villarino et al. (2017); Argentina	Grassland → fertilized cropland	10 years	-30 % SOC
Fujisaki et al. (2015); Brazil	Tropical forests→ fertilized cropland	Several decades	-60 % SOC
Heikkinen et al. (2013); Finland,	Fertilized cropland	1974-2009	-220 kg ha-1 yr-1 (0.4 %/yr)
Hanegraaf et al. (2009); Netherlands	Fertilized cropland	1987-2003	5.0 % → 4.5 % (0.03 %/yr)
Nafziger & Dunker (2011); Morrow plots, USA	Fertilized cropland	75 years	2.9 → 2.2 % (24 % after 24 years), 2.9 → 1.5 % (48 % after 75 years)
Siband (1974); Senegal	Forest → fertilized cropland	45-180 years	2.7 → 1.2 % (55 %), then 0.6 % (77.8 % total)

Authors	Context/fertilization	Duration	SOC Change
Du Toit (1992); South Africa	Grassland → fertilized cropland (n=50)	85 years	-10 to -75 %
Wei et al. (2014); China	Forest → fertilized cropland (n=453)	>50 years	-35 % first decade, -45 % 11-50 yrs, -53 % >50 yrs
	------------------------------Fertilization effect------------------------------		
Zingore et al. (2005); Zimbabwe,	Forest → cropland	20 years	-52 % unfertilized, -22 % fertilized
Ludwig et al. (2007); Germany	Cropland (fertilized vs unfertilized)	100 years	-25 % unfertilized, 0% with fertilization
Poeplau et al. (2016); Sweden	Cropland (N fertilized, NPK; 2NPK)	60 years	-0.007 ton C ha yr-1 (N), +0.008 (NPK)+0.075 (2NPK)
Poulton et al. (2018); Rothamsted, UK	Cropland with 0, 5 to 10 tons straw	20 years	No change
	NPK vs 2N-PK	20 years	-0.16 ton C ha yr-1 ; +0.82 ton C ha yr-1
	NPK + 30 ton ha yr-1 manure ;	20 years	+0.2 t C ha-1yr-1

- > Line 60: decline -> declines
- > OK

Section 3:

Lines 101-102: How does this nonlinear correlation look like? Please specify.

> There is an exponential increase and the sentence was edited as follows: "*Liu et al. (2023) who additionally pointed out that SOM increases exponentially with fertilizer amounts* »

Section 4:

Lines 129: are these based on nutrient offtake? Please specify.

- The sentence was as follows: "Considering a production of 7 tons of wheat grain per hectare (world average), the recommended fertilization would be 161 kg of N, 70kg P2O5, 140kg K2O."

- It now reads: "*Considering a production of 7 t ha⁻¹ of wheat grain (world average), the recommended fertilization, based on nutrient offtake by the harvested grain and straw, would be 161 kg N, 70 kg P_2O_5, and 140 kg K_2O per hectare.*"

Line 133: Here you mention 'current fertilization' but the numbers in Line 129 refer to 'recommended'. Please explain.

- The sentence was "*Current fertilization thus induces a nutrient gap from 12.5% for P, 13% for N to 42% for K2O*"
  And was replaced by : "The *recommended fertilization thus induces a nutrient gap of 12.5% for P,13% for N and 42% for K2O*"

- Lines 128-134: Can you use kg P instead of P2O5 and kg K instead of K2O?

- The amounts were recalculated as follows: "*Considering a production of 7 t ha⁻¹ of wheat grain (world average), the recommended fertilization, based on nutrient offtake by the harvested grain and straw, would be 161 kg N, 30.5 kg P, and 116 kg K per hectare. Following Kirkby et al. (2014), an additional 25 kg N, 4.4 kg P, and 83 kg K per hectare per year would be required to support decomposition of ~5 t ha⁻¹ of wheat straw, resulting in a total nutrient need per hectare of 186 kg N, 34.9 kg P, and 199 kg K. The recommended fertilization thus induces a nutrient gap of approximately 13% for N, 12.5% for P, and 42% for K, highlighting the need to balance nutrient supply to avoid priming and SOC losses during residue decomposition.*"

Section 5:

Lines 162: Both legumes and zero tillage are suggested as practices to improve nutrient balances while the citations give the opposite evidence on SOM Suggest to rephrase and connect better to Lines 174-176.

- Line 162 was as follows: "*A possibility to improve the nutrient balance into soils and thus to lessen SOM losses due to mining is to favor natural nutrients inputs of for instance N by legume cover crops (despite cover crops per see having not shown a frank tendency to enhance SOM levels, Chaplot and Smith, 2023) and to promote zero tillage (also not showing direct increase in SOM stocks, e.g. Baker et al 1997) to limit nutrients losses by soil erosion*"
- Lines 174-76 were as follows: "*In a context where the two of the most promising land management practices that are zero tillage and cover cropping alone did not yield the expected benefits for SOM stock building (Baker et al, 1997; Chaplot and Smith, 2003),..*"
- We now suggest to better explain that these two practices while improving the nutrient balance are not successful for soil C stocks:
- From line 166: "*Legume cover crops and zero tillage may help improve nutrient balances and limit nutrient losses. However, these practices alone have not consistently resulted in increases in soil organic carbon (Chaplot and Smith, 2003; Baker et al., 1997), highlighting the need for additional measures to rebuild SOM stocks*"