SINGLE-IMPACT FICHE
ORGANIC FARMING SYSTEMS

IMPACT: CARBON SEQUESTRATION

Data extracted in October 2021

Note to the reader: This fiche summarises the impact of organic systems on CARBON SEQUESTRATION. It is based on 8 peer-reviewed synthesis research papers[1]. Each synthesis paper includes a number of individual studies, which ranges in this case from 9 to 102.

1.WEIGHT OF THE EVIDENCE

- CONSISTENCY OF THE IMPACT: The effect on CARBON SEQUESTRATION of organic farming systems, as compared to conventional systems are reported as:
  - per unit of area: positive effects were reported for organic systems, with 7 (6 of high quality) synthesis papers for cropping systems and 2 for livestock/mixed systems and. Only one synthesis paper reported no significant effect for livestock/mixed systems. Positive effects are reported for soil organic matter content, soil organic stocks, and soil organic carbon sequestration rate. One meta-analysis reported that, beyond the effects of fertilization intensity, crop residue traits (leaf nitrogen content, leaf dry matter content, fine-root carbon and nitrogen) also play a significant role driving the effects of organic farming on soil organic carbon (SOC) stocks and carbon sequestration rates.

    Uncertain* results were reported by 2 synthesis papers.
  - per unit of product: no results were available.

All synthesis papers but one include results of experiments conducted in Europe.

Table 1. Summary of effects of carbon sequestration. The numbers between parentheses indicate the number of synthesis papers with a quality score of at least 50%. Details on quality criteria can be found in the next section. Some synthesis papers reported effects for more than type of system.

Impact	Metric	Impacts per unit of agricultural land				Impacts per unit of product			
		Positive	Negative	No effect	Uncertain	Positive	Negative	No effect	Uncertain
Organic cropping systems									
Increase Carbon sequestration		7 (6)	0	0	2 (1)				
Organic livestock systems									
Increase Carbon sequestration		2 (2)	0	1 (1)	0				

QUALITY OF THE SYNTHESIS PAPERS: *The quality score summarises 16 criteria assessing the quality of three main aspects of the synthesis papers: 1) the literature search strategy and studies selection; 2) the statistical analysis; 3) the potential bias. Details on quality criteria can be found in the methodology section of this WIKI.*

[1] Research synthesis papers include a formal meta-analysis or systematic reviews with some quantitative results

2. IMPACTS

The main characteristics and results of the 8 synthesis papers[1] are summarized in **Table 2**. Summaries of the meta-analyses provide fuller information about the results reported in each synthesis paper, in particular about the modulation of effects by factors related to soil, climate and management practices.

Table 2. Main characteristics of the synthesis papers reporting impacts on carbon sequestration.

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Aguilera, E; Lassaletta, L; Gattinger, A; Gimeno, BS. 2013	Field studies (i.e. excluding laboratory and experimental greenhouse studies) conducted under Mediterranean climatic conditions in croplands (including arable crops, orchards and horticulture, but excluding permanent grassland and forests) assessing the performance of organic systems in comparison to conventional systems. In study organic croplands organic practices were applied for at least three consecutive years prior to sampling.	Global (Mediterranean climate)	79	Organic cropping systems	Conventional systems	SOC content and C sequestration rate.	Carbon sequestration is effectively promoted by organic farming practices in Mediterranean cropped soils. This relative increase of SOC sequestration over conventional practices is more marked in intensive cropping systems, where the difference in carbon inputs are higher.	75%
Garcia-Palacios, P; Gattinger, A; Bracht-Jorgensen, H; Brussaard, L; Carvalho, F; Castro, H; Clement, JC; De Deyn, G; D'Hertefeldt, T; Foulquier, A; Hedlund, K; Lavorel, S; Legay, N; Lori, M; Mader, P; Martinez-Garcia, LB; da Silva, P; Muller, A; Nascimento, E; Reis, F; Symanczik, S; Sousa, J; Milla, R. 2018	Long-term studies (at least 3 consecutive years) assessing the performance of organic systems in comparison to conventional systems.	Global	101	Organic systems	Conventional systems	Top soil organic carbon stocks, top soil organic carbon sequestration rates and soil respiration.	Organic farming positive effects on soil respiration, SOC stocks, and SOC sequestration rates were significant, even in organic farms with low manure application rates.	94%
Gattinger A; Muller A; Haeni M; Skinner C;	Studies assessing the performance of organic systems in	Global	74	Organic systems (all systems,	Nonorganic systems (both conventional	SOC concentration, SOC stock, and	Metaanalysis of all three effect sizes revealed	75%

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Fliessbach A; Buchmann N; Mäder P; Stolze M; Smith P; El-Hage Scialabba N; Niggli U. 2012	comparison to conventional systems. In study organic systems organic practices were applied for at least three consecutive years prior to sampling.			mixed farming systems with zero-input from external)	and integrated systems)	C sequestration rate	significantly higher SOC concentrations, SOC stocks, and carbon sequestration rates in soils under organic compared with nonorganic farming management.	
Kopittke, PM; Dalal RC; Finn D; Menzies NW 2016	Long-term studies (minimum 5 years) assessing the performance of organic systems in comparison to conventional systems.	Global	102	Organic systems	Conventional systems	Stock of Organic C in soil (kg m-2)	Organic systems increase soil carbon stock by 8%, compared to conventional systems. However, the result is rated as uncertain, due to the lack of statistical tests.	44%
Mondelaers, K; Aertsens, J; Van Huylenbroeck, G. 2009	Studies assessing the performance of organic systems in comparison to conventional systems.	Global	9	Organic systems	Conventional systems	Organic matter content in soil (%).	Organic matter content in organic plots is significantly higher than in conventional plots.	50%
Smith, OM; Cohen, AL; Rieser, CJ; Davis, AG; Taylor, JM; Adesanya, AW; Jones, MS; Meier, AR; Reganold, JP; Orpet, RJ; Northfield, TD; Crowder, DW 2019	Previous meta-analyses including studies assessing the performance of organic systems in comparison to conventional systems.	Global	9	Organic systems (annual and perennial crops)	Conventional systems	SOC, C stock (kg /ha)	Higher mean soil carbon content in organic systems than in conventional systems. Similar level of variability.	56%
Tuomisto HL; Hodge ID; Riordana P; Macdonald DW 2012	Field studies, modelling studies and Life Cycle Assessment studies of organic systems in comparison to conventional systems in Europe.	Europe	71	Organic systems	Conventional systems	Soil organic matter per unit of area	The results indicate that organic farming generally leads to significantly higher soil organic matter content, but some conventional farming systems do have the potential to achieve similar or even higher soil organic matter levels when they include the application of manures.	69%

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Ugarte, CM; Kwon, H; Andrews, SS; Wander, MM. 2014	Field-based studies and on-farm research conducted in the continental United States assessing the performance of organic systems in comparison to conventional systems.	Continental USA	55	Organic systems	Conventional systems	Soil organic carbon content	The meta-analysis of studies using shallow sampling methods (0 to 20 cm [0 to 7.8 in]) suggested that organic cropping systems are able to increase SOC relative to that found under conventional monocultures with intensive reliance on external inputs.	44%

3. KNOWLEDGE GAPS

Aguilera, E, 2013	According with this analysis of the available data, C input is the main driver of the changes in SOC produced after the adoption of RMPs. However, information on C input was only provided in 42.2% of the data sets studied, and in most cases this information was incomplete. Thus, usually only the amount of C applied in the external C input was provided, while the internal sources of C were ignored.
Garcia-Palacios, 2018	1)Future studies looking at the role of root residue traits for SOC responses to OF; 2) Studies measuring the dynamics of crop residue decomposition in farms subjected to contrasting management practices are particularly needed; 3) Functional traits of cultivars need to be included in future studies addressing the ecosystem - level implications of intraspecific trait variability in agroecosystems; 4) More research is needed to address whether the influence of farming practices on SOC storage is driven by changes in crop litter lability and/or in microbial carbon use efficiency and community composition.
Gattinger A, 2012	The data mainly cover top soil and temperate zones, whereas only few data from tropical regions and subsoil horizons exist.
Kopittke, PM, 2016	1)The depth of sampling varied widely. These differences in sampling depths would influence the results obtained. 2)the bias of the published literature to report outcomes where significant changes are observed, with studies finding no significant differences less likely to be published.