SINGLE-IMPACT FICHE – ORGANIC SYSTEMS

IMPACT: CARBON SEQUESTRATION

Data extracted in September 2020

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: All the 8 synthesis papers[1] show a positive effect of organic systems on the mean levels of carbon sequestration (see **Table 1**). All results are expressed per unit area (e.g., per ha). One synthesis paper also reports no effect of organic systems on the variability of carbon sequestration across different environments. All but one include results of experiments conducted in Europe. Organic farming systems effects were always compared to conventional systems.

Table 1. Summary of impacts. The effect with the higher score is marked in bold and the cell coloured. The numbers between parenthesis indicate the number of synthesis papers[1] with a quality score of at least 50%. Details on quality criteria can be found in the next section.

Effects per unit of area (e.g., per ha)					
Impact	**Comparator**	**Positive**	**Negative**	**No effect**	**Uncertain**
Increase carbon sequestration: soil organic matter	Conventional systems	**8 (6)**	0	1*	**0**

* In this impact, the effect size is reported not only based on mean value, but also based on variance. The objective was to check if organic farming leads to more variable carbon sequestration than conventional. The same was done for yield (see fiche).

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.

- QUALITY OF THE SYNTHESIS PAPERS[1]: [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 this document →]

  As shown in the "Quality score" of the table in section 2, the quality level ranges from 44% to 94%, with only two synthesis papers with a quality score lower than 50%. The least frequently satisfied quality criteria were "Number of studies at each step of the selection process", "Individual effect sizes reported",

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

"Individual studies weighted", "Dataset available", and "Publication bias analysed" (only satisfied in 3 synthesis papers).

2. IMPACTS

The main characteristics and results of the 8 synthesis papers[1] are summarized in **Table 2**. The references are ordered chronologically with the most recent publication date first.

Table 2. Main characteristics of the synthesis papers reporting impacts on carbon sequestration. All detailed results of each synthesis study are reported in the summary reports.

Nr	Reference	Population	Geographical scale	Intervention	Comparator	Conclusion	Quality score	Global effect
1	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	Organic and conventional systems	Global	Organic systems	Conventional systems	Higher mean soil carbon content in organic systems than in conventional systems. Similar level of variability.	56%	Positive on mean effect. No effect on variability.
2	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	Organic and conventional systems (cereals, vegetables, orchard/viticulture and grasslands).	Global	Organic systems	Conventional systems	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%	Positive (per unit of area)
3	Kopittke, PM; Dalal RC; Finn D; Menzies NW. 2016	Organic and conventional systems	Global	Organic systems	Conventional systems	Organic systems increase soil carbon stock by 8%, compared to conventional systems.	44%	Positive (per unit of area)
4	Ugarte, CM; Kwon, H; Andrews, SS;	Organic systems and conventional systems	Continental USA	Organic systems	Conventional systems (dominant systems within the region from	The meta-analysis of studies using shallow sampling methods (0 to 20 cm [0 to 7.8 in]) suggested that organic cropping systems are	44%	Positive (per unit of area)

Nr	Reference	Population	Geographical scale	Intervention	Comparator	Conclusion	Quality score	Global effect
	Wander, MM. 2014				which data was extracted)	able to increase SOC relative to that found under conventional monocultures with intensive reliance on external inputs.		
5	Aguilera, E; Lassaletta, L; Gattinger, A; Gimeno, BS. 2013	Organic and conventional systems	Global (Mediterranean climate)	Organic systems	Conventional systems	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%	Positive (per unit of area)
6	Tuomisto HL; Hodge ID; Riordana P; Macdonald DW. 2012	Organic and conventional systems	Europe	Organic systems	Conventional systems	The results indicate that organic farming generally leads to 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%	Positive (per unit of area)
7	Gattinger A; Muller A; Haeni M; Skinner C; Fliessbach A; Buchmann N; Mäder P; Stolze M; Smith P; El-Hage Scialabba N; Niggli U. 2012	Organic and nonorganic systems	Global	Organic systems	Nonorganic systems (both conventional and integrated systems)	Meta-analysis of all three effect sizes revealed significantly higher SOC concentrations, SOC stocks, and carbon sequestration rates in soils under organic compared with nonorganic farming management.	75%	Positive (per unit of area)
8	Mondelaers, K; Aertsens, J; Van Huylenbroeck, G. 2009	Organic and conventional systems	Global	Organic systems	Conventional systems	Organic matter content in organic plots is significantly higher than in conventional plots.	50%	Positive (per unit of area)

3. KNOWLEDGE GAPS

[They are extracted from each synthesis paper, synthesized and consolidated]

- The data mainly cover top-soil and temperate zones, whereas only few data from tropical regions and subsoil horizons exist.

- Information on C input was not always reported precisely. Usually only the amount of C applied in the external C input was provided, while the internal sources of C were ignored.
- Role of root residue traits for SOC responses to organic farming.
- Studies measuring the dynamics of crop residue decomposition in farms subjected to contrasting management practices are particularly needed.
- 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.
- Functional traits of cultivars need to be included in future studies addressing the ecosystem-level implications of intraspecific trait variability in agroecosystems.

4. SYSTEMATIC REVIEW SEARCH STRATEGY

Keywords	TOPIC: ("organic farm*" OR "organic agriculture" OR "organic system*" OR "organic product*") AND TOPIC: ("meta-analy*" OR "systematic* review*" OR "evidence map" OR "global synthesis" OR "evidence synthesis" OR "research synthesis")
Search dates	No time restrictions
Databases	Web of Science and Scopus, run on 20 July 2020
Selection criteria	Three main criteria led to the exclusion of a synthesis paper: (1) the paper does not deal with organic systems; (2) the paper does not assess the impacts of organic systems in comparison to another cropping system; (3) the paper is neither a meta-analysis nor a systematic review. Synthesis papers that passed the relevance criteria were subject to critical appraisal carried out on paper by paper basis. From an initial number of 122 synthesis papers, we finally selected 8 meta-analyses or systematic reviews.