FARMING PRACTICE
ORGANIC FARMING SYSTEMS

IMPACT: CARBON SEQUESTRATION

Reference 8

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 Crop traits drive soil carbon sequestration under organic farming Journal of Applied Ecology 30, 1–10. 10.1111/1365-2664.13113

Background and objective

Organic farming (OF) enhances top soil organic carbon (SOC) stocks in croplands compared with conventional farming (CF), which can contribute to sequester C. As farming systems differences in the amount of C inputs to soil (e.g. fertilization and crop residues) are not enough to explain such increase, shifts in crop residue traits important for soil C losses such as litter decomposition may also play a role.

The objective of the paper is to assess whether the traits of crop residues (leaves and roots) consistently determine soil organic carbon sequestration rates under organic farming. The objective of the global meta analysis is to explore whether organic farming increased soil respiration, top SOC stocks and top SOC sequestration rates compared with conventional farming.

Search strategy and selection criteria

Two literature searches were conducted in the ISI Web of Knowledge on 7th July 2015, with no restriction on publication year, using the following term combinations: 1) (soil respiration) and (agricultur* or farming) and (sustainable or agroecology or organic or polyculture or diversified or traditional or no tillage or compost or green manure or extensive or cover crops or ecolog*); and 2) (soil carbon or soil organic matter or SOC or SOM) and (agricultur* or farming) and (sustainable or agroecology or organic or polyculture or diversified or traditional or no tillage or compost or green manure or extensive or cover crops or ecolog*). In addition, the authors also screened previous reviews about the topic (Gattinger et al. 2012; Kremen & Miles 2012; Marrion & Wander 2012; Tuomisto et al. 2012; Aguilera et al. 2013). Studies comparing tillage vs. no/or reduced tillage without adding synthetic fertilizers or pesticides in the conventional farming practice were excluded. The following criteria were considered: (1) If the study manipulated other factors (e.g. soil inoculum, irrigation), only results from non-manipulated plots were considered. (2) In order to conduct a weighted meta-analysis (Gurevitch & Hedges 1999), data collection was limited to studies in which means, standard deviations (SD) and sample size were reported or could be calculated. Where SD could be neither extracted nor calculated, SD was set equal to 1/10 of the mean. When suitable studies lacked information, the authors were contacted and asked for their original data. (3) When soil respiration or SOC were measured at more than one soil depth, only the uppermost layer was chosen. (4) When soil respiration or SOC were measured at different time points, the average value was calculated. (5) Studies comparing tillage vs. no/or reduced tillage without adding synthetic fertilizers or pesticides in the CF practice were excluded. (6) In some cases, more than one paper reported data from a particular experiment. Only data from the study covering the longest period were reported.

Data and analysis

Practices were tagged as conventional farming (CF) if using inorganic fertilizers and/or chemical pesticides, and as organic farming (OF) if not using those inputs. To obtain crop species trait values, data were averaged by contributing author to account for disproportionate author contributions to any particular trait. When polycultures (e.g. crop rotations) were used, community-weighted means were calculated. Statistical analysis: Significance of Cohen's d was assessed whether its bias-corrected 95%-bootstrap confidence interval (CI) overlapped zero, based on 999 iterations. To help the interpretation of the magnitude of the Cohen's d, the probability of superiority (or "common language effect size") was calculated following Ruscio (2008). This is the probability that a randomly sampled OF case study will have a higher observed response variable than a randomly sampled CF case study (Grissom & Kim, 2005). Weighted random-effects models were used to test whether the set of methodological and biological covariates extracted from papers and global databases influenced the effect sizes.

. Cohen's d calculations and meta-analyses were conducted with MetaWin v2.1.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
101	Long-term studies (at least 3 consecutive years) assessing the performance of organic systems in comparison to conventional systems.	Organic systems	Conventional systems	Metric: Top soil organic carbon stocks, top soil organic carbon sequestration rates and soil respiration.; Effect size: Effect size: Cohen's d measuring the standardized difference between organic and conventional systems on soil respiration, top SOC stocks and top SOC sequestration rates.	93.75

Results

- Positive effects of organic farming (OF) (standardized difference between organic farming and conventional farming) in soil respiration (probability of superiority c. 84%), SOC stocks (c. 68%), and SOC sequestration rates (c. 91%).
- The positive OF-effects were still significant in organic farms with low manure rates (LMR, European Livestock Units per hectare <=1).

- The meta-analysis highlighted that, beyond the effects of fertilization intensity, crop residue traits (leaf N, leaf dry matter content, fine-root C and N) also play a significant role driving the effects of organic farming on SOC stocks and sequestration rates.
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- NULL
- NULL

Factors influencing effect sizes

- Fertilisation intensity : Fertilization intensity and climate were the main drivers of the organic farming effects on SOC stock and SOC sequestration, when evaluating studies in the global meta-analysis using the same crop species in organic vs. Conventional farming.
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Conclusion

Organic farming positive effects on soil respiration, SOC stocks, and SOC sequestration rates were significant, even in organic farms with low manure application rates.