FARMING PRACTICE
ORGANIC FARMING SYSTEMS

IMPACT: BIODIVERSITY

Reference 4

Smith, OM; Cohen, AL; Reganold, JP; Jones, MS; Orpet, RJ; Taylor, JM; Thurman, JH; Cornell, KA; Olsson, RL; Ge, Y; Kennedy, CM; Crowder, DW 2020 Landscape context affects the sustainability of organic farming systems. Proceedings of the National Academy of Sciences of the United States of America 117: 2870-2878. 10.1073/pnas.1906909117

Background and objective

Assessing how landscape context affects sustainability may aid in targeting organic production to landscapes that promote high biodiversity, crop yields, and profitability. The objective is to quantify the effects of landscape context on the sustainability of organic versus conventional agriculture using four socioecological sustainability metrics: 1) biotic abundance, 2) biotic richness, 3) crop yield, and 4) profitability. This report focuses on biodiversity.

Search strategy and selection criteria

A search was conducted for studies reporting organic vs. conventional abundance, richness, yield, and profit comparisons. First, references from 12 prior meta-analyses were searched and then used ISI Web of Knowledge to search for additional studies published after the last date of the most recent meta-analysis from which metadata were available for biotic communities, yield, and profitability. The search was performed in December 2017 using the terms "organ* AND conven* AND diversity* OR rich* OR abund*" from 2013 to 2017 for biotic abundance and biotic richness,* "*yield AND organ* AND conven*" from 2013 to 2017 for yield, and "*profit AND organ* AND conven*" for 2015 to 2017 for profitability. 11 inclusion criteria: 1) the study reported one or more responses on individual crop species in organic and conventional treatments for yield and profitability; 2) the study reported primary data not in another included paper; 3) the organic systems were those that authors stated were organically certified or followed certification standards. Conventional systems were those that the authors stated were conventional or used recommended rates of synthetic chemical inputs and included low-input conventional systems. If studies reported data for both high- and low-input conventional systems, we only used data from the high-input conventional systems; 4) the organic and conventional treatments were spatially interspersed in a landscape or at the same experimental station to eliminate bias in landscape context; 5) there were more than two replicates of organic and conventional treatments; 6) the study reported coordinates, or they were provided, to degrees minutes seconds; 7) the study was peer-reviewed; 8) the study did not include "subsistence" agriculture or integrated systems (a blend of both organic and conventional practices) instead of conventional or organic farming; 9) biotic studies reported data from within plots, fields, or farms, or adjacent field borders; 10) the study reported the mean as numerical or graphical data or it could be calculated, and biotic richness data were reported in both organic and conventional systems for n > 2 taxa identified to order, family, genus, species, or morphospecies; and 11) the study was in English.

Data and analysis

Metaregression was used to examine whether effect sizes were influenced by variables reflecting the landscape context. For each response variable, we ran generalized linear mixed effects models with a Gaussian error distribution in the lme4 package. Models of different levels of complexity were ranked based on AICc to identify the top models for each response based on a criteria of ΔAICc <2.0 from the most-well-supported model. The associated Akaike weights (ω) and model-averaged partial regression coefficients for each covariate were computed based on the 90% confidence set. The relative importance of each covariate on the log response-ratio effect sizes was determined from the sum of Akaike weights across the entire model set, with 1 being the most important (present in all models with weight) and 0 the least important. Covariates were considered as strong drivers of the response variable if they appeared in top models (ΔAICc <2) and had a relatively high summed Akaike weight (ω > 0.5). Covariates were additionally considered statistically significant if their unconditional 90% confidence interval did not overlap with zero.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
59	Studies assessing the performance of organic systems in comparison to conventional systems.	Organic systems (Cereals, Fruits, Oil crops, Pulses, Root, Vegetables)	Conventional systems	Metric: Biotic abundance, biotic richness of functional groups (Natural enemy, Herbivore, Pollinator, Producer) and taxa (Vertebrate, Arthropod, Microbe, Plant); Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control.	87.5

Results

- Organic systems had greater biotic abundance (mean effect size = 0.32, 90% CI: 0.19 to 0.45) (t101 = 4.01, P = 0.0001) and biotic richness (mean effect size = 0.32, 90% CI: 0.22 to 0.43) (t93 = 5.88, P < 0.0001) than conventional systems.
- The benefits of organic farming for biotic abundance and richness were best predicted by average crop field size in the landscape.
- A one-unit increase in average crop field size resulted in a 3.1% and 2.3% increase in the biotic abundance or richness, respectively, in organic relative to conventional systems.
- Effects of field size on abundance and richness in organic compared to conventional systems were consistent across organism groups, functional groups, continents, biomes,croptypes, and level of development.
- NULL

Factors influencing effect sizes

- Crop field size : Biodiversity gains increased as average crop field size in the landscape increased.

Conclusion

Organic sites had greater biodiversity (34%) than conventional sites. Biodiversity gains increased as average crop field size in the landscape increased, suggesting organic farms provide a “refuge” in intensive landscapes.