FARMING PRACTICE
ORGANIC FARMING SYSTEMS

IMPACT: PESTS AND DISEASES

Reference 10

Muneret, L; Mitchell, M; Seufert, V; Aviron, S; Djoudi, E; Petillon, J; Plantegenest, M; Thiery, D; Rusch, A. 2018 Evidence that organic farming promotes pest control Nature Sustainability 1, 361-368 10.1038/s41893-018-0102-4

Background and objective

It remains unclear how organic farming affects the balance between biological control potential and pest infestation. On the one hand, it has been suggested that farming systems under organic management experience higher pest pressures than conventional ones using pesticides due to lower efficiency of organic pest control practices. On the other hand, several studies have found lower levels of pest infestation in organic farming systems due to either farming practices that limit pest establishment and development (for example, crop rotation) and/or positive impacts of organic management on natural enemies. Analysing the balance between biological pest control and pest infestation for organic agriculture.

Search strategy and selection criteria

To perform the two meta-analyses, the authors collected studies evaluating the effect of organic farming on either pest infestation levels (weeds, pathogens and pests) or biological control services. They used two sets of keywords for study collection to identify the relevant articles in the Institute for Scientific Information Web of Knowledge: 1) 'organic AND conventional AND (pest OR disease OR pathogen OR weed)' and 2) 'organic AND conventional AND (parasitism OR predation OR 'infestation rate' OR 'predation rate' OR biocontrol OR 'natural regulation' OR mortality OR survival OR 'biological control' OR 'natural pest control' OR 'weed control' OR 'seed predation'. The literature search included studies published between 1956 and April 2017. They screened the bibliography from related reviews. They also added four unpublished datasets provided by the authors (from three different experiments). To be included in the dataset, studies had to report data comparing either pest infestation levels or biological control services between organic and conventional farming systems. Organic farming was defined by the exclusion of synthetic fertilizers and pesticides, and took into account both organic as well biodynamic farming systems. In contrast, conventional farming allowed for synthetic inputs even if the intensity of pesticide use highly varied across the dataset, ranging from 'integrated pest management' systems to 'high-input' systems. Data from both organic and conventional farming systems had to be original and strictly comparable in the study to be considered. To be included in the dataset about biological control, studies had to quantify natural pest control by antagonistic organisms, and whether or not this followed pest inoculation or introduction by the experimenter. The studies had to clearly indicate the mean, any measure of variance (that is, standard deviation, standard error of the mean or confidence interval) and the sample size (a minimum of three observations was tolerated) of both organic and conventional treatments to be included. In the case of partial or unclear information reported, they contacted the authors. They did not include studies that explored pest infestation or biological control before and after conversion from conventional to organic farming because of their mismatched study design (that is, the comparison of pest infestation levels across years in a given farm).

Data and analysis

Data extraction: If a study evaluated the effect of several conventional as well as organic treatments, the authors computed an effect size for each pair of most comparable treatments (for example, same dates, equal tillage intensity). If several conventional treatments were compared to one single organic, all the conventional treatments were considered as variants and the researchers randomly selected one to calculate an effect size. They only selected 'low input systems' and 'integrated pest management' as control when there was no other variant of conventional treatment. If there were several organic compared to one conventional treatment, they included them all in the dataset and compared each organic treatment to the same conventional treatment. This dependence was then taken into account in the models. When several pest stages were examined in a primary study, they extracted one measure for each pest stage at a given date because the researchers assumed that they could lead to different damages and they were probably controlled by several natural enemy species. When the data reported weed infestation through weed soil cover, density and biomass, they extracted the weed soil cover values. As a second choice, they extracted data as weed biomass followed by weed density. In addition, if the authors of the primary studies reported results of a time series survey, the authors of the meta analyses calculated as many effect sizes as was possible. However, when an error term for each time point was not available, they calculated the mean as well as the standard deviation across time. They extracted data from graphics using Image J software, texts or tables, and additionally received many datasets from authors. They were not able to directly examine the relationship between biological control potential and pest infestation levels due the low number of studies (that is, 16 studies) that jointly measured comparable data on these two aspects. Moreover, these studies were largely unbalanced considering the moderators they examined, as they were dominated by studies on parasitism rates of insects in annual crops, which strongly limited the scope of the potential analysis. Effect size calculation: For each comparison between one organic and one conventional farming system, the y calculated the standardized mean difference using the Hedges' d index. They considered Hedges' d < 0.2 as small effects, 0.2–0.8 as medium effects and >0.8 as large effects.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
134	Studies assessing the performance of organic systems in comparison to conventional systems.	Organic cropping systems	conventional cropping systems	Metric: 1) Biological control potential (predation rate, parasitism rate and soil-suppressiveness, that is, soil ability to suppress pathogens following their inoculation); 2) pest infestation (disease severity or incidence, pest abundance or pest density, weed soil cover, weed biomass or weed density); Effect size: Hedge's d (standardized difference) comparing the considered metrics between intervention and control	93.75

Results

- Overall, the average level of biological control services was higher in organic than in conventional fields (standardized mean difference Hedges' dgrand mean = 0.31 ± 0.30 (± 95% confidence interval).

- After accounting for confounding moderators (see factors), the analysis of the number of pest species shows that, on average, there is a significantly higher level of biological control in organic than in conventional fields for individual pests (dsingle = 0.42 ± 0.26). However, no differences between organic and conventional fields were found for studies examining pest communities (dcommunity = 0.18 ± 0.32).
- The positive effect of organic management on biological control was detected both for perennial (dperennials = 0.56 ± 0.52) and annual crops (dannuals = 0.43 ± 0.41).
- Overall, organic fields exhibited higher pest infestation levels than conventional fields (dgrand mean = 0.23 ± 0.16). However, this effect was highly dependent on the pest type: no difference was found in the levels of animal infestation (danimal pests = 0.08 ± 0.21) between conventional and organic farming systems, but weed infestation was much higher (dweed = 1.02 ± 0.22) and pathogen infestation lower (dpathogen = −0.38 ± 0.23) in organic than in conventional fields.
- Studies considering multiple pest species found higher pest infestation levels in organic than in conventional fields, whereas studies considering only one pest species reported similar levels of pest infestation between organic and conventional fields.

Factors influencing effect sizes

- Study type : Studies conducted in experimental plots reveal higher level of pest infestation in organic farming more frequently than studies performed in real commercial farms.
- Crop type : Organic farming practices in perennial cropping systems lead to efficient control of overall pest infestations, which is obviously not necessarily the case in annual cropping systems.

Conclusion

Results show that, compared to conventional cropping systems, 1) organic farming promotes overall biological pest control potential, 2) organic farming has higher levels of overall pest infestations but 3) this effect strongly depends on the pest type. The meta analyses show that there are lower levels of pathogen infestation, similar levels of animal pest infestation and much higher levels of weed infestation in organic than in conventional systems.