SINGLE-IMPACT FICHE – ORGANIC SYSTEMS

IMPACT: CROP YIELD

Data extracted in October 2021

Note to the reader: This fiche summarises the impact of organic systems on CROP YIELD[1]. It is based on 11 peer-reviewed synthesis research papers[2]. Each synthesis paper includes a number of individual studies, which ranges in this case from 9 to 150.

1.WEIGHT OF THE EVIDENCE

- CONSISTENCY OF THE IMPACT:
  - Crop yield per unit of area: All the 11 synthesis papers[2] reported average (along different cropping seasons) crop yield losses in organic systems compared to conventional systems (see **Table 1**). The reported average yield-losses are in the range of 5-30%. One study (Ponisio et al, 2015, ref. 13) reports that yield gaps of organic versus conventional farming drop from -25% to -8% when considering full productivity of diversification techniques (multi-cropping and crop rotations, respectively), instead of only the main cash-crop yield (typically done by other studies). Non-significant crop yield gaps were reported for perennial crops, by two synthesis papers. A couple of synthesis papers also compared the yield variability in subsequent cropping seasons between organic and conventional systems. These studies showed either no effect, or an increased level of variability in organic systems.
    The reported effects concerned a large range of crop species (like cereals, legume crops, horticulture, and vineyards). All the synthesis papers[2] included results of experiments conducted in Europe.
  - Results regarding agricultural land use efficiency per unit of product and livestock farming production yield can be found in the fiche 'Agricultural land use'.

Table 1. Summary of effects. The effect with the higher score is marked in bold and the cell coloured. 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 one type of system.

		Impacts per unit of agricultural land				Impacts per unit of product			
Impact	**Metric**	**Positive**	**Negative**	**No effect**	**Uncertain ***	**Positive**	**Negative**	**No effect**	**Uncertain ***
Organic cropping systems									
Increase Crop yield	Main cash crop yield	0	9 (9)	2 (2)	1(1)	See results in the fiche 'Agricultural land use'			
	Crop yield stability along years	0	1 (1)	**2 (2)**	0				
Organic livestock systems									
See results in the fiche 'Agricultural land use'									

[1] Crop yield is typically measured for cash crops only, as total biomass or target crop produce harvested per hectare per year. Organic farming systems rely on crop diversification strategies (e.g. rotations, multicropping, cover crops), (significantly more and more often than conventional farming according the most recent meta-analysis by Alvarez, 2021, ref.30). However, research studies typically do not account for co-productions of fodder/forage through crop diversification techniques.

[2] Research synthesis papers include meta-analysis or systematic reviews

* Number of synthesis papers that report relevant results but without statistical test comparison of the intervention and the control.

- 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 this document →.*

As shown in the "Quality score" in **Table 2,** the quality the 11 synthesis papers retrieved ranged from 50% to 100%. The least frequently satisfied quality criteria were: "Search string", "Number of studies of each step", "Individual effect sizes", "Individual studies weighted", "Heterogeneity of results analysed" and "Publication bias analysed".

2. IMPACTS

The main characteristics and results of the 11 synthesis papers 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 yields. All detailed results of each synthesis study are reported in the summary reports →.

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric		Conclusion	Quality score
Alvarez, R 2021	Studies comparing organic crops (Cereals, legumes, vegetables, others) with conventional crops. 229 comparisons between organic and conventional management; 47 were on-farm studies and 182 were experiments.	Global	80	Organic crops (Cereals, legumes, vegetables, others)	Conventional systems	Crop yield, Crop productivity		The yields under organic farming were on average 25% lower than the conventional ones, reaching a yield gap of 30% for cereals. The intensity of soil use was also lower in organic systems, the size of the reduction depending on the type of study: field experiments (7%) or on-farm studies (20%). Combining the yield gap with the reduction in the number of crops harvested in the rotation, a productivity gap of 29% to 44% was estimated depending on the type of crops included in the rotation.	81%

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
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 assessing the performance of organic systems in comparison to conventional systems.	Global	9	Organic systems (annual and perennial crops)	Conventional systems	Crop yield	Lower mean yield and higher yield variability in organic systems than in conventional systems. No significant difference in perennials crop yield.	56%
Doring, J; Collins, C; Frisch, M; Kauer, R 2019	Field studies assessing the performance of organic in comparison to conventional viticulture systems.	Europe, South Africa, USA, Australia	17	Organic systems	Conventional systems	Vine yield, Pruning material production	A yield decrease of 18 % in organic and biodynamic viticulture compared to conventional viticulture was observed when all available data from scientific field trials were assessed.	50%
Katayama, N; Bouam, I; Koshida, C; Baba, YG 2019	Studies assessing the performance of organic in comparison to conventional perennial orchards and vineyards.	Global	29	Organic orchards and vineyards	Conventional systems	Crop yield	Organic orchards and vineyards show significantly reduced crop yield compared to conventional systems.	94%
Knapp, S; van der Heijden, MGA. 2018	Long-term (at least four years of observation for the same crops) field-scale experiments assessing the performance of organic systems in comparison to conventional systems.	Global	39	Organic systems	Conventional systems	Crop yield stability in time (crop yield variability along 4 years): absolute value and relative (variability divided by yield)	While there was a significant difference for relative stability between organic and conventional agriculture, there was no significant difference for absolute stability.	100%

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Lesur-Dumoulin, C; Malezieux, E; Ben-Ari, T; Langlais, C; Makowski, D. 2017	Studies conducted in experimental stations or on-farm trials (farm surveys excluded) assessing the performance of organic in comparison to conventional horticultural systems.	Global	52	Organic horticulture	Conventional systems	Mean yield, yield probability distribution across experiments and interannual yield variances.	The meta-analysis, based on a global comprehensive experimental dataset, shows that yields in organic horticulture are on average 10 to 32% lower than those in conventional horticulture, but they exhibit large variation across experiments.	81%
Ponisio, LC; M'Gonigle, LK; Mace, KC; Palomino, J; de Valpine, P; Kremen, C 2015	Studies assessing the performance of organic systems in comparison to conventional systems.	Global	115	Organic systems	Conventional systems	Crop yield	This meta-analysis found relatively small, and potentially overestimated, differences in yield between organic and conventional agriculture (i.e. organic yield gaps of 15.5 and 22.9%), despite historically low rates of investment in organic cropping systems.	81%
Seufert, V; Ramankutty, N; Foley, JA 2012	Studies assessing the performance of organic systems in comparison to conventional systems.	Global	66	Organic systems	Conventional systems	Crop yield	Overall, organic yields are 25% lower than conventional. But these yield differences are highly contextual, depending on system and site characteristics.	94%
Smith, OM; Cohen, AL; Reganold, JP; Jones, MS; Orpet, RJ; Taylor, JM; Thurman, JH; Cornell, KA; Olsson,	Studies assessing the performance of organic systems in comparison to	Global	78	Organic systems (Cereals, Fruits, Oil crops, Pulses, Root, Vegetables)	Conventional systems	Crop yield	Organic sites had lower yields (18%).	88%

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
RL; Ge, Y; Kennedy, CM; Crowder, DW 2020	conventional systems.							
Tuomisto HL; Hodge ID; Riordana P; Macdonald DW 2012	Field studies, modelling studies and Life Cycle Assessment studies assessing the performance of organic systems in comparison to conventional systems in Europe.	Europe	71	Organic systems	Conventional systems	Crop yield	Organic farming in Europe has generally significantly lower yields (-25% in average). However, no comprehensive statistical analysis was performed and the results are set as uncertain.	69%

3. KNOWLEDGE GAPS

- Long-term performance of organic agriculture under different management regimes;
- Study organic systems under a wider range of biophysical conditions;
- Examine the relative yield performance of smallholder agricultural systems;
- Evaluate the performance of farming systems through more holistic system metrics;
- Conduct new experiments in countries from the Southern Hemisphere;
- Collect standard data on crop management and environmental characteristics;
- More information about the influence of differing soil moisture content and physiological performance of the management systems on fruit set.

Doring et al.,2019	More information about the influence of differing soil moisture content and physiological performance of the management systems on fruit set should be gained in the future.
Katayama et al., 2019	Future meta-analytic studies should focus on the role of large-scale factors on biodiversity and ecosystem services in orchards/vineyards.
Lesur-Dumoulin et al., 2017	To conduct new experiments in countries from the Southern Hemisphere, to collect standard data on crop management and environmental characteristics.
Seufert et al., 2012	To understand better the performance of organic agriculture, we should: 1 systematically analyse the long-term performance of organic agriculture under different management regimes; 2 study organic systems under a wider range of biophysical conditions; 3 examine the relative yield performance of smallholder agricultural systems; 4 evaluate the performance of farming systems through more holistic system metrics.

Alvarez 2021	In rotations designed by organic farmers, the years without harvest crops were almost three times more than in conventional rotations. In this analysis, only the harvest crops were taken into account for estimating productivity and the effects of management on livestock production generated during the pasture phase of rotations were ignored due to lack of data.

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") TOPIC: ((organic near/4 farm*) OR (organic near/4 agric*) OR (organic near/4 produc*) OR (organic near/3 livestock) OR (organic near/3 animal)) AND TOPIC: ("animal*" OR "livestock" OR "ruminant*" OR "small ruminant*" OR "cattle" OR "dairy cattle" OR "dairy" OR "beef cattle" OR "sheep" OR "ewe*" OR "lamb*" OR "swine" OR "pig*" OR "porcine*" OR "goat*" OR "rabbit*" OR "poultry" OR "chicken*" OR "broiler*" OR "turkey*" OR "hen*" OR "horse*" OR "mule*" OR "milk" OR "egg" OR "beef" OR "cheese" OR "meat" OR (animal near/2 protein*) OR "yogurt" OR "bacon" OR "pork") 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 for the first time in July 2020 and updated in September 2021 and October 2021.
Selection criteria	Four 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 report results on the effect of specific farming practices (e.g. organic fertilisation, green manure, alternative pest control techniques, etc.) which are part of organic systems, instead of the effect of the whole farming system; (4) the paper is neither a meta-analysis nor a systematic review including quantitative results. Synthesis papers that passed the relevance criteria were subject to critical appraisal carried out on paper-by-paper basis. From the 220 potentially relevant synthesis papers, 140 were excluded after reading the title and abstract, and 50 after reading the full text according to the above-mentioned criteria. Finally, 30 synthesis papers were selected for organic farming systems, from which 11 were relevant for this impact.