SINGLE-IMPACT FICHE
COVER AND CATCH CROPS

IMPACT: SOIL BIOLOGICAL QUALITY

Data extracted in January 2022
Fiche created in February 2024

Note to the reader: This fiche summarises the effects of Cover and catch crops on SOIL BIOLOGICAL QUALITY. It is based on 8 synthesis papers[1], including from 17 to 269 primary studies.

1. WEIGHT OF THE EVIDENCE

<u>CONSISTENCY OF THE IMPACT</u>

The effect of cover/catch crops on SOIL BIOLOGICAL QUALITY is reported in **Table 1**.

The table below shows the number of synthesis papers with statistical tests reporting i) a significant difference between the Intervention and the Comparator, that is to say, a significant statistical effect, which can be positive or negative; or ii) a non-statistically significant difference between the Intervention and the Comparator. In addition, we include, if any, the number of synthesis papers reporting relevant results but without statistical test of the effects. Details on the quality assessment of the synthesis papers can be found in the methodology section of this WIKI.

- Compared to bare soil or fallow, cover crops have a positive effect on SOIL BIOLOGICAL QUALITY, according to 7 results out of 8, and non-significant effect according to one paper.
- The results refer to soil microbial, nematodes, michorryzal populations abundance, diversity and colonization.
- The positive effect is confirmed for leguminous cover crops, while non-legume cover crops showed one positive result and one non-significant effect.
- The positive effect is confirmed also for cover crops (all types and mixed-species) or vegetation cover applied to orchards/tree crops.

All selected synthesis papers included studies conducted in Europe (see **Table 2**).

Table 1: Summary of effects. Number of synthesis papers reporting positive, negative or non-statistically significant effects on environmental and climate impacts. The number of synthesis papers reporting relevant results but without statistical test of the effects are also provided. When not all the synthesis papers reporting an effect are of high quality, the number of synthesis papers with a quality score of at least 50% is indicated in parentheses. The reference numbers of the synthesis papers reporting each of the effects are provided in **Table 3**. Some synthesis papers may report effects for more than one impact or more than one effect for the same impact.

				Statistically tested			Non-statistically tested
Impact	Metric	Intervention	Comparator	Significantly positive	Significantly negative	Non-significant	
Increase soil biological quality	Soil biological quality	Cover crops	Bare soil	7	0	2	0
		Legume cover crops	Bare soil	1	0	0	0
		Non-legume cover crops	Bare soil	1	0	1	0

<u>QUALITY OF THE SYNTHESIS PAPERS</u>

The quality of each synthesis paper was assessed based on 16 criteria regarding three main aspects: 1) the literature search strategy and primary studies selection; 2) the statistical analysis conducted; and 3) the evaluation of potential bias. We assessed whether authors addressed and reported these criteria. Then, a quality score was calculated as the percentage of these 16 criteria properly addressed and reported in each synthesis paper. Details on quality criteria can be found in the methodology section of this WIKI.

2. IMPACTS

The main characteristics and results of the 8 synthesis papers are reported in **Table 2** with the terminology used in those papers, while **Table 3** shows the reference numbers of the synthesis papers reporting for each of the results shown in **Table 1**. Comprehensive information about the results reported in each synthesis paper, in particular about the modulation of effects by factors related to soil, climate and management practices, are provided in the **summaries of the synthesis papers** available in this WIKI.

Table 2: Main characteristics of the synthesis papers reporting effects on soil biological quality. The references are ordered chronologically with the most recent publication date first.

[1] Synthesis research papers include either meta-analysis or systematic reviews with quantitative results. Details can be found in the methodology section of the WIKI.

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Ref5	Not specified	Global	81	Cover crops	no cover crop (fallow) . all other aspects of management held constant like in the intervention.	1) total phospholipid-derived fatty acid (PLFA); 2) microbial biomass C (MBC); 3) microbial biomass N and (MBN); 4) total bacteria; 5) total fungi; 6) fungi/bacteria ratio	Compared to no cover crop, cover crop overall enhanced phospholipid-derived fatty acids, microbial biomass carbon and nitrogen by 24, 40, and 51%, respectively. Soil total bacteria and total fungi, and the groups in them increased by 7–31% with cove crop compared to no cover crop. Fungi were affected more by cover crop than bacteria as indicated by the greater fungi/bacteria ratio.	75%
Ref6	Not specified	Global	103	Cover crops	Bare soil	Soil nematodes: 1) Total density; 2) Abundance of bacterial feeders; 3) Abundance of fungal feeders; 4) Abundance of omnivore-predators; 5) Abundance of plant feeders; 6) Taxonomy richness; 7) Shannon diversity index; 8) Maturity index; 9) Plant parasite index; 10) Nematode channel ratio; 11) Enrichment index; 12) Structure index	The authors found positive effects of cover crop on the total nematode abundance (+45.3%).	94%
Ref10	Data from North America, Europe, Africa, and Asia, specifically eastern China; Cash crop type: corn, soybean, wheat, vegetable, corn-soybean rotation, corn-soybean-wheat rotation, and other	Global	269	Cover and catch crops (legume, grass, multi-species mixture, and other)	No cover/catch crop	1) Soil fauna (SoilFauna); 2) fungal indicators (Fungal); 3) other microbial indicators (O-Microbial); 4) enzymatic assays (Enzyme); 5) microbial biomass carbon (MBC)	All soil biological properties showed significantly positive responses to cover crops	62%
Ref12	Arable crops	Global (including EU)	60	Cover crops	Bare soil with the same treatments than in the intervention	soil microbial abundance; soil microbial activity; soil microbial diversity	Overall, cover cropping significantly increased parameters of soil microbial abundance, activity, and diversity by 27%, 22%, and 2.5% respectively, compared to those of bare fallow.	88%
Ref19	Annual crops (Maize, wetland rice, soybean, cereals, vegetables, cotton, Brassicaceae)	Global	25	Cover crops	No cover crop	1) Arbuscular mycorrhizal fungi abundance/colonization; 2) Microbial Phosphorous; 3) Phosphatase activity	Cover crops (depending on the type) either enhance or have no effect on the soil microbial community.	81%
Ref24	Arable crops in Mediterranean area	Global (Mediterranean climate). The authors analysed data from 57 publications that included data from 326 experiments and 1062 comparisons (Table 2): 26 publications from a wider review of Mediterranean farming practices (Shackelford et al., 2017) and 31 publications from our new searches (see File S3 for a list of included publications and a modified PRISMA flow diagram). The data came from approximately 50 species or mixtures of cover crops, 12 food crops, and 5 countries: Italy (24 publications), the United States of America (20 publications), Spain (9 publications), France (2 publications), and Greece (2 publications).	57	Winter cover crops (legumes, non legumes, mixtures).	Bare soil	Soil microbial biomass	Compared to plots without cover crops, plots with cover crops had 41% more microbial biomass.	88%
Ref29	Vineyards. Global dataset. About 40% of all datasets originated from irrigated vineyards, 50% were rainfed vineyards and the other studies did not provide information on the use of irrigation. Most datasets came from vineyards under Mediterranean climates (n = 100), oceanic climates (n = 56), and steppe or continental climates (n = 22; three studies included vineyards from different climates). Most studies implemented randomized block designs within one experimental vineyard (n = 113), only few studies implemented block designs in several vineyards (n = 12), whereas 56 datasets used individual vineyards as replicate. The majority of studies investigated the effects of bare soil management (mostly due to tillage, sometimes by use of herbicides or both) compared to cover crops or natural vegetation (n = 137 datasets). We investigated the effects of conventional vs. organic management in 27 studies	Global. Major wine producing regions world-wide except Asian countries, New Zealand and Argentina	74	Cover crops or natural vegetation growth for soil cover in vineyards	Bare soil or removal of spontaneous vegetation in vineyards by herbicides use or tillage	Soil fertility: Soil fauna abundance (nematodes, earthworms, springtails, Oribatida, invertebrates) and biological quality indicator; Arbuscular mycorrhiza abundance (fungal spores and colonisation); and Nutrient cycling processes: (Soil fauna feeding activity; Soil microbial biomass; Soil microbial respiration and activity; Soil macronutrient content and availability)	Soil fertility parameters showed significant positive responses to extensive natural vegetation management in the mixed-effect model.	94%

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
	and 17 datasets originated from other types of intensive vs. extensive vegetation management like the contrast of single to diverse cover crop species in inter-rows or mulching vs. mowing of vegetation.							
Ref32	Zea mais, Glycine max, others	Global	17	Cover crops: 1) Graminoids; 2) Legumes; 3) Non-legume dicots	Winter fallow	Arbuscular mycorrhizal fungi (AMF) colonization of subsequent cash crop roots	Cover crops increased colonization of summer cash crop roots by 28·5% (95% CI: 12·1–47·4) relative to winter fallows.	75%

Table 3: Reference numbers of the synthesis papers reporting for each of the results shown in **Table 1**.

				Statistically tested			Non-statistically tested
Impact	Metric	Intervention	Comparator	Significantly positive	Significantly negative	Non-significant	
Increase soil biological quality	Soil biological quality	Cover crops	Bare soil	Ref5, Ref6, Ref10, Ref12, Ref19, Ref24 and Ref29		Ref6 and Ref19	
		Legume cover crops	Bare soil	Ref32			
		Non-legume cover crops	Bare soil	Ref32		Ref32	

3. FACTORS INFLUENCING THE EFFECTS ON SOIL BIOLOGICAL QUALITY

Table 4: List of factors reported to significantly affect the size and/or direction of the effects on soil biological quality, according to the synthesis papers reviewed.

Factor	Reference number
Annual precipitation	Ref5
Climate	Ref12
Fertilizer rate	Ref12
No factor reported	Ref24
Soil P content	Ref19
Soil pH	Ref5
Soil texture	Ref5
Soil type	Ref12
Termination method	Ref5
Termination type	Ref12

4. KNOWLEDGE GAPS

Table 5: Knowledge gap(s) reported by the authors of the synthesis papers included in this review.

Ref Num	Gap
Ref6	These findings are dependent on the current limits of soil nematology, in particular (i) the possible lack of consideration of rare taxa due to the low number of individuals identified per soil sample, (ii) the low resolution of the taxonomic assignment (genus or family) which can lead to underestimating taxonomic richness, or (iii) the low consideration of the functional traits that may better capture the ecological strategies of nematodes. Our global pattern was mainly influenced by the three geological areas (Asia, Europe and America) and thus may not represent fully the worldwide pattern.
Ref12	Funnel plots indicate between-study heterogeneity and possible publication bias.

5. SYNTHESIS PAPERS INCLUDED IN THE REVIEW

Table 6: List of synthesis papers included in this review. More details can be found in the summaries of the meta-analyses.

Ref Num	Author(s)	Year	Title	Journal	DOI
Ref5	Muhammad, I; Wang, J; Sainju, UM; Zhang, SH; Zhao, FZ; Khan, A	2021	Cover cropping enhances soil microbial biomass and affects microbial community structure: A meta-analysis	Geoderma 381, 114696	10.1016/j.geoderma.2020.114696
Ref6	Puissant, J; Villenave, C; Chauvin, C; Plassard, C; Blanchart, E; Trap, J	2021	Quantification of the global impact of agricultural practices on soil nematodes: A meta-analysis	SOIL BIOLOGY & BIOCHEMISTRY, 161, 108383	10.1016/j.soilbio.2021.108383
Ref10	Jian, Jinshi; Lester, Brandon J.; Du, Xuan; Reiter, Mark S.; Stewart, Ryan D.	2020	A calculator to quantify cover crop effects on soil health and productivity	Soil and Tillage Research 199, 104575	10.1016/j.still.2020.104575
Ref12	Kim, N; Zabaloy, MC; Guan, KY; Villamil, MB	2020	Do cover crops benefit soil microbiome? A meta-analysis of current research	SOIL BIOLOGY & BIOCHEMISTRY, 142, 107701.	10.1016/j.soilbio.2019.107701
Ref19	Hallama, M; Pekrun, C; Lambers, H; Kandeler, E	2019	Hidden miners - the roles of cover crops and soil microorganisms in phosphorus cycling through agroecosystems		10.1007/s11104-018-3810-7
Ref24	Shackelford, GE; Kelsey, R; Dicks, LV	2019	Effects of cover crops on multiple ecosystem services: Ten meta-analyses of data from arable farmland in California and the Mediterranean	LAND USE POLICY, 88, 104204.	10.1016/j.landusepol.2019.104204
Ref29	Winter, S; Bauer, T; Strauss, P; Kratschmer, S; Paredes, D; Popescu, D; Landa, B; Guzman, G; Gomez, JA; Guernion, M; Zaller, JG; Batary, P	2018	Effects of vegetation management intensity on biodiversity and ecosystem services in vineyards: A meta-analysis	J APPL ECOL	10.1111/1365-2664.13124
Ref32	Bowles, TM; Jackson, LE; Loeher, M; Cavagnaro, TR	2017	Ecological intensification and arbuscular mycorrhizas: a meta-analysis of tillage and cover crop effects	Journal of applied ecology 54, 6, 1785-1793	10.1111/1365-2664.12815