SINGLE-IMPACT FICHE
COVER AND CATCH CROPS

IMPACT: GHG EMISSIONS

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 GHG EMISSIONS. It is based on 5 synthesis papers[1], including from 21 to 269 primary studies.

1. WEIGHT OF THE EVIDENCE

CONSISTENCY OF THE IMPACT

The effect of cover/catch crops, as compared to bare soil, on GREENHOUSE GAS EMISSION (only as direct emissions from soil during the fallow period) is reported separately for CH_4 and N_2O (**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.

- CH_4 emissions were significantly increased by cover crops according to 1 synthesis paper dealing with legume, grass and multi-species mixture.
- N_2O emissions resulted in variable effects. Cover crops in general or multi-species mixtures did not significantly affect N_2O emissions according to 4 synthesis studies, while either 2 positive and 4 negative results were also reported, depending on several factors, such as the cover crop residue management methods, the mineral nitrogen fertilization rates associated, etc.
- Legume cover crops, especially if associated to additional mineral nitrogen fertilization lead to significant increase in N_2O emissions (2 results) or to non-significant change (1 result).
- Non-legume cover crops resulted in either non-significant or negative effect on N_2O emission, respectively according to 2 and 1 synthesis papers.
- For cover crops applied to orchards/tree crops, only 1 synthesis paper reported no significant effect for N_2O emissions.

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 ghg emissions	CH_4 emission	Cover crops	Bare soil	0	1	0	0
Increase ghg emissions	N_2O emission	Cover crops	Bare soil	2	4	4	0
Decrease ghg emissions	N_2O emission	Legume cover crops	Bare soil	0	2	0	0
		Non-legume cover crops	Bare soil	1	1	2	0

QUALITY OF THE SYNTHESIS PAPERS

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

[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.

The main characteristics and results of the 5 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 ghg emissions. The references are ordered chronologically with the most recent publication date first.

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
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) CH_4 emission; 2) N_2O emission	Cover crops significantly increased greenhouse gas (i.e., CO_2, CH_4, and N_2O) emissions.	62%
Ref18	Cover cropping versus non-cover	Global. The experimental sites were across Asia, Australia, Europe and North and South America.	31	Cover crops (legume and non-legume) and native grasses in orchards	No soil cover	N_2O emission	Cover cropping increased N_2O emissions by 15% compared to non-cover treatments, but the effect was not significant (95% CIs: −30% to 89%).	69%
Ref22	Arable crops	Global (including EU)	48	Cover crops (legume/non-legume; incorporated/surface/removed)	Bare soil with the same treatments than in the intervention	N_2O emission	Emissions of CO_2 and N_2O varied with cover crop species, quality and quantity of biomass residue, and method of residue placement inthe soil. Cover crops increased CO_2 emissions compared to no cover crop. Legume cover crops emitted more N_2O than non legume or no cover crops, with lower emissions for non legumes than no cover crop.	69%
Ref33	Arable crops	Global (including EU)	21	Cover crops (with distinction between legume and non-legume)	Bare soil with the same treatments than in the intervention	1) N_2O emissions; 2) N_2O emissions along the whole year; 3) N_2O emissions during cover crop season; 4) N_2O emissions during cash crop season	We found strong evidence that replacing bare fallows with covers crops (both legume and non-legume) reduced N_2O emissions in the cover crop period, while on the whole year no effect was recorded.	69%
Ref38	Arable crops	Global (including EU)	26	Cover crops (legume/non-legume; incorporated/surface)	Bare soil with the same treatments than in the intervention	N_2O emissions	The use of green manure increased N_2O emissions using legume cover crops, while no effect was observed with non-legume cover crops.	81%

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 ghg emissions	CH_4 emission	Cover crops	Bare soil	Ref10			
Increase ghg emissions	N_2O emission	Cover crops	Bare soil	Ref22 and Ref33	Ref10, Ref22, Ref33 and Ref38	Ref18, Ref22, Ref33 and Ref38	
Decrease ghg emissions	N_2O emission	Legume cover crops	Bare soil	Ref22 and Ref38			
		Non-legume cover crops	Bare soil	Ref22	Ref33	Ref33 and Ref38	

3. FACTORS INFLUENCING THE EFFECTS ON GHG EMISSIONS

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

Factor	Reference number
Cover crop residue management	Ref22
Cover crop type	Ref22
N fertilisation rate	Ref33 and Ref38
Period	Ref33
Period of Nitrous Oxide Measurement	Ref38

4. KNOWLEDGE GAPS

The authors did not report knowledge gaps in the reviewed synthesis papers.

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
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
Ref18	Gu, JX; Nie, HH; Guo, HJ; Xu, HH; Gunnathorn, T	2019	Nitrous oxide emissions from fruit orchards: A review	Atmospheric Environment 201, 166-172	10.1016/j.atmosenv.2018.12.046
Ref22	Muhammad, I., Sainju, U.M., Zhao, F., (...), Fu, X., Wang, J.	2019	Regulation of soil CO_2 and N_2O emissions by cover crops: A meta-analysis	Soil and Tillage Research 192, pp. 103-112	10.1016/j.still.2019.04.020
Ref33	Han, Z; Walter, MT; Drinkwater, LE	2017	N_2O emissions from grain cropping systems: a meta-analysis of the impacts of fertilizer-based and ecologically-based nutrient management strategies	NUTRIENT CYCLING IN AGROECOSYSTEMS, 107, 335-355.	10.1007/s10705-017-9836-z
Ref38	Basche, AD; Miguez, FE; Kaspar, TC; Castellano, MJ;	2014	Do cover crops increase or decrease nitrous oxide emissions? A meta-analysis	JOURNAL OF SOIL AND WATER CONSERVATION, 69, 471-482.	10.2489/jswc.69.6.471

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