SINGLE-IMPACT FICHE
COVER AND CATCH CROPS

IMPACT: CROP YIELD

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 CROP YIELD. It is based on 16 synthesis papers[1], including from 10 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 CROP YIELD (of the cash crop grown after the cover crop) differs depending on the type of cover/catch crop (**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.

- For cover crops in general and for mixed-species cover crops, 8 results reported non-significant effect in crop yield, while 5 results showed a positive effect (I.e., increase of crop yield) and 1 result showed a negative effect.
- More specifically, cover crops of leguminous species show overall a positive effect on subsequent cash crop yield (7 results), while other 3 results reported no significant effect and 1 reported significant yield losses.
- Cover/catch crops of non-legume species resulted in no significant change (7 results), while other 3 results reported significantly negative effects on crop yield.
- For cover crops or vegetation cover applied to orchards/tree-crops, 2 results reported no significant effect on the tree-crop yield, while 1 result (for legume cover crops) reported positive effects and 1 result (for non-legume cover crops) negative effects.
- The main factors explaining variability were the mineral-nitrogen fertilization rates associated to cover crops, the method for termination and post-management of the cover crop (green manuring vs residues removal), the cover crop biomass production and the pedo-climatic conditions.

Out of the 16 selected synthesis papers, 13 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 crop yield	Cash crop yield	Cover crops	Bare soil	5	1	8	1
		Legume cover crops	Bare soil	7	1	2	0
		Non-legume cover crops	Bare soil	0	3	7	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 16 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 crop yield. The references are ordered chronologically with the most recent publication date first.

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Ref2	fruit tree species (apple, citrus, grape, jujube, kiwi fruit, peach, pear, plum)	Global	116	Ground cover (including cultivated green manure, sod cultivation, natural, vegetation, grass, and cover crop)	Clean tillage management	Fruit yield	Cover cropping with legumes induced significant improvements in fruit yield and weight of frutis. Non-legume cover crops were not effective for weight of fruits and had negative effect on fruit yield.	69%
Ref7	Annual crops	Global	99	Cover crop (nonleguminous, leguminous, and nonlegume–legume cover crop mixtures).	no cover crop (fallow)	Succeeding crop yield	Cover crop did not affect succeeding crop yield.	69%
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) Cash crop yield; 2) Cash crop biomass	Applying cover crops also significantly improved cash crop (corn, soybean, wheat, vegetable, corn-soybean rotation, corn-soybean-wheat rotation, and other) biomass production and yield.	62%
Ref13	Tree crops (Orchards, vineyards) in the Mediterranean area. The fruit tree crops used for the study were mostly grapevines (Vitis vinifera L.) at 36% of the sample size, olive trees (Olea europaea L.) at 34% of the sample size, almond trees (Prunus dulcis (Mill.) D.A. Webb) at 15% of the sample size and citrus trees (Citrus x sinensis Osbeck, Citrus x limon (L.) Osbeck) at 7% of the sample size. We also used other fruit trees, such as avocado (Persea americana Mill.), carob (Ceratonia siliqua L.), peach (Prunus persica (L.) Stokes), chestnut (Castanea sativa Mill.) and walnut (Juglans regia L.), representing 8% of the total dataset.	Global (mediterranean climates)	46	Permanent intercropping (PC) (45%) and annual intercropping (AC) (55%). Permanent intercropping refers to the maintenance of a permanent cover crop in the alleys, such as aromatics (Thymus sp, Lavandula sp, Salvia sp, Rosmarinus sp, Brachypodium sp, Asparagus sp or natural grass), while annual intercropping means the presence of cover crops in the alleys that are annually harvested or incorporated into the soil.	Mono-cropping in orchards. Mono-cropping indicates the presence of the tree crop alone with no other vegetation cover in the alleys (bare soil).	Main crop yield	Crop yield was not affected by intercropping either permanent or annual cover crops between tree alleys, compared to mono-cropping.	81%
Ref19	Annual crops (Maize, wetland rice, soybean, cereals, vegetables, cotton, Brassicaceae)	Global	25	Cover crops	No cover crop	Main crop yield	The integration of cover crops into crop rotations generally increased main crop yields. Main crop yield benefit was determined by main crop species, cover crop type, and their interaction.	81%
Ref20	Mediterranean agro-ecosystems	Mediterranean agroecosystems	10	Cover crops	No cover crops	1) Crop yield; 2) Biomass yield	The sample size for mulching, cover cropping, and organic weed management was less than eight and no statistical analysis was carried out. Therefore, the result was set as 'uncertain'.	62%
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	Food crop yield	The use of green manure showed no effect on crop yield compared both to N fertilized systems and no N fertilized systems.	88%
Ref25	Cotton fields	US, Brasil, Greece	104	Cover crops	No cover crops	Seed cotton yield; Lint yield	Overall, cover crops had a positive effect on cotton yield.	69%
Ref27	Cereals and vegetables	Global. Of the 46 studies, 36 were conducted in North America, 6 in Europe, 3 in Asia, and 1 in South America. Studies from the United States alone accounted for 72% of the total studies used for this review	25	Cover crops. Of the total studies, 94% planted cover crops in the fall, whereas 6% planted cover crops in the spring. These cover crops were terminated mechanically (70% of studies) or with herbicides (30% of studies).	no cover crop (fallow) . all other aspects of management held constant like in the intervention.	Cash crop yield	Use of cover crops for early season weed suppression did not affect grain crop yield, but improved yield of vegetable crops.	75%

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Ref28	Arable fields with cereal crops	US and EU	28	Cover crop (nonleguminous, leguminous, and nonlegume–legume cover crop mixtures). Nonleguminous cover crops included both grasses and broadleaves.	No cover crops	Cash crop yield	There was no significant effect of cover crops (either leguminous or non-leguminous) on subsequent crop yields.	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 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.	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	Grape quantity	Grape quantity and Must quality (sugar content, titratable acidity, yeast assimilable nitrogen) showed no significant responses to extensive natural vegetation management in the mixed-effect model. The authors conclude there is no trade-off between grape yield and quality vs. biodiversity or other ecosystem services.	94%
Ref30	In all the experiments the commercial crops were soybean or corn and always sowed after the cover crop.	Pampas	62	1) Cover crops; 2) Legumes; 3) Non-legume; 4) Mix cover crops;	No cover crops	Cash crop yield	With non-legume cover crops, corn yield tended to decrease in average ca. 8%, although this difference was not significant. Biculture cover crops did not affect corn yield while a significant increase of around 7% was obtained with a legume cover crop. Soybean yield was minimally (but significantly negatively) affected when a fallow was replaced by a cover crop.	81%
Ref34	Corn fields in north america (US and Canada)	North America	65	Winter cover crops (legumes, grass, mixture)	No cover crops	Maize yield	Grass winter cover crops neither increased nor decreased corn yields. Corn that followed a legume winter cover crop yielded 21% more than without a cover. Mixture cover crops increased corn yields by 13%.	88%
Ref37	Spring cereals	EU Nordic countries. Denmark, Sweden, Finland and Norway	35	Winter catch crops undersown to spring cereal. The catch crops were four non-legume species (Italian ryegrass (Lolium multiflorum Lam.), perennial ryegrass (Lolium perenne L.), Westerwolds ryegrass (L. multiflorum Lam. var westerwoldicum) and rapeseed (Brassica napus L.)) and two legume species (white clover (Trifolium repens L.) and red clover (Trifolium pratense L.)).	Bare fallows	Crop yield	Non-legume catch crops reduced grain yield by 3% with no changes in grain N content. In contrast, legumes and mixed catch crops increased both grain yield and grain N content by 6%. The trade-off between potential grain yield loss and environmental benefits seems tolerable and can be taken into account in environmental subsidy schemes.	81%
Ref39	Irrigated agricultural cropping system	Global. Irrigated land is present in many regions of the world, and the scientific literature selected represented a global data-set. The geographical distribution of the selected articles was as follows: North America (44%), Europe (38%), Asia (14%) and South America (4%). Most data came from the European Mediterranean basin (35%) and from the Midwest of the United States (30%).	44	Replacing winter fallow by a non-legume CC (39 experiments); Replacing winter fallow by a legume CC (20 experiments)	No cover crops	Yield of subsequent crop	Replacing a fallow with a legume cover crop had a positive effect on crop yield, with a mean increase of 25%. If the fallow was replaced by a non-legume CC, the mean effect on Y was not significant.	69%
Ref40	Conventional and diversified systems	USA and Brazil	35	Fertilization using cover crops as green manure (with distinction between legume and non-legume)	Bare soil with mineral-N fertilization	Crop yield	On average, the legume-fertilized crops averaged 10% lower yields than conventional N-fertilization. However, yields under green manure fertilization were not	50%

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
							significantly different relative to conventional systems when legume biomass provided at least 110 kg N ha1. No effect was observed for non-legume cover crops.	

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 crop yield	Cash crop yield	Cover crops	Bare soil	Ref10, Ref19, Ref25, Ref27 and Ref34	Ref30	Ref7, Ref13, Ref19, Ref24, Ref25, Ref27, Ref29 and Ref30	Ref20
		Legume cover crops	Bare soil	Ref2, Ref24, Ref25, Ref30, Ref34, Ref37 and Ref39	Ref40	Ref7 and Ref28	
		Non-legume cover crops	Bare soil		Ref2, Ref24 and Ref37	Ref7, Ref25, Ref28, Ref30, Ref34, Ref39 and Ref40	

3. FACTORS INFLUENCING THE EFFECTS ON CROP YIELD

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

Factor	Reference number
Cash crop seeding time	Ref7
Climate	Ref40
Climate zone	Ref2
Cover crop biomass production	Ref7
Cover crop phenology	Ref40
Fruit tree age	Ref2
Mineral fertilisation rate	Ref40
N fertilisation rate	Ref37
Nitrogen fertilisation rates	Ref34
No factor reported	Ref24
Pedo-climatic zone	Ref7
Soil P content	Ref19
Soil type	Ref7, Ref25, Ref37 and Ref40
Termination of cover crop before main crop	Ref34
Termination type	Ref25
Tillage	Ref40

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

Ref Num	Author(s)	Year	Title	Journal	DOI
Ref2	Fang, LF; Shi, XJ; Zhang, Y; Yang, YH; Zhang, XL; Wang, XZ; Zhang, YT	2021	The effects of ground cover management on fruit yield and quality: a meta-analysis	ARCHIVES OF AGRONOMY AND SOIL SCIENCE	10.1080/03650340.2021.1937607
Ref7	Wang, J; Zhang, SH; Sainju, UM; Ghimire, R; Zhao, FZ	2021	A meta-analysis on cover crop impact on soil water storage, succeeding crop yield, and water-use efficiency	Agricultural Water Management, 256, 107085	10.1016/j.agwat.2021.107085
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
Ref13	Morugan-Coronado, A; Linares, C; Gomez-Lopez, MD; Faz, A; Zornoza, R	2020	The impact of intercropping, tillage and fertilizer type on soil and crop yield in fruit orchards under Mediterranean conditions: A meta-analysis of field studies	Agric. Syst. 178, 102736	10.1016/j.agsy.2019.102736
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
Ref20	Lee, H; Lautenbach, S; Nieto, APG; Bondeau, A; Cramer, W; Geijzendorffer, IR	2019	The impact of conservation farming practices on Mediterranean agro-ecosystem services provisioning-a meta-analysis	REG ENVIRON CHANGE	10.1007/s10113-018-1447-y
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
Ref25	Toler, HD; Auge, RM; Benelli, V; Allen, FL; Ashworth, AJ	2019	Global Meta-Analysis of Cotton Yield and Weed Suppression from Cover Crops	Crop science 59, 3, 1248-1261	10.2135/cropsci2018.10.0603
Ref27	Osipitan, OA; Dille, JA; Assefa, Y; Knezevic, SZ	2018	Cover Crop for Early Season Weed Suppression in Crops: Systematic Review and Meta-Analysis	Agronomy Journal 110, 6, 2211-2221	10.2134/agronj2017.12.0752
Ref28	Thapa R, Mirsky SB, Tully KL	2018	Cover Crops Reduce Nitrate Leaching in Agroecosystems:A Global Meta-Analysis	Journal of Environmental Quality 47, 6, 1400-1411	10.2134/jeq2018.03.0107
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
Ref30	Alvarez, Roberto; Steinbach, Haydee S.; De Paepe, Josefina L.	2017	Cover crop effects on soils and subsequent crops in the pampas: A meta-analysis	Soil and Tillage Research 170, 53-65	10.1016/j.still.2017.03.005
Ref34	Marcillo GS, Miguez FE	2017	Corn yield response to winter cover crops: An updated meta-analysis	JOURNAL OF SOIL AND WATER CONSERVATION 72, 3, 226 -239	10.2489/jswc.72.3.226
Ref37	Valkama E, Lemola R, Känkänen H, Turtola E	2015	Meta-analysis of the effects of undersown catch crops on nitrogen leaching loss and grain yields in the Nordic countries	Agriculture, Ecosystems & Environment 203, 93-101	10.1016/j.agee.2015.01.023
Ref39	Quemada, M.; Baranski, M.; Nobel-de Lange, M. N. J.; Vallejo, A.; Cooper, J. M.	2013	Meta-analysis of strategies to control nitrate leaching in irrigated agricultural systems and their effects on crop yield	AGRICULTURE ECOSYSTEMS & ENVIRONMENT	10.1016/j.agee.2013.04.018
Ref40	Tonitto, C; David, MB; Drinkwater, LE	2006	Replacing bare fallows with cover crops in fertilizer-intensive cropping systems: A meta-analysis of crop yield and N dynamics	AGRICULTURE ECOSYSTEMS & ENVIRONMENT, 112, 58–72.	10.1016/j.agee.2005.07.003

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