SINGLE-IMPACT FICHE
COVER AND CATCH CROPS

IMPACT: SOIL WATER RETENTION

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 WATER RETENTION. It is based on 8 synthesis papers[1], including from 6 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 SOIL WATER RETENTION 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.

- The effect of cover/catch crops, as compared to bare soil, on SOIL WATER RETENTION is variable.
- For cover crops in general, 4 out of 10 results report a positive effect (i.e. increase in soil water retention), while 3 results show no significant effect, 3 show a negative effect and 1 report uncertain results (without statistical test of the effects).
- Among the reviewed evidence, 1 synthesis paper dealing with cover crops applied to orchards/tree-crops reports a positive effect for leguminous species and no significant effect for non-legumes species.
- Factors influencing the effect of covert/catch crops on soil water retention include soil depth, the soil type and textural properties, the type of cover crop management methods, and the cover crop biomass production.

Out of the 8 selected synthesis papers, 7 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 water retention	Soil water retention	Cover crops	Bare soil	2	3	3	1
		Legume cover crops	Bare soil	1	0	0	0
		Non-legume cover crops	Bare soil	0	0	1	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

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 water retention. 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
Ref2	fruit tree species (apple, citrus, grape, jujube, kiwi fruit, peach, pear, plum)	Global	116	1) Legume cover crops; 2) Non-legume cover crops;	Clean tillage management	Soil moisture content	Legume cover crops significantly increase soil moisture content. Non-legume cover crops had no significant effect.	69%
Ref7	Annual crops	Global	99	Cover crops	no cover crop (fallow)	Soil water storage at succeeding crop planting 1) for the whole profile (SWSPT); 2) to a depth of 30 cm (SWSP30); 3) Precipitation soil-storage efficiency during the fallow period;	Cover crop decreased Precipitation storage efficiency (during the cover crop period) by 33.4% and soil water storage for the whole profile (SWSPT) at soil depth by 13.2%, but increased water storage to a depth of 30 cm (SWSP30) by 6.0% ($P < 0.05$) compared to no cover crop.	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 crops	No cover/catch crop	Soil water content	Cover crops did not affect soil water content.	62%
Ref21	Arable fields	Global	28	Cover crops	no cover crop (fallow)	Water drainage	This meta-analysis indicated a reduction in drainage in 90% of the studies analyzed and a mean weighted reduction between 32 and 27 mm compared to that of bare soil.	88%
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	Bare soil	Soil water content	Plots with cover crops had 13% less water ($R = 0.87$; CI 0.83 - 0.93), measured in spring, before the food crops were planted.	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	Soil water budget parameters (Water stress integral, water loss, volumetric soil water content)	Soil water budget parameters (Water stress integral, water loss, volumetric soil water content) showed no significant responses to extensive natural vegetation management in the mixed-effect model.	94%
Ref30	In all the experiments the commercial crops were soybean or corn and always sowed after the cover crop.	Pampas	62	Cover crops	No cover crops	1) Soil available water (30 - 90 cm depth); 2) Soil available water (100-250 cm depth);	The impact of cover crops on available water stored in the soils depended on the soil depth considered.	81%
Ref31	Annual crops	Global	6	Cover crops	No cover crop	Water retained at field capacity, Soil porosity	There was evidence of improvements in both hydrologic properties analyzed (however, no statistical analysis is provided).	56%

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 water retention	Soil water retention	Cover crops	Bare soil	Ref7 and Ref21	Ref7, Ref24 and Ref30	Ref10, Ref29 and Ref30	Ref31
		Legume cover crops	Bare soil	Ref2			
		Non-legume cover crops	Bare soil			Ref2	

3. FACTORS INFLUENCING THE EFFECTS ON SOIL WATER RETENTION

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

Factor	Reference number
Cover crop biomass production	Ref7
Pedo-climatic zone	Ref7
Soil depth	Ref30
Soil type	Ref7
Termination method	Ref7

4. KNOWLEDGE GAPS

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

Ref Num	Gap
Ref7	Although no publication bias was found in this meta-analysis (Supplementary Table S3), limited data available for PSE, SWSP, succeeding crop yield, ET, and WUE in certain climatic zones and soil texture as well as residue management practices may have resulted in inconclusive results. For example, RR of cover crop for PSE was greater in loam, but lower in all other soil textures. Residue removal increased PSE, but reduced SWSPT and SWSP30. Similarly, succeeding crop yield and ET in response to cover crop compared to no cover crop were lower, but WUE was greater for silty clay loam soil (Fig. 5). This resulted in the reduced reliability of interpretation for certain parameters in some soil and climatic conditions and residue management Practices. Increased data availability, however, will enhance the meta-analysis of these data in the future.

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
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
Ref21	Meyer, N; Bergez, JE; Constantin, J; Justes, E	2019	Cover crops reduce water drainage in temperate climates: A meta-analysis	Agronomy for Sustainable Development 39, 3	10.1007/s13593-018-0546-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
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
Ref31	Basche, AD; DeLonge, MS	2017	The Impact of Continuous Living Cover on Soil Hydrologic Properties: A Meta-Analysis	SOIL SCI SOC AM J, 81, 5, 1179-1190	10.2136/sssaj2017.03.0077