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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

Background and objective

Cover cropping is practiced to enhance soil health and sustain succeeding crop yield; however, the effect of cover crop on soil water storage, succeeding crop yield, and water-use efficiency (WUE) may not be consistent in all regions. (1) evaluate how cover crop species and management impact PSE, SWSP, succeeding crop yields, ET, and WUE under various soil and climatic conditions, and (2) determine if cover crop biomass and termination date relate to these parameters.

Search strategy and selection criteria

Peer-reviewed research articles published between 1980 and 2020 were searched in Web of Science, Google Scholar, and China National Knowledge Infrastructure Database to determine the cover crop effects on SWSP, PSE, succeeding crop yields, ET, and WUE. Keywords included soil water, precipitation storage efficiency, crop yield, water use efficiency, cover crop, catch crop, and green manure. The search provided 485 publications including both rainfed and irrigated systems. i. Field studies that reported soil water content, cover crops grown between the harvesting of a previous cash crop and planting of a succeeding cash crop, and cash crops with similar management practices, such as irrigation, fertilization, and tillage, were selected for the study. Studies conducted on greenhouse and pot experiments were excluded. Studies that included cover crop as an intercrop with other crops were also excluded. ii. Data included comparison of cover crops vs. no cover crop (fallow) in a region with similar soil and climatic conditions. Studies with the no control treatment were discarded. iii. Treatments were replicated at least three times, and mean values were shown with standard deviation (SD) or standard error (SE). iv. In humid and subhumid regions, two to three crops could be grown in a year. In such cases, only data for those crops that were exclusively stated as cover crops were used for analysis. Data for crops used as supplemental cash crops in a year were excluded. Subjected to these criteria, 117 studies from 99 publications from studies conducted across the world were selected for the meta-analysis

Data and analysis

To determine the cover crop effect on PSE, SWSP, succeeding crop yield, ET, and WUE, mean effect size and 95% bootstrapped confidence intervals (CIs) were computed by using a random model analysis with MetaWin 2.1 software (Sinaure Associate Inc., Sunderland, USA). The effect was not significant when CIs crossed zero.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
99	Annual crops	Cover crops	no cover crop (fallow)	Metric: Water-use efficiency by succeding cash crop; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	68.75

Results

- Data for succeeding crop ET and WUE (188 and 148 paired observations). 129 paired observations for PSE, 465 for SWSPT and 152 for SWSP30, respectively.
- Cover crop significantly increased WUE of succeeding crop by 5.0% compared to no cover crop. The increase was contributed primarily by legume cover crop, with limited effect of nonlegume and mixture of legume and nonlegume cover crops. Cover crop decreased evapotranspiration of the succeeding cash crop by 6.2%.
- Cover crop, overall, decreased PSE by 33.4% compared to no cover crop. This was true for legume, nonlegume, and legume and nonlegume cover crop mixture.
- All cover crop species and mixtures also exhibited lower SWSPT, with an overall decline of 13.2% for cover crop compared to no cover crop. In contrast, cover crop overall increased SWSP30 by 6.0% compared to no cover crop, especially for nonlegumes and legumes, but not for the mixture
- NULL

Factors influencing effect sizes

- Pedo-climatic zone : Cover crop increased succeeding crop WUE compared to no cover crop in the semiarid, subhumid, and humid regions. Cover crop reduced PSE compared to no cover crop in all climatic regions, except for the humid region. The reduction in PSE was greater in the arid and subhumid regions than in the semiarid region. The SWSPT was lower with cover cropping than without in arid, semiarid, and subhumid regions, but not in the humid region. The SWSP30 increased with cover cropping compared to no cover cropping in semiarid and humid regions, but minimum impact in arid and subhumid regions.
- Soil type : Cover crop increased succeeding crop WUE in silt loam, silt clay loam, and clay loam soils, but decreased it in sandy loam soil. Cover crop also reduced PSE compared to no cover crop in silt loam and clay loam soils, but increased in loam soil. Cover crop also reduced SWSPT in sandy loam, loam, silt loam, and clay loam soils, with little effect in silty clay loam soil. SWSP30 due to cover crop vs. no cover crop was greater in silt loam, loam, and silt clay loam.
- Termination method : Cover crop residue placed at the surface increased, but residue removal reduced succeeding crop WUE. Surface placement and incorporation of cover crop residue into the soil significantly reduced PSE, compared to residue removal (no-effect). Residue incorporation into the soil increased, but residue removal decreased SWSP30 compared to surface placement of the residue.
- Cover crop biomass production : The PSE was maximized at cover crop biomass of around 5.0 Mg ha−1.

Conclusion

Cover crop increased water use efficiency of the succeding cash crop by 5.0% ($P < 0.05$) compared to no cover crop.