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Background and objective

Tree crops are mainly planted on sloped farmland, which can lead to soil erosion caused by runoff. As an important tree crop management strategy, ground cover management has been effective in controlling runoff generation and soil loss. However, a global overview is needed to comprehensively quantify the effectiveness of ground cover on water and soil conservation. a) quantify the effectiveness of ground cover management in reducing runoff, soil loss and nutrient loss from tree crop systems; and (b) quantify the effectiveness of ground cover management according to the slope and climatic conditions of the tree crop system. The aim of this study is to provide evidence-based rationale for implementing more sustainable tree crop management practices.

Search strategy and selection criteria

This study built a database that quantified the effect of ground cover management to reduce runoff, soil and nutrient losses in tree crop systems. Peer-reviewed articles from January 1990 to July 2020 were selected using Web of Science and China National Knowledge Infrastructure (CNKI) databases. Three fields were used for the search in the title, abstract or keywords of the articles. The first field was tree crop type, with the following search terms: "orchard" or "apple" or "citrus" or "vineyard" or "almond" or "olive". The second field was cover crop type, and the search terms were "cover crop" or "ground cover" or "catch crop" or "green manure". The third field was soil variable, with the search terms "runoff" or "soil loss" or "erosion" or "nutrient loss" or "soil and water conservation". The case studies were chosen following the strict quality criteria: (a) The experiments or observations were conducted under field conditions (i.e., no laboratory, rainfall simulation or runoff simulation experiments, etc.); (b) Both the ground cover and control (clean tillage or bare ground management) treatments were included in each case study, and the two treatments were exposed to the same environmental conditions; (c) the targeted article contained at least one response variable (runoff or soil loss or nutrients loss observations); (d) when the variable was measured at multiple time points, the average value was calculated to meet the accurate observation results; (e) multiple ground cover species in one study were considered as independent observations.

Data and analysis

The mean percentage change and 95% confidential intervals were computed and compared with Sigmaplot V12.0 (Systat, San Jose, USA). Positive reduction percentages indicated significant reductions of runoff or soil loss or nutrient losses as a result of ground cover relative to clean tillage management. When the CI crossed the invalid line (including 0), the ground cover effectiveness was deemed not significant.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
85	Tree crops (orchards)	1) Cover crops; 2) Legume cover crops; 3) Non-legume cover crops	Clean tillage management	Metric: 1) Runoff reduction; 2) Soil loss reduction; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	81.25

Results

- 342 runoff, 407 soil loss observations were collected from 85 articles.
- Compared to the clean tillage, cover crop management showed significant efficiency in reducing runoff (50.3%) and soil loss (72.7%).
- The non-legume species more effectively reduced runoff and soil losses than legume cover crops
- NULL
- NULL

Factors influencing effect sizes

- Vegetation coverage : Vegetation coverage (VC: 50–65%, 65–80% or 80–100%): as vegetation coverage increased, runoff and soil losses decreased.
- Slope gradient : Slope gradient (<10°, 10–15°, 15–20°, 20–25° or >25°). In all field sites with different slopes, the ground cover was more effective in reducing soil loss than runoff (Figs. 3 and 4). When the field slope was greater than 15°, a continuous decline of ground cover reduction effect was observed as the slope increased. When the field slope ranged from 10 to 15° and 15 to 20°, ground cover reduced runoff by 56.7 to 61.8% and soil loss by 68.2 to 78.6%. In fields with slopes less than 10° and between 20 and 25°, ground cover only reduced runoff by 43.0 to 43.5% and soil loss by 64.0 to 78.6%. When the fields slope was above 25°, ground cover reduced runoff by 39.8% and soil loss by 58.7%. mean annual precipitation (MAP: <400 mm, 400–800 mm or >800 mm).

Conclusion

Cover cropping showed significant efficiency in reducing runoff, soil losses from tree-crops fields.