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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

Background and objective

A meta-analysis specially based on tree crops was conducted to evaluate the changes in soil organic carbon (SOC), soil N and P, and crop yield in a Mediterranean climate, which are affected by: (i) management practices (crop diversification, tillage, fertilization); (ii) environmental characteristics, such as soil clay and climatic variables; and (iii) study length. Assess the implication of crop diversification, tillage and fertilization in Mediterranean orchards on soil nutrients, soil organic carbon and crop yield. For this purpose, we compared the use of cover crops in the alleys related to mono-cropping, and the use of organic fertilizers and minimum tillage/no-tillage related to conventional mineral fertilizer and conventional tillage, respectively.

Search strategy and selection criteria

Literature searches were conducted in SCOPUS, targeting peer reviewed articles published online through July 2019. To obtain the papers listed, the authors used the keywords "almond OR olive OR citrus OR vineyard OR grapevine OR orchard", "AND" combinations of the following items: "Mediterranean climate", "cover crop", "intercropping", "alley crop", "multicrop", "agroforestry", "crop yield" and "soil". 1) Laboratory or greenhouse studies were excluded, and only studies performed in field conditions and carried out in a Mediterranean climate were chosen; 2) When several papers included data from the same experiment, the longest study with the most soil and crop variables was chosen.

Data and analysis

The authors decided to weight observations using the sample sizes to ensure statistical significance by keeping a sufficient sample size: studies with larger sample sizes were weighted higher during aggregation. For the uncertainty analysis, we reported the means and 95% confidence intervals (CIs). The CIs were constructed by non-parametric bootstrapping (nboot = 10 000). The bootstrapping was only carried out for treatments with $n \geq 8$, as the bootstrap is unreliable when the sample size is too small. The effect of treatment was considered as significant if the 95% bootstrap CI did not overlap with zero.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
46	Tree crops (Orchards, vineyards) in the Mediterranean area. The fruit tree crops used for the study were mostly grapevines (<i>Vitis vinifera</i> L.) at 36% of the sample size, olive trees (<i>Olea europaea</i> L.) at 34% of the sample size, almond trees (<i>Prunus dulcis</i> (Mill.) D.A. Webb) at 15% of the sample size and citrus trees (<i>Citrus x sinensis</i> Osbeck, <i>Citrus x limon</i> (L.) Osbeck) at 7% of the sample size. We also used other fruit trees, such as avocado (<i>Persea americana</i> Mill.), carob (<i>Ceratonia siliqua</i> L.), peach (<i>Prunus persica</i> (L.) Stokes), chestnut (<i>Castanea sativa</i> Mill.) and walnut (<i>Juglans regia</i> L.), representing 8% of the total dataset.	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 (<i>Thymus</i> sp, <i>Lavandula</i> sp, <i>Salvia</i> sp, <i>Rosmarinus</i> sp, <i>Brachypodium</i> sp, <i>Asparagus</i> 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).	Metric: 1) Soil organic carbon stock; 2) Soil carbon sequestration rates; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	81.25

Results

- Both annual and permanent intercropping (cover crops with tree crops) were associated with a significant increase in SOC compared to mono-cropping.
- SOC was slightly higher in permanent cover crops systems than in annual cover crops systems, with a mean Wlog(RR) of 0.33 and 0.17, respectively. On average, C sequestration rate also increased (not statistically significant) by 0.43 mg ha⁻¹ yr⁻¹ in AC and 1.01 mg ha⁻¹ yr⁻¹ in PC, with 60% and 71% of studies showing a positive rate.
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Factors influencing effect sizes

- No factors influencing effect sizes to report

Conclusion

Both annual and permanent intercropping (cover crops with tree crops) were associated with a significant increase in SOC stocks (Mg /ha) compared to mono-cropping. Results on SOC sequestration rates (Mg /ha /year) were not statistically significant.