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Editorial: Cover crops and green manures: providing services to agroecosystems

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Editorial on the Research Topic
Cover crops and green manures: providing services to agroecosystems

1 Introduction

Soil health is the capacity of a soil to function within natural or managed ecosystem boundaries, sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health (1). Soil health indicators are closely linked to the capacity of the soil to provide essential ecosystem services, which contribute significantly to human well-being. Some ecosystem services are food and fiber production, biodiversity conservation, nutrient cycling, and carbon sequestration. However, the conversion of native grasslands into croplands, a process known as "agriculturization," has led to the depletion of soil organic carbon content, one of the key components of soil health (2). Consequently, agriculturization has negatively impacted on the ability of the soil to provide these vital ecosystem services.

Adopting sustainable management practices helps alleviate or even reverse the negative impact of agriculturization on the ecosystem services provision. Sustainable management practices should be considered based on their economic viability, social responsiveness, and environmental impact, complexifying their feasibility on agricultural production systems. Cover crops and green manures are usually called "service crops" to highlight the multiple ecosystem services they offer to the agroecosystems (3). Thus, integrating cover crops and green manures into crop rotations appears to be a promising sustainable management strategy.

The global adoption of cover crops and green manures in cash crop rotations has recently increased. However, possible trade-offs between their benefits and side effects may hinder their widespread use. Additionally, the limited adoption of cover crops by farmers can be attributed to a lack of information regarding the ecosystem services these crops provide across diverse climate and soil conditions, as well as variations in cover crop species, management practices, and production systems. The objective of this Research

Topic was to address these research gaps by compiling studies that provide innovative insights into the inclusion of cover crops in agroecosystems, focusing on their relationships with: i) nutrient cycling, soil fertility, and plant nutrition; ii) soil quality indicators and overall soil health; iii) cash crop productivity and quality; iv) soil biology and biodiversity; and v) greenhouse gas emissions and carbon sequestration.

2 This Research Topic

Different services provided by cover crops and green manures across various agroecosystems were highlighted in this Research Topic. In their investigation of weed suppression, Wirén et al. emphasized the effectiveness of both single and mixed cover crop species in managing weed populations. This aspect is crucial for reducing reliance on chemical herbicides and supporting more sustainable farming practices. Complementing this Research Topic, García et al. demonstrated that incorporating Canavalia as a green manure increased tobacco (*Nicotiana tabacum* L.) yields compared to a fallow, with this effect further enhanced through integration with arbuscular mycorrhizal fungi (AMF), allowing for reductions in mineral fertilizer use. This synergy illustrates the potential of integrated practices to maximize crop productivity while decreasing dependence on synthetic fertilizers.

Nutrient cycling and soil fertility were the ecosystem services mainly addressed in this Research Topic. Cover crops modify nutrient cycling in the systems by acting as catch crops during fallow periods and releasing the nutrients after their termination. In this context, Couëdel et al. showed that crucifer-legume mixtures optimized nutrient uptake during fallow periods compared to sole cover crops. Although some negative competition for specific nutrients was observed, the overall compatibility of these mixtures enhanced the provision of ecosystem service by reducing nutrient losses, mainly through leaching and/or runoff, and promoting nutrient recycling for the following cash crop. Similarly, Yang Y. et al. revealed that leguminous cover crops improved soil phosphorus availability and citrus growth in phosphorus-deficient soils, further highlighting the importance of these crops in nutrient management strategies. Moreover, Yang X. et al. showed in a comparative analysis of cover crops under different tillage methods that hairy vetch outperformed other species in maize (*Zea Mays* L.) grain yield, while providing valuable nitrogen credits upon termination. These findings underscore the critical role of cover crops in promoting nutrient cycling and their potential as a nutrient management strategy for achieving sustainable agricultural practices.

Environmental benefits of green manures were another important topic discussed in this Research Topic. Lyu et al. provided a detailed review of the impact of green manure application on soil nitrogen transformation and cash crop nitrogen uptake and utilization. The authors argued that the total or partial replacement of inorganic nitrogen fertilizers with green manures prevented nitrate leaching and ammonia volatilization, while the effect on N_2O emissions depended on cover crop management and environmental conditions. Moreover, they emphasized the importance of aligning nitrogen mineralization and immobilization with the nutrient demand of cash crops to improve nitrogen use efficiency and reduce potential losses. Additionally, Cafaro La Menza and Carciochi characterized various cover crop species and related them to their main contributions to agroecosystems. These authors stated that grasses are suitable for soil erosion control, weed suppression, and enhancing carbon balances, while legumes like vetch are essential for nutrient recycling and adding nitrogen to cropping systems. This synthesis-analysis highlighted that the selection of cover crop species should be based on the specific ecosystem services needed in the agroecosystem.

To properly evaluate the benefits of including cover crops and green manures in agroecosystems, a long-term assessment should be undertaken to avoid erratic responses from specific years. In this context, Wang et al. demonstrated that extending mulching duration in orchard systems significantly increased soil nitrogen and phosphorus levels, along with microbial activity. This finding highlighted the long-term benefits of green manures as a sustainable soil management practice.

In integrated crop-livestock systems, farmers are often tempted to use cover crops as animal feed. Although, by definition, this could not strictly be considered a cover crop (as cover crops are defined as species that grow between two cash crops and are not grazed or harvested), it is a possibility in current cropping systems. In this regard, Fu et al. highlighted the drawbacks of mowing ryegrass (*Lolium perenne* L.), which could lead to declines in soil nutrient content, enzyme activities, and microbial community composition, despite increases in cash crop yield. These results underscore the complexity of managing cover crops and the challenges in determining the appropriateness of this practice within cropping systems.

3 Concluding remarks/ future directions

The studies compiled in this Research Topic showed the multifaceted role of cover crops and green manures in enhancing agroecosystem services. However, assessing their impact is inherently complex, as it is influenced by various factors. While some benefits, such as improved nutrient cycling and soil health, are consistently observed, others may vary significantly based on local environmental conditions and agricultural practices. To effectively evaluate the contributions of cover crops and green manures, a holistic approach seems essential. This approach should encompass

not only the immediate agronomic benefits but also the broader ecosystem services they provide with a focus on the long-term.

In conclusion, this Research Topic serves as a valuable resource for advancing our understanding of cover crops and green manures, facilitating more informed decisions regarding their adoption and maximizing their benefits while minimizing potential trade-offs. As we continue to explore the potential of these crops, it is imperative to evaluate them with a comprehensive perspective, ensuring that we consider economic, social, and environmental aspects.

Author contributions

WC: Writing – original draft, Writing – review & editing. JG: Writing – review & editing. NW: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

1. Doran JW. Soil health and global sustainability: Translating science into practice. *Agriculture Ecosyst Environ.* (2002) 88:119–27. doi: 10.1016/S0167-8809(01)00246-8

2. Wyngaard N, Crespo C, Angelini H, Eyherabide M, Larrea G, Reussi Calvo N, et al. The effect of agriculture on topsoil carbon stocks is controlled by land use, climate, and soil properties in the Argentinean Pampas. *CATENA*. (2022) 212:106126. doi: 10.1016/j.catena.2022.106126

3. Pinto P, Fernández Long ME, Piñeiro G. Including cover crops during fallow periods for increasing ecosystem services: Is it possible in croplands of Southern South America? *Agriculture Ecosyst Environ.* (2017) 248:48–57. doi: 10.1016/j.agee.2017.07.028