soil systems

Editorial

Advancements in Soil and Sustainable Agriculture

Mohamed Houssemeddine Sellami * and Antonella Lavini

National Research Council of Italy (CNR), Institute for Agricultural and Forestry Systems in the Mediterranean (ISAFOM), 80055 Portici, Italy; antonella.lavini@cnr.it
* Correspondence: mohamed.sellami@isafom.cnr.it

1. Introduction

The growing interest in soil health and sustainable agriculture has emerged as a paramount element in addressing the multifaceted challenges facing modern agriculture [1]. In an era marked by mounting pressures for increased food production, heightened environmental conservation, and urgent climate change mitigation, innovative strategies have surfaced to accord soil health and productivity a central role [2]. This shift in perspective acknowledges the indispensable significance of soil as a fundamental substrate for crop growth as well as its crucial role in carbon sequestration and the maintenance of ecological equilibrium. Notably, this paradigmatic transformation has fostered the adoption of a spectrum of innovative approaches [3]. Precision agriculture, enabled by technological advancements, has revolutionized resource management by optimizing resource allocation, fine-tuning nutrient application, and curtailing detrimental environmental impacts, all while facilitating the sustainable stewardship of soil [4,5]. In tandem, organic farming practices have gained prominence, underlining the imperative of eschewing synthetic chemicals, nurturing natural soil ecosystems, and augmenting the organic matter content in soils [6]. Complementing these strategies is the integration of biofertilizers, which harness the inherent power of beneficial microorganisms to stimulate nutrient cycling and enhance soil structure [7,8]. These dynamic developments collectively epitomize a burgeoning era of soil-centered agriculture, one that wholeheartedly aligns with the overarching objective of advancing agricultural productivity while concurrently upholding the principles of long-term environmental sustainability [9,10]. Within this context, this Special Issue titled "Advancements in Soil and Sustainable Agriculture" directs its attention toward novel and inventive methods for rendering contemporary agriculture more soil-friendly as well as strategies for enhancing soil productivity. This Special Issue comprises eleven papers, consisting of eight research articles and three review articles, authored by a diverse group of scientists.

2. A Comprehensive Review of Published Articles

As per the scholarly articles released in this Special Issue from 2022 to 2023, this Editorial categorizes the research papers into four specific themes:

Nutrient Management and Soil Health: This set of articles is dedicated to the relationship between nutrient management and its influence on various soil health indicators. The research papers authored by Gagnon and Ziadi (Contribution 1), Arrobas et al. (Contribution 2), de São José et al. (Contribution 3), and Denton-Thompson and Sayer (Contribution 4) are grouped within this thematic, exploring how nutrient management practices, including the use of soil amendments, biofertilizers, micronutrients, and residue management, impact soil characteristics, metal availability, and plant health. In their study, Gagnon and Ziadi (Contribution 1) examine the residual effects of applying paper mill biosolids and forest-derived liming materials on soil properties and metal availability. Their findings underscore that the application of these materials enhances soil properties without causing

check for updates

Citation: Sellami, M.H.; Lavini, A. Advancements in Soil and Sustainable Agriculture. *Soil Syst.* **2023**, *7*, 98. https://doi.org/10.3390/soilsystems7040098

Received: 25 October 2023
Accepted: 27 October 2023
Published: 31 October 2023

an increase in metal availability, showcasing the potential of sustainable nutrient management practices. Arrobas et al. (Contribution 2) assess the effects of humic and fulvic acids on soil and olive plant properties, revealing a minimal impact on tissue elemental composition and dry matter yield. However, their research underscores the need for a more comprehensive understanding of how to optimize the advantages of these soil amendments for crop production and sustainability. de São José et al. (Contribution 3) investigate the impact of managing eucalyptus harvest residues on soil organic carbon content and stock. Their study evaluates the use of the carbon management index (CMI) to determine the relationship between residue management and soil health. Their research emphasizes the importance of maintaining certain components (bark and branches) in order to increase soil carbon retention. In addition, Denton-Thompson and Sayer (Contribution 4) conduct a review of microbial nutrient mobilization in natural ecosystems and its potential to improve crop nutrition. Their work emphasizes the benefits of co-applying biofertilizers with conventional fertilizers to enhance nutrient uptake. This research underscores the critical importance of comprehending microbial nutrient mobilization for enhancing both crop nutrition and soil sustainability.

Soil management and Agricultural sustainability: This theme encompasses an examination of diverse agricultural practices, including tillage systems, crop rotations, and biochar utilization, and their influence on critical aspects of soil, such as carbon sequestration, microbial activity, crop yields, and overall soil sustainability. Notably, the research papers authored by Gualberto et al. (Contribution 5), Sellami and Terribile (Contribution 6), and Bogale et al. (Contribution 7) are grouped within this thematic area, delving into the repercussions of these agricultural practices on soil carbon sequestration, microbiological activity, yield, and overall soil sustainability. In the work by Gualberto et al. (Contribution 5), the authors investigate the impact of alterations in land use on soil organic carbon fractions in Northeastern Brazil. Their study showcases how distinct land management approaches can uphold soil health indicators, indicating that specific crop rotations and practices play a pivotal role in preserving topsoil quality and retaining essential active carbon components within the soil. In the study conducted by Sellami and Terribile (Contribution 6), the authors provide a bibliometric analysis of the evolution of soil health research. Their analysis spotlights the mounting emphasis on comprehending the consequences of soil management for biochemical processes, microbiological activities, and greenhouse gas emissions. This work underscores the significance of holistic, integrated strategies for sustainable soil management. Furthermore, Bogale et al. (Contribution 7) review the independent and symbiotic effects of soil tillage systems and biochar on soil carbon sequestration and crop production. Their research indicates that the combined influence of soil tillage techniques, such as conservation tillage, and the incorporation of biochar can foster soil carbon sequestration while enhancing crop physiology, yield, nutrient uptake, and soil health indicators. This approach offers a promising solution for advancing agricultural sustainability.

Soil Contamination and Phytoremediation: This thematic area centers on soil contamination and the application of phytoremediation as a strategy for improving soil health and mitigating contamination. Specifically, the research articles authored by Joya-Barrero et al. (Contribution 8), Ahmad et al. (Contribution 9), and Faria et al. (Contribution 10) fall under this thematic category, with a primary focus on soil contamination and the application of phytoremediation to improve soil health and mitigate contamination. In their study, Joya-Barrero et al. (Contribution 8) investigate the sources of cadmium in cacao crop soils and suggest strategies for reducing its presence. This research emphasizes the importance of understanding both natural and anthropogenic sources of soil contaminants and proposes practical solutions like selecting low-accumulator crops and amending soils with microorganisms to reduce metal content. The work of Ahmad et al. (Contribution 9) concentrates on the phytoextraction capacities of different crops, such as Brassica species, with respect to remediating soil contaminated with toxic metals. The outcomes highlight the potential of these crops as efficient agents for remediating soil polluted by toxic metals, thereby underscoring their pivotal role in promoting soil sustainability. Furthermore, Faria et al. (Contribution 10) investigate the impact of arbuscular mycorrhiza fungal communities on the uptake of essential and toxic metals by wheat plants. This research underscores the critical role of these fungal communities in enhancing crop resilience to metal toxicity, thereby contributing to sustainable agricultural practices and the overall health of soil ecosystems.

Soil Nitrogen Management and Environmental Impact: Under this thematic area, a sole article authored by De Marco (Contribution 11) is included. It delves into the nitrogen budget and employs statistical entropy analysis pertaining to the Tiber River catchment. This study amalgamates diverse methodologies to assess the implications of altering nitrogen usage scenarios, underscoring the significance of comprehending the factors behind varying nitrogen budgets at both the catchment and sub-catchment scales. This research makes a valuable contribution to endeavors aiming to diminish nitrogen accumulation and mitigate environmental hazards in heavily impacted ecosystems.

3. Conclusions

The amalgamation of these diverse themes epitomizes the intricate tapestry of contemporary soil and sustainable agriculture research. Within the articles published in this Special Issue “Advancements in Soil and Sustainable Agriculture” lies a shared commitment to confront the multifaceted challenges of modern agriculture. One of the overarching goals of these diverse studies is to promote the sustainability of the Earth’s most fundamental resource: soil. Soil sustainability is, without a doubt, at the heart of these endeavors. It is the very foundation upon which agriculture, the backbone of human civilization, is built. Therefore, as the world grapples with ever-mounting pressures, ranging from the increasing demand for food production to the urgent need for environmental conservation and climate change mitigation, the importance of nurturing our soil’s health and longevity cannot be overstated. Through the collaborative efforts of scientists, researchers, and agricultural practitioners, these themes underscore the significance of innovative solutions that are essential to securing a more sustainable and environmentally conscious agricultural future. These investigations, collectively, offer profound insights into the intricate dynamics of soil health and its intimate connection with the ecological well-being of our planet. They emphasize the vital role of holistic, integrated strategies in promoting not only agricultural productivity but also the long-term sustainability of our planet’s delicate ecosystems. As we navigate the complexities of the 21st century, this collective pursuit embodies our shared commitment to nurturing and preserving the very earth beneath our feet, ensuring that it remains fertile, vibrant, and sustainable for generations to come. In the ever-evolving narrative of agriculture, it is clear that the chapters dedicated to soil sustainability are not only essential but also pivotal to the success and well-being of humanity and our planet.

Author Contributions: Conceptualization, M.H.S.; methodology, M.H.S.; investigation, M.H.S.; writing—original draft preparation, M.H.S. and A.L.; writing—review and editing, M.H.S.; visualization, M.H.S.; supervision, M.H.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

List of Contributions

1. Gagnon, B.; Ziadi, N. Paper Mill Biosolids and Forest-Derived Liming Materials Applied on Cropland: Residual Effects on Soil Properties and Metal Availability. *Soil Syst.* **2023**, *7*, 40. https://doi.org/10.3390/soilsystems7020040.
2. Arrobas, M.; de Almeida, S.F.; Raimundo, S.; da Silva Domingues, L.; Rodrigues, M.Â. Leonardites Rich in Humic and Fulvic Acids Had Little Effect on Tissue Elemental Composition and Dry Matter Yield in Pot-Grown Olive Cuttings. *Soil Syst.* **2022**, *6*, 7. https://doi.org/10.3390/soilsystems6010007.

3. de São José, J.F.B.; Vargas, L.K.; Lisboa, B.B.; Vieira, F.C.B.; Zanatta, J.A.; Araujo, E.F.; Bayer, C. Soil Carbon Stock and Indices in Sandy Soil Affected by Eucalyptus Harvest Residue Management in the South of Brazil. *Soil Syst.* **2023**, *7*, 93. https://doi.org/10.3390/soilsystems7040093.
4. Denton-Thompson, S.M.; Sayer, E.J. Micronutrients in Food Production: What Can We Learn from Natural Ecosystems? *Soil Syst.* **2022**, *6*, 8. https://doi.org/10.3390/soilsystems6010008.
5. Gualberto, A.V.S.; de Souza, H.A.; Sagrilo, E.; Araujo, A.S.F.; Mendes, L.W.; de Medeiros, E.V.; Pereira, A.P.d.A.; da Costa, D.P.; Vogado, R.F.; da Cunha, J.R.; et al. Organic C Fractions in Topsoil under Different Management Systems in Northeastern Brazil. *Soil Syst.* **2023**, *7*, 11. https://doi.org/10.3390/soilsystems7010011.
6. Sellami, M.H.; Terribile, F. Research Evolution on the Impact of Agronomic Practices on Soil Health from 1996 to 2021: A Bibliometric Analysis. *Soil Syst.* **2023**, *7*, 78. https://doi.org/10.3390/soilsystems7030078.
7. Bogale, A.A.; Melash, A.A.; Percze, A. Symbiotic and Asymmetric Causality of the Soil Tillage System and Biochar Application on Soil Carbon Sequestration and Crop Production. *Soil Syst.* **2023**, *7*, 48. https://doi.org/10.3390/soilsystems7020048.
8. Joya-Barrero, V.; Huguet, C.; Pearse, J. Natural and Anthropogenic Sources of Cadmium in Cacao Crop Soils of Santander, Colombia. *Soil Syst.* **2023**, *7*, 12. https://doi.org/10.3390/soilsystems7010012.
9. Ahmad, I.; Malik, S.A.; Saeed, S.; Rehman, A.-u.; Munir, T.M. Phytoremediating a Wastewater-Irrigated Soil Contaminated with Toxic Metals: Comparing the Efficacies of Different Crops. *Soil Syst.* **2022**, *6*, 77. https://doi.org/10.3390/soilsystems6040077.
10. Faria, J.M.S.; Teixeira, D.M.; Ferreira, D.; Barrulas, P.; Brito, I.; Pinto, A.P.; Carvalho, M. Manganese Uptake to Wheat Shoot Meristems Is Differentially Influenced by Arbuscular Mycorrhiza Fungal Communities Adapted to Acidic Soil. *Soil Syst.* **2022**, *6*, 50. https://doi.org/10.3390/soilsystems6020050.
11. De Marco, A.; Fornasier, M.F.; Screpanti, A.; Lombardi, D.; Vitale, M. Nitrogen Budget and Statistical Entropy Analysis of the Tiber River Catchment, a Highly Anthropized Environment. *Soil Syst.* **2022**, *6*, 17. https://doi.org/10.3390/soilsystems6010017.

References

1. Davis, A.G.; Huggins, D.R.; Reganold, J.P. Linking Soil Health and Ecological Resilience to Achieve Agricultural Sustainability. *Front. Ecol. Environ.* **2023**, *21*, 131–139. [CrossRef]
2. Handayani, I.P.; Hale, C. Healthy Soils for Productivity and Sustainable Development in Agriculture. *IOP Conf. Ser.* **2022**, *1018*, 012038. [CrossRef]
3. FAO. *Healthy Soils Are the Basis for Healthy Food Production*; FAO: Rome, Italy, 2015; Available online: https://www.fao.org/soils-2015/news/news-detail/en/c/277682/ (accessed on 24 October 2023).
4. Rayhan Shaheb, M.d.; Sarker, A.; Shearer, S.A. Precision Agriculture for Sustainable Soil and Crop Management. In *Soil Science—Emerging Technologies, Global Perspectives and Applications*; IntechOpen: London, UK, 2022; Volume 49. [CrossRef]
5. Nath, S. A vision of precision agriculture: Balance between agricultural sustainability and environmental stewardship. *Agron. J.* **2023**, *Early View*, 1–18. [CrossRef]
6. Gamage, A.; Gangahagedara, R.; Gamage, J.; Jayasinghe, N.; Kodikara, N.; Suraweera, P.; Merah, O. Role of Organic Farming for Achieving Sustainability in Agriculture. *Farming Syst.* **2023**, *1*, 100005. [CrossRef]
7. Bhardwaj, D.; Ansari, M.W.; Sahoo, R.K.; Tuteja, N. Biofertilizers function as key player in sustainable agriculture by improving soil fertility, plant tolerance and crop productivity. *Microb. Cell. Fact.* **2014**, *13*, 66. [CrossRef] [PubMed]
8. Mącik, M.; Gryta, A.; Frąc, M. Biofertilizers in Agriculture: An Overview on Concepts, Strategies and Effects on Soil Microorganisms. *Adv. Agron.* **2020**, *162*, 31–87. [CrossRef]
9. Trap, J.; Éric, B. Intensifying the Soil Ecological Functions for Sustainable Agriculture: Acting with Stakeholders. *Curr. Res. Environ. Sustain.* **2023**, *5*, 100225. [CrossRef]
10. Mehmet Tuğrul, K. *Soil Management in Sustainable Agriculture. Sustainable Crop Production*; IntechOpen: London, UK, 2020. [CrossRef]