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Editorial

Integrated Soil Management: Food Supply, Environmental Impacts, and Socioeconomic Functions

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Soil is a key resource for agricultural production and, consequently, for food supply and sustainable development [1,2]. In fact, the quality of soil impacts the characteristics of the outputs obtained and the income of the farms, with implications for the performance of the agricultural sector and the various associated upstream and downstream activities [3]. Soil and climate conditions are among the first variables considered by agricultural decision-makers when they need to select the most adequate production to draw up agricultural plans [4]. On the other hand, food supply chains and various socioeconomic activities have impacts on soil quality, generating, in some cases, what can be called circular and cumulative processes [5]. In these frameworks, integrated soil management is fundamental to preserving the quality of the soil and its functions for sustainable development and to guaranteeing the safety and security of the food obtained for human health and balanced nutrition [6–8]. For adjusted management, soil legislation and policies play a relevant role, as well as the associated institutions at the national, European and international levels. Nonetheless, the legislation and public policies seem to have been more concerned with the air and water quality than soil health. The outputs from the international scientific community reveal that there is a field to be explored, namely through multidisciplinary approaches, considering smart methodologies and addressing gaps related to specific particularities of the soil management dimensions. These insights are fundamental to supporting the policymakers and decision-makers and give suggestions for future research. This is particularly important when it is still needed to convince the national and European institutions to prioritize specific soil health problems [9].

This Editorial refers to the Special Issue "Integrated Soil Management: Food Supply, Environmental Impacts, and Socioeconomic Functions". The Special Issue highlights bringing a broader perspective on soil management, namely in its relationship with food supply, environmental dimensions, and socioeconomic activities. From a total of twenty-six manuscripts submitted for consideration and peer review, fourteen were accepted for publication and inclusion in this Special Issue (two reviews and twelve articles). The published contributions are listed below followed by a description review to encourage the reader to explore them.

Cárceles Rodríguez et al. (contribution 1) reviewed the impact of conservation agricultural practices on soil health and their role in agricultural sustainability. Their study concludes that the main challenge of conserving and improving soil health is guaranteeing its long-term productivity and environmental sustainability, and to reach this will be vital to develop new tools and methodologies to assess soil quality and health that can be used to evaluate and guide soil management decisions.

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Rubiales (contribution 2) critically reviewed the achievements and prospects in broomrape (*Orobanche crenata*) management and resistance breeding to facilitate legume reintroduction into Mediterranean rain-feed farming systems. The author stressed that several strategies have been proposed for crenate broomrape management but considering that temperate legumes in the area are low-input crops, they have been found to be largely uneconomical or hard to grow, leaving the use of resistant cultivars as the most desirable option.

Martinho et al. (contribution 3) investigate the spatial correlations of the soil nutrient balance around the world and analyse how this variable is interrelated with agricultural soil emissions, agricultural output, and food supply. Results highlight that there is space for common strategies worldwide to preserve soil quality, as in some parts of the world the problems are similar. In these frameworks, the international organisations may have a determinant contribution.

Hredoy et al. (contribution 4) investigates the impact of landfill leachate of Amin Bazar landfill on the environmental compartments. The authors found that mitigation measures are critical for preventing soil and water contamination because the leachate from the landfill site has a higher degree of contamination with respect to the analysed parameters, which contribute to the surrounding environmental components including the surface water, groundwater, soil, and plants by polluting them adversely. However, the authors claim that a gap remains in investigating the feasibility of becoming involved in the development of a waste management system as well as ensuring ideal environmental standards for municipal solid waste and balancing environmental quality.

Arrobas et al. (contribution 5) investigates fertilisation programmes oriented towards ecological intensification in European chestnut (*Castanea sativa* Mill.) rainfed orchards and managed with increasingly intensive cropping practices. Results highlight that it seems appropriate to base the annual fertilisation plan on leaf nutrient concentration because these large trees had a poor response to the annual application of fertilisers.

Parveen et al. (contribution 6) investigates the impact of phytohormones, e.g., indole acetic acid and gibberellic acid, on mung bean (*Vigna radiata* L.) yield, seed nutritional profile, and soil N availability in the sub-tropical region of Pakistan. The findings of the study highlight that the combined treatment of the two phytohormones followed by the sole application of each phytohormone were most effective treatments to improve the morpho-physiology and nutrient profile of mung beans; however, the underlying molecular mechanisms need to be explored further.

Nacoon et al. (contribution 7) investigates the effects of different species of arbuscular mycorrhizal fungi (*Claroideoglomus etunicatum*; *Rhizophagus variabilis*; *Rhizophagus nov. spec.*; *Acaulospora longula*) on the growth performance and concentrations of bioactive substances of black rice in a pot experiment under laboratory conditions. Results highlight that *Rhizophagus variabilis* was the best inoculum for increasing grain yield and bioactive compounds.

Cavalaris et al. (contribution 8) investigates the impacts on soil compaction, along with the changes in soil carbon, and aims to identify the optimum tillage schemes that compromise benefits and drawbacks. The findings show that permanent no-tillage was the most effective method for sequestering soil carbon and highlight that carbon credits in carbon farming may be halved if periodic deep tillage operations should be introduced to counteract the consequences of extreme soil compaction.

Sheshnitsan et al. (contribution 9) investigates the level of selenium in soils and its accumulation in plants as well as identifying the factors associated with selenium bioaccumulation in the hydrogeochemical province with high selenium in groundwater. The research results indicated that the absence of antagonistic interactions with heavy metals in the soil–plant system contributes to the enhanced selenium accumulation in plants in the Lower Dniester Valley. Finally, this study shows the complexity of the interactions between selenium and heavy metals in the soil–plant system and their potential impact on agricultural practices. The authors conclude that further studies are required to identify the reasons for the high mobility of selenium and the significant content of its water-soluble forms in soils.

Landi et al. (contribution 10) investigates the potential efficacy of pot cultivation systems using commercial substrates to avoid plant-parasitic nematode infestations and simultaneously increase free-living nematode populations. The findings show that substrates rich in organic matter such as coconut fibre, even though they are unable to prevent accidental introduction during cultivation, could still play an important role in suppressing plant-parasitic nematodes. The main conclusion of this study is that a gap in the knowledge exists and more studies are needed to investigate the mechanisms determining differences in plant-parasitic nematodes between plant species and to explore the effectiveness of combining pot cultivation with other control methods.

Kintl et al. (contribution 11) investigates the potential influence of soil heterogeneity in terms of nutrient contents on differences in the chemical composition of individual parts of chickpea (*Cicer arietinum* L.) plants (stems, leaves, pods and seeds). The authors concluded the heterogeneity of certain elements (nutrients) and soil reactions on the ability of chickpea to uptake and translocate these elements into plant organs and seeds, thus proving that soil heterogeneity strongly affects the overall fitness of chickpea. Moreover, the authors claim that farmers can influence detected plot heterogeneity by taking appropriate measures (mineral and organic fertilisation, liming, etc.) using a system of precision agriculture.

Choudhary et al. (contribution 12) investigates the effects of crop residue, nutrient management, and soil moisture on methane emissions from maize, rice, soybean, and wheat production systems. Results highlight the complexity of methane dynamics and emphasise the importance of integrated crop, nutrient, and soil moisture (irrigation) management strategies that need to be developed to minimise methane emissions from agricultural production systems to mitigate climate change. The authors claim that the findings of this study will help develop more accurate models for mitigating greenhouse gas emissions from agricultural soils.

Wang et al. (contribution 13) investigates the effects of varying the rates of five chicken manure applications on the accumulation and distribution of antibiotic resistance genes across different soil depths using metagenomic sequencing. The authors found that antibiotic resistance genes were predominantly concentrated in the surface soil and exhibited a significant decrease in type and abundance with increased soil depth. This paper offers valuable insights for environmental risk assessments regarding the utilisation of livestock manure resources. Additionally, the authors highlight that it furnishes a scientific foundation for farmland application strategies pertaining to livestock manure.

Buckle et al. (contribution 14) investigates the effects of a selection of management practices and environmental factors on the presence and abundance of arbuscular mycorrhizal fungi in upland Welsh grasslands. The research results suggest that grazing sheep and cattle together had the highest overall influence on arbuscular mycorrhizal fungi abundance compared to grazing sheep or cattle separately. Results highlight that high plant diversity correlated with high arbuscule and vesicle abundance, but conversely, the application of lime reduced vesicle abundance. The authors claim that these findings offer new insights into the effects of management practices on arbuscular mycorrhizal fungi. The main conclusion of this study is that mixing livestock, increasing plant diversity, and reducing lime applications are shown here to improve the abundance of arbuscular mycorrhizal fungi and could, therefore, help to inform sustainable farm management decisions in the future.

The contributions published in this Special Issue offer new insights into further studies on soil quality and agricultural performance, the impact of agricultural activities on soil quality, soil functions, and sustainability, the quantification of heavy metals in soil, and organic agriculture and soil parameters. However, a multidisciplinary approach integrating soil quality with food supply, environmental dimensions, and socioeconomic activities could provide new insights. Another knowledge gap highlights that studies on topics such as soil management, food safety and security, climate-smart agriculture and soil management, agriculture 4.0 and soil characteristics, Industry 4.0 and its impact on soil, and the calculation of potentially toxic elements in soil are welcome.

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