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Editorial

Soil Quality and Crop Nutrition

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Soil quality has been defined as the "continued capacity of soil to function as a vital living system, within ecosystem and land use boundaries, sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal and human health" [1]. Hence, the assessment in time of soil quality and the direction of change with time is a prerequisite for sustainable land management. The quality of a soil depends on both its intrinsic properties and on exogenous factors able to affect, among others, the microbial community inhabiting it and the availability of nutrients, aspects which are strongly interdependent between them.

The Special Issue "Soil Quality and Crop Nutrition" provides new insights into the effect of intrinsic soil properties and exogenous factors on nutrient cycling and soil microbial biomass and activities that, in turn, regulate crop nutrition.

The articles cover a range of topics: five articles deal with organic amendment and fertilization, two with soil management, two with intrinsic soil properties, and one with the presence of specific microorganisms able to affect soil quality and crop nutrition.

The article by Lucia et al. [2] aimed at investigating the effect of sewage sludge deriving from the citrus processing industry on soil fertility and lettuce growth performance. In a pot experiment, lettuce was cultivated using a soil amended or not with different amounts of citrus sewage sludge. Results suggested that citrus sludges have great potential in ameliorating soil fertility as the lettuce biomass production increased, even without affecting the $(K^+ + Na^+)/(Ca^{2+} + Mg^{2+})$ ratio. Such results are of great importance since about 60% of the operating costs of wastewater treatment plants in Europe can be associated with the treatment and disposal of products [3]. Current methods of sewage sludge utilization include agricultural application, landfilling, incineration, drying, and composting and/or vermicomposting. The reuse of sewage sludge coming from the citrus processing industry for agricultural purposes has to be stimulated since may contribute on the one hand to reducing costs of disposal and, on the other hand, to increase soil organic matter (SOM), especially in semiarid environments [4,5]. Moreover, the reuse fits with the principle of circular economy as aimed by European Commission. In line with the study of Lucia et al. [2], Wichrowska and Szczepanek [6] compared the effect of a bio-fertilizer in affecting potato quality with farmyard manure (FYM) and organic and mineral fertilizers. The tested biofertilizer consisted of yeast, lactic acid bacteria (Lactobacillus and Lactococcus), Pseudomonas, Actinobacteria, and Azotobacter as well as small amounts of micro-and macronutrients. The authors found that the application of the bio-fertilizer significantly increased the content of essential and non-essential amino acids (tyrosine, methionine, and asparagine) in potato tuber protein. The key role of microorganisms in improving soil biological fertility and nutrient availability was also confirmed by the study of Griebsch et al. [7]. They investigated the persistence of up to seven years of the microsymbiont Bradyrhizobium japonicum in soil cultivated with soybean and its ability in entering an effective symbiosis with soybean for up to seven years. The supply of organic amendment to soil not only may contribute to improving soil fertility and crop quality but also may be of help in restoring the biological quality of contaminated soils. Such a topic

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was investigated by Wyszkowska et al. [8], who tested the effectiveness of finely-ground barley straw and bentonite in mitigating the effects of agricultural soil contamination with the herbicide Successor T 550 SE. The bentonite and spring barley straw were used at the dose of 10 g kg^{-1} of soil. Based on the soil quality index calculated from the activity of seven enzymes, Wyszkowska et al. [8] concluded that barley straw was more effective in restoring soil homeostasis than bentonite.

The role of inorganic fertilizers in improving the availability of macronutrients is well-known. However, nitrogen (N) and potassium (K) fertilizers may also contribute to increasing the availability of trace elements among which some are useful for crop nutrition and quality, but others may be dangerous being heavy metals. Wyszkowski and Brodowska [9] found, in soil fertilized with N and K at increasing rates, that K fertilization enhanced the content of cadmium by 83% and lead by 32% while reducing the amounts of chromium by 10% and iron by 3% in the soil, particularly in the series with a lower N dose (130 mg N kg^{-1} soil). On the other hand, N fertilization increased the contents of zinc and iron, copper, manganese, chromium, and cobalt while reducing the contents of cadmium and nickel and lead. However, in the study of Wyszkowski and Brodowska (2023), the permissible standards for trace elements content in the soil were not exceeded.

For homogeneous fertilization and crop management practices, however, soil intrinsic factors could play a key role, especially in dry regions. Indeed, particle size analysis could help improve knowledge of the soil–plant relationships to obtain favorable conditions for better yield. Zaaboubi et al. [10] developed a granulometric index for durum wheat that was well correlated with yield. Analyzing 350 independent samples of cereal soils from eastern Algeria, they found that the two fractions that most influenced the textural imbalance were fine silt and coarse sand with a contribution of 41% and 37%, respectively. Another important exogenous factor affecting soil quality is the position of the soil in the landscape. Indeed, investigating the soil of savannah floodplains in the eastern plains of Colombia, Salamanca-Carreño et al. [11] found that high values of nutrients in the "low" physiographic position, although both "low" and "bank" positions have low levels of most nutrients.

Additionally, soil mulching, especially in semiarid environments, may improve soil fertility and crop yield. The study of Paliaga et al. [12] showed that mulching soil with black plastic geotextiles increased SOM, cation exchange capacity, microbial biomass, and microbial quotient, thus suggesting high SOM accessibility by soil microorganisms. Moreover, mulching favored fungi over bacteria, and Gram-positive bacteria over Gram-negative bacteria, thus contributing to the establishment of a microbial community more efficient in utilizing C sources. The improvement in soil quality and fertility, in turn, leads to a higher orange yield in mulched soil. Moreover, Paliaga et al. (2023) found that reversing mulching with tillage rapidly decreased soil quality and orange yield, thus confirming the deleterious effect of tillage especially in semiarid Mediterranean environments.

The importance of soil management in affecting soil and crop quality and production was also proved by Ren et al. [13] for rice. The authors investigated continuous rice cultivation and changes in cropping systems (new paddy fields developed from uplands, continuous uplands, and new uplands developed from paddy soils) and fertilization in South China over the period from 1980 to 2017. A significant increase in soil pH, available phosphorus, and K in all cropping systems was found, although coupled with low fertilizer use efficiency. Additionally, they confirmed that in such environment changes in cropping systems and fertilization are responsible for the dynamics of C and N with consequences on soil quality.

Similar topics were studied also by Šimon and Madaras [14]. They investigated different soil organic C pools and their Fourier-transform infrared (FTIR) spectra in soil samples taken between 2004 and 2017 from 13 field experiments (unfertilized, mineral fertilizer, farmyard manured treatment, and organic and mineral fertilizer treatment) established in different soils and climatic conditions of the Czech Republic. Both organic and combined fertilization significantly increased SOM content and quality in most of

the experiments compared to unfertilized treatments. In contrast, the highest content of recalcitrant aromatic SOM components was determined in unfertilized soils. Their results proved that fertilization regimes increased both labile and total C pools and soil organic C pools. Moreover, FTIR spectral detection had equal sensitivity to the changes, and, overall, none of the investigated parameters or indices tested could be used as a stand-alone to describe soil organic C quality.

This Special Issue provides a comprehensive overview of studies on soil quality and crop nutrition, also offering novel insights into recent advancements in soil management. The 10 papers published in this issue were contributed by researchers across the continents of America, Europe, Asia, and Africa. The guest editors would like to express their sincere gratitude to all the contributors, authors, and reviewers who helped maintain the high research standards in this Special Issue.

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