Editorial

Crop Yield and Soil Quality Are Partners in a Sustainable Agricultural System

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1. Introduction

Agricultural practices involving the excessive use of chemical fertilizers and pesticides pose major risks to the environment and human health. Over the last two decades, great attention has been paid to the development of sustainable eco-friendly agricultural management practices, aiming to improve soil quality and increase crop yields while maintaining environmental sustainability. For this purpose, management practices such as intercropping, crop rotation, precision fertilization, no-till, and chisel plowing are employed, as well as the addition of amendments and the use of plant-growth-promoting rhizobacteria (PGPR), arbuscular mycorrhizal fungi (AMF), endophytes, and biostimulants. This Special Issue contains original contributions detailing cutting-edge research and review articles that help to assess the effect of sustainable agricultural practices on soil quality and plant health. The latter is related to the alleviation of abiotic or biotic stresses that plants undergo.

2. Inoculation with Beneficial Soil Microbes

Most studies dealing with the application of ecofriendly management practices are focused on plant growth and development [1,2], but studies of their effects on soil communities are sparse. Exceptions are the soil bacterial communities that are under extensive investigation due to the development of metagenomics tools. The effects of different inoculants on plant biomass and the indigenous rhizosphere microbial community of *Lactuca sativa* are presented in two studies [3,4]. According to Nikolaidou et al. [3], the inoculation of *L. sativa* roots with *Bacillus subtilis* (PGPR) inhibited the inoculation by *Rhizophagus irregularis* (AMF) at a percentage of 50%, while both inoculants acted competitively to free-living fungi. Compared to relevant studies, the authors mentioned that the negative interactions were due to limitations in soil nutrients (P and K) recorded in this specific soil. However, both inoculants acted synergistically, inducing a positive effect on plant growth. In the same line, Angelina et al. [4] inoculated the roots of *L. sativa* plants with two PGPR species (*B. subtilis*, Gram-positive and *P. fluorescens*, Gram-negative) and developed them in soils of similar soil texture but of different management history: an organic and a conventional cultivated soil. The differences in plant growth were related only to soil management history, while the effect of the inoculants on the communities of the free-living microbes depended on soil history. Distinct rhizosphere microbial communities induced by inoculants were identified only in organically cultivated soil.

3. Intercropping and Organic Farming Effect on Soil Bacteria and Nutrient Stocks

Intercropping increases the productivity per unit of land through better utilization of resources, control of disease, and reduction of soil erosion [5]. Yang et al. [6] examined whether an intercropping system of maize and mushroom had an influence on the soil bacterial diversity, richness, and community structure compared to maize monoculture. Additionally, the effect of intercropping on soil nutrients was considered. Intercropping

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increased soil organic matter and the richness and diversity of the bacterial community but had no effect on the amount of soil-available nitrogen compared to monocultures. Due to these positive effects, the authors suggest that this is a sustainable agricultural practice for the black soil zone in Northeast China.

Relevant to soil quality but mainly concerning the soil nutrient stocks was the study by Brock et al. [7]. Although the use of organic farming is considered an eco-friendly approach if stocking rates in mixed-crop livestock farms are too low (which is very common in farms in Germany), sustainability may be threatened since a declined in C content is recorded [8]. The use of an additive source of carbon such as compost produced by plant residues in the interior of the farms and the fertilization with potassium sulfate (in the case of a potassium-fixing soil) seemed promising. The study showed that the application of compost and fertilizer in farms with low stocking rate compensated the soil organic matter loss and the nutrient exports, increased the productivity of legume plants by mitigating the stress imposed by P deficiency, and facilitated the overall crop production, although it has still remained at moderate levels.

4. Irrigation, Fertilization, and Environmental Conditions Affecting Crop Production

Field production of melon largely depends on the thermal conditions and precipitation during the growing season due to the production of aboveground biomass with a high coefficient of transpiration [9]. However, water soil availability is limited in light soils with low water-holding capacity and nutrient retention. In order to identify the best water and fertility conditions for melon production, Rolbiecki et al. [10] examined the effect of drip irrigation plus nitrogen fertigation on the yield and the nutritional characteristics of fruits of two species of Cucurbitaceae compared to the effects of drip irrigation plus broadcast nitrogen fertilization. The method of drip irrigation–nitrogen fertigation proved to be the most suitable practice for the cultivation of Cucurbitaceae in very light soil in Poland. It increased the total marketable fruit yield by almost 13% and positively influenced the melons' nutritive value by affecting the concentration of total sugars, monosaccharides, ascorbic acid, total carotenoids, and polyphenols.

For the improvement of crop yield under specific environmental conditions, the necessity for studying the interactions between plant genotypes and multienvironmental traits (GEN) is globally recognized. In this line, Katsenios et al. [11] studied the quality and the quantity of grain production in four maize hybrids under different soil environmental conditions. The authors aimed to identify the conditions that are most suitable for maize productivity and whether these were differentiated in relation to maize genotype and/or to the characteristic under consideration (e.g., yield or protein content). The authors found idiosyncratic responses, showing that general rules concerning maize productivity could not be applied. The GEN effect explained a low percentage of the variation and could not lead to the selection of a stable genotype for all environments. However, the authors suggested the division of the region into mega-environments and introduced the most suitable genotype for every environment.

5. Plant Based Nematicides and Zeolites' Amendments

Biostimulants are substances that could be used as biological control agents against plants' pests and diseases. The essential oils (EOs) of aromatic plants are used in many fields because of their antimicrobial, antifungal, antioxidant, and antibacterial activities [12]. The biological activity of EOs is related to their chemical composition, which is influenced by the specific climatic, seasonal, and geographic conditions affecting the aromatic species from which EOs derive [13]. In this line, Ntalli et al. [14] examined in vitro the nematicidal activity of seven Greek Lamiaceae species used as hydrosols or as water extracts against the phytoparasitic nematodes *Meloidogyne javanica* and *M. incognita*. *Meloidogyne incognita*, *M. javanica*, and *M. arenaria* infect *Solanaceae* and *Malvaceae*, have broad host ranges, and are in the list of the most economically damaging root-knot nematodes [15]. The *Origanum vulgare* plant was the one with stronger effects on nematodes'

suppression; nevertheless, applications at high concentrations in pots became phytotoxic for tomato plants. *O. vulgare* seems to be a sustainable solution against nematodes' pathogenicity, and it could be a sustainable solution for essential oil leftovers use. Further, the authors suggested that the preparation and application of this nematicide is quite easy for non-experts (e.g., farmers).

Apart from biostimulants, other amendments could also provide positive impacts on many functions such as plants' metabolism, germination, photosynthesis, and nutrient absorption. Zeolites are naturally occurring, alkaline-hydrated aluminosilicates with a wide range of applications on soil physicochemical variables (water-holding capacity, infiltration rate, cation exchange capacity, hydraulic conductivity) and plants' nutrient use efficiency. Nutrients that are tied to zeolites because of zeolites' structural complexity are released slowly into soil, enabling the synchronization between nutrient release and plant absorption, thus reducing leaching. The improvement of the wide range of agronomic and horticultural crops with respect to growth, yield, and quality traits with the application of zeolites has been well reported by various researchers [16,17]. A literature review of the structure and the applications of zeolite in agriculture is presented by Mondal et al. [18], who recorded a "boost" in relevant studies since 2018.

6. Sustainability in CH₄ Emissions

A sustainable agricultural system must rely on low emissions of gases such as CO₂, NO₂, N₂O, and CH₄, as they are involved in climate change. More specifically, CH₄ has a relatively high global warming potential [19]. The conditions that determined CH₄ emission in boreal and temperate peatlands are not similar to those occurring in tropical peatlands because of differences in environmental factors, peat soil properties, peat temperature, peatland-use practices, vegetation composition and structure, and microbial diversity and population. Since tropical peatlands are commonly used in agriculture, inappropriate drainage may lead to increased CH₄ emissions in these areas. The examination of the changes that the fluctuations in water table imposed on CH₄ emission [20], in different periods of a year, showed that CH₄ emission is a quite complicated process depending on many agents: the microbial CH₄ production and consumption and its transportation by molecular diffusion and by non-microbial processes taking place in peat soils. Water table fluctuations affected emissions, but the emissions in an open field area were significantly lower than in field lysimeters. Due to this inconsistency and the complexity of CH₄ production, the authors proposed more long-term studies to be designed in the future.

7. Land Suitability for Specific Crop Production

Said et al. [21] approached the concept of agricultural sustainability in Egypt by emphasizing land capability. The assessment of land capability depends on the evaluation of the soil quality and expresses the capacity of a soil ecosystem to function in order to sustain crop production in parallel with reduced soil degradation and increased ability to perform a number of soil functions [22,23]. Such an approach integrates soil characteristics, topography, vegetation cover, land use, and climate conditions [24]. The mapping of soils on the Northwestern coast of Egypt in terms of soil fertility, their discrimination in classes by using multivariate analysis, and the fitting between these classes and the needs of specific crops gives valuable information to decision-makers that are involved in the development of the agricultural sector in Egypt.

8. Conclusions

The effects of different management practices even when these are considered "sustainable", they appear quite idiosyncratic and depend on environmental conditions, plant identity, soil fertility, and previous management practices. Although in most cases positive effects on crop productivity were recorded, the effects on microbial soil communities varied. Additionally, these studies revealed the lack of knowledge concerning the effects of biostimulants and biofertilizers on indigenous soil communities' structure and function. However,

to consider an agricultural management system as a sustainable one, both partners (plant and soil) must exhibit an enhanced ability to recover after disturbances such as fire, grazing, climate change, and pesticide application. Advanced knowledge must be developed in this direction.

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