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EDITORIAL

Soils for food security

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Food security is among the most fundamental of national interests and productive farmland is essential for secure grain supply. With the increase of agricultural intensification and the impact of global climate change, the soil in the earth is facing various degradation problems such as compaction, acidification, and salinity. Such soil degradation is usually caused by inadequate or excessive fertilizer input and insufficient litter return to boost soil organic matter, resulting in food insecurity and a need for more sustainable management. Thus, improving soil quality or health is foundational for sustainable crop production, provide greater internal capacity to reduce external input and resistant to environmental changes. As soil is a complex and multicomponent system, the effect of single practices on soil quality are limited and systems engineering by incorporating various innovations and practices to improve soil quality and crop yield is required. Therefore, it is imperative to demand holistic research from multiple disciplines to minimize soil degradation while simultaneously promoting soil health and crop production.

In recent years, China has experienced an alarming scale of loss and deterioration of arable land. The total area of farmland has declined from 135 Mha in 2009 to 128 Mha in 2019, with a 5.6% decrease in only 10 years. Also, more than two thirds of the farmland consist fields producing only low to medium yields as they are affected by various soil degradation problems including compaction, salinization, and acidification. Therefore, protecting or preserving the farmland is an essential task in China to meet the demands of food self-sufficiency. This special issue of 8 articles presents the substantive progress that China has made in remediating soil degradation and improvement of farmland quality. The regenerative solutions for rebuilding fertile soils and developing a framework for improving soil health are discussed.

Saline-alkali land is an important resource in China, and reclamation and quality improvement of saline-alkaline soil can effectively expand land use potential and relieve food pressure, which is vital for increasing food production and ensuring national food security. Wang et al. (https://doi.org/10.15302/J-FASE-2024551) summarize the established principles and technologies of saline soil reclamation to support plant growth such as salt leaching, covering, blocking, ion balance adjustment, and soil fertility improvement. They then introduced the main progress that China has made in saline soil reclamation and utilization, and described the featured technologies in different saline-alkali regions. The advances in research on selecting crops for saline soil were also described, including growing halophytic plants, breeding salt tolerant cultivars, and developing functional microbial inoculants. Finally, the authors analyzed the current problems and challenges faced in efficient exploitation of saline-alkali land, and proposed future directions and prospects.

Soil acidification, particularly accelerated by excessive fertilize application, poses a threat to global food production by reducing crop yield and harming ecosystem health through increased mobility of heavy metals. Wang et al. (https://doi.org/10.15302/J-FASE-2024562) provide a thorough analysis of the processes that contribute to soil acidification, including the use of acidifying fertilizers and the subsequent nitrate leaching, which intensifies the loss of base cations and increases soil acidity. Their paper proposes stage-specific management strategies designed for specific soil pH and conditions.

Intensive agriculture can damage soil structure due to passes of heavy machinery and frequent tillage. A typical phenomenon is soil compaction, with degradation of soil properties and negative impact on crop growth. Long et al. (https://doi.org/10.15302/J-FASE-2024566) review the factors contributing to soil compaction and the negative effects of soil compaction on crop growth. Based on these, the authors proposed the strategies to mitigate soil compaction, in particular the bio-tillage, that is, utilizing crop roots as tillage tools to create biological pores, and enhance soil quality and structure.

Continuous cropping obstacles (CCOs) are some of the most severe problems in intensive agriculture that compromise soil health and reduce crop production by 22% on average. By conducting a meta-analysis, Wang et al. (https://doi.org/10.15302/J-FASE-2024543) systematically analyzed the causes of CCOs including changes of soil physiochemical properties, plant autotoxicity, and destabilization of microbial food web. The authors quantify the incidence of soilborne pathogens in different crops, and the effect of CCOs on crop growth and disease index. In response, comprehensive mitigation measures for CCOs are discussed including accurate fertilizer applications, crop diversification, conservation tillage, and biological control.

Black soils are known for their high fertility and substantial agricultural output, however, they are also prone to degradation, which can lead to significant releases of greenhouse gases. Tong et al. (https://doi.org/10.15302/J-FASE-2024567) use the digital soil mapping techniques to reveal the global distribution of black soils. This mapping provides a clear view of black soil distribution at a country level and the associated agricultural output. Their study addresses environmental challenges to black soils, such as erosion, nutrient depletion, pollution, and compaction, primarily from intensive land use. This detailed mapping underscores the critical role of black soils in sustaining future agricultural productivity and ecological stability.

Quality is the core feature of cultivated land. Chen et al. (https://doi.org/10.15302/J-FASE-2023523) propose a multidimensional framework to assess cultivated land quality, including suitability, contiguity, resistance, and ecological stress. This comprehensive approach helps in understanding the status and agricultural potential of various regions in China. Their study also recommends specific improvement strategies for farmlands ranging from low to high productivity to optimize land use effectively.

Healthy soil is foundational to realizing ecosystem functions and services in supporting human society. Zhang et al. (https://doi.org/10.15302/J-FASE-2024561) provide perspectives on how to construct healthy soil. Using an analogy to human health, it is argued that healthy soil system construction requires the optimization of both dynamic and inherit soil properties. Soil health assessment in China shows that nutrients contents are often in excess whereas biological and physical attributes are negatively affected. Based on these analyses, the authors propose a schematic of the interaction of soil health and resource input in agroecosystems.

It is imperative for farmers to develop and adopt effective regenerative and sustainable practices to rebuild healthy soil as continued soil degradation threatens global food security. Montgomery (https://doi.org/10.15302/J-FASE-2023530) summarizes the history of land degradation and overviews the degraded land area, analyzes the causes of soil degradation, in particular the agricultural practices and human urbanization. He then proposes regenerative solutions such as conservation agriculture, intensive rotational grazing, and agroforestry which should be used to reverse soil solution and build soil health. Overall, soil security is a solid foundation for food security and one of critical challenges that humanity faces over the coming decades.

Dr. Guangzhou Wang, Associate Professor of Plant Nutrition at China Agricultural University, China. His research mainly focuses on the plant–microbe interactions, aiming at exploring the microbial potentials to benefit crops in stressful and competitive situations. He has published 28 peer-reviewed papers in domestic and international high profile journals such as *Nature Communications*, *Ecology Letters*, and *Global Change Biology*. He is currently committee members of both Soil Health Working Group of Soil Science Society of China and the Rhizosphere Nutrition Professional Committee of the Chinese Society of Plant Nutrition and Fertilizer Science. He is also served as a reviewer for *New Phytologist, Journal of Ecology*, *Journal of Applied Ecology*, and others.

Dr. Qichao Zhu, a full-time Associate Professor in the College of Resources and Environment at China Agricultural University since 2020. His research mainly focuses on the quantification, modeling, and mitigation on soil acidification, as well as the interaction with crop productivity, heavy metal pollution, and related environmental impacts. He is also involved in agricultural development strategy consulting research using the tools of mass flow assessment, indicator system comprehensive assessment, and multi-objective optimization on agricultural food system. Over the last 10 years, he has published more than 30 peer-reviewed international papers from his research. He is currently a Young Guest Editor of *Frontiers of Agricultural Science and Engineering*.

Dr. Junling Zhang, Professor of the Department of Plant Nutrition, National Academy of Agriculture Green Development, College of Resources and Environmental Sciences, China Agricultural University. She obtained her PhD from the University of Hohenheim, Germany. Her research focuses on soil health, and in particular she is interested in the biodiversity and function of soil microbial communities. She has been working in understanding aboveground and belowground interactions, in particular how plant–microbial interactions affect nutrient fluxes, plant productivity, and soil fertility. The impact of mycorrhizal fungi on plant growth, productivity and quality, and other ecosystem services is also among her research interest. She has published more than 100 peer-reviewed papers in a number of international SCI-indexed journals.