horticulturae

Editorial

Special Issue "Horticultural Plant Nutrition, Fertilization and Soil Management"

Fernando del Moral Torres [1,2]

1 Department of Agronomy, University of Almería, Ctra. Sacramento s/n, 04120 Almería, Spain; fmoral@ual.es
2 Campus of International Excellence in Agri-Food CEIA3, CIAIMBITAL, Calle Alfonso XIII 13, 14001 Cordoba, Spain

1. Introduction

The world's population is expected to increase from the current 8 billion to 9.7 billion by 2050 and could reach a peak of almost 10.4 billion in the mid-2080s [1]. According to Watson et al. [2], "more than 77% of land (excluding Antarctica) and 87% of the ocean have been modified by the direct effects of human activities".

Therefore, one of the most important challenges for a successful future will be to feed a growing population without increasing the area under cultivation. In order to meet this challenge, we need to intensify crops production, but, to date, the intensification of agricultural systems has generally led to a loss of biodiversity and soil degradation, as observed in different regions with different climates and different types of soils [3–10]. The challenge will thus be to develop sustainable and efficient soil management systems using intensive production models in which soil biodiversity is not affected [11–13]. This will require (i) a correct diagnosis of the agrosystems, considering the socioeconomic context in which they operate, and (ii) the use of restorative practices, based on ecological intensification assumptions [14,15], which involve the use of biological resources, the increased efficacy and efficiency of the agrochemicals used, and the adoption of new forms of management [16–18].

Horticultural production faces these global challenges in changing political, socioeconomic, and climatic scenarios that require the continuous revision of soil management and fertilization techniques. The need to understand the impact of emerging techniques for the recovery of biodiversity and soil ecosystem services and the development and application of biofertilizers specifically designed for this purpose, as well as the reuse of organic residues in circular economy environments and the implementation of new tools and technologies (nano-and bio-technologies), applied to reduce the environmental impact of horticultural cropping systems and to increase efficiency in the uptake and use of nutrients, have led to the publication of this Special Issue, which aims to compile the latest studies in the field of nutrition, fertilization, and soil management in horticultural crops.

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2. An Overview of Published Papers

In their research on the physiological and molecular mechanisms influencing crop response to stress, Kostic et al. (2022) elucidate the dynamics surrounding IRT (iron-regulated transporter) protein expression in tomato (*Solanum lycopersicum*). They highlight a remarkable decrease in IRT expression as the iron concentration in the nutrient solution increases, resulting in iron accumulation in the roots without translocation to the leaves. This phenomenon mitigates the risk of iron toxicity in tomato crops. In contrast, marigold (*Tagetes erecta*), used as a sensitive crop for comparison, demonstrates increased susceptibility to iron toxicity due to its limited ability to downregulate IRT in response to increased iron availability. In addition, this study evaluates the behavior of secondary proteins involved in iron uptake, such as FRO (ferric reduction oxidase) and plasma membrane H^+-ATPase, revealing parallel patterns in both species.

In turn, Zhao et al. (2024) delve into the physiological and molecular mechanisms underlying nitrogen deficiency stress in banana seedlings. Their research provides valuable information on the transcriptional regulatory mechanisms governing banana responses to low-nitrogen stress, facilitating the development of new varieties with improved nutrient utilization capacity.

In the field of improving the effectiveness and efficiency of crop fertilization, Sriraj et al. (2022) investigate the potential of Neem leaf extract as a natural nitrification inhibitor. Their results reveal a concentration-dependent decrease in nitrification ranging from 12.5% to 70% compared to the control. Consequently, there is a noticeable increase in $N\text{-}NH4^{+}$ levels along with a reduction in the levels of $N\text{-}NO_3^{-}$ in the soil, resulting in a decrease in biomass production in treatments using Neem leaf extract.

Beltyukova et al. (2023) further explore iminodisuccinic acid (IDS) as an alternative to EDTA in agricultural practices. Their research shows an accelerated biodegradation rate of IDS (4.5 times faster than EDTA), a superior germination rate with *Raphanus sativus* (2.4–2.6 times higher than EDTA) and lower ecotoxicity against *Daphnia magna* and *Chlorella vulgaris*. These findings position IDS as a promising chelating agent for the application of microelements in plant nutrition.

Ahmed et al. (2023) perform a comparative analysis between the foliar application of Zn and Zn oxide nanoparticles (ZnO-NPs) in tomato crops. Their study demonstrates the superior efficiency of ZnO-NPs over conventional Zn application, particularly highlighting the performance of 100 ppm ZnO-NPs in improving the growth parameters, physiological traits, yield attributes and quality traits of tomatoes under greenhouse soil conditions.

Almutairi et al. (2023) address the use of nanoparticles (Se, Ti and Si) in mango cultivation under drought stress. Their results highlight the positive impact of the external nanoparticle spraying of these micronutrients, improving the growth attributes, yield and fruit quality of mango trees while mitigating the adverse effects of stress conditions. The authors propose optimum concentration levels of each element to maximize efficacy.

Ibanez et al. (2023) provide a comprehensive review of the critical steps involved in the production and marketing of biofertilizers. Their thorough review covers microorganism selection, the exploration of new environmental sources, the extension to field trials, encapsulation techniques, current application systems, and regulatory considerations. In addition, they highlight key stakeholders driving the promotion of biofertilizers as cost-effective and environmentally friendly alternatives to chemical fertilizers.

In this Special Issue, four research teams contribute insights into crop production across diverse agricultural contexts. Tóth et al. (2024) focus on exploring the viability of utilizing recycled agricultural waste in an apple orchard to address critical waste management and agro-ecological challenges, such as declining soil organic matter (SOM) and insufficient soil water and nutrient management. Their study evaluates the impact of various soil conditioners derived from chicken manure, bentonite, and superabsorbent polymers on soil quality indicators.

Trejo-Téllez et al. (2022) delve into the greenhouse production of *Solanum quitoense* (lulo or naranjilla) seedlings, investigating different combinations of organic materials. Their findings suggest that increasing the proportion of sugarcane compost up to 60% in the material mix enhances seedling growth and ensures an optimal plant nutrient status.

Zhang et al. (2023) conduct a comparative analysis of various fertilizer management approaches in winter jujube (*Ziziphus jujuba* Mill.) cultivation. They observe that organic fertilizer application enhances the qualitative aspects of the crop, such as total soluble solid and protein contents, in contrast to sole inorganic fertilizer application. However, they note a trade-off, with total yield decreasing at high rates of mineral fertilizer application. Their conclusion advocates for a balanced approach, combining both fertilizer types to achieve a high fruit yield without compromising quality.

Wambugu et al. (2024) tackle the challenge of poor seed potato quality in Kenya, focusing on the impact of stock solution concentration on minituber quality in hydroponic culture. Their study identifies nitrogen concentration in stock solutions as the primary determinant of minituber quality, highlighting its significant influence on overall seed potato output.

3. Future Research That Should Be Considered

After reviewing the contributions featured in this Special Issue, it is evident that future research avenues merit consideration. Chief among these is the exploration of physiological and molecular mechanisms that influence crop responses to stress, encompassing not only nutritional deficiencies but also crucial adaptations to challenges like drought, elevated temperatures, and salinity levels. This underscores the necessity for investigations into enhancing the efficacy and efficiency of mineral fertilizers, with a particular focus on advancements in nano- or micro-fertilizer technologies. As highlighted by Beltyukova et al. (2023), it becomes imperative to assess the impact of these novel micro-fertilizers on crop yield and quality across diverse production environments, along with their implications for soil microbial communities.

Moreover, the pursuit of superabsorbent polymers and their integration into soil conditioner formulations emerges as another compelling area of interest, especially within the broader context of mitigating the effects of global climate change. Such developments hold significant promise in bolstering the sustainability and productivity of agrosystems.

In the field of biofertilizers, the research trajectory must pivot towards the development of optimized and cost-effective bioformulations that present a tangible alternative to chemical methodologies. New research must focus on understanding the dynamics of microbial communities over time. There is a need to quantify how these communities influence the stability and resilience of ecosystem services, which directly impact crop productivity. In addition, delving into potential synergies or antagonisms between microbial groups is paramount to avoiding inadvertently accelerating one service at the expense of others. Understanding how agricultural practices influence the abundance and composition of these ecosystem service-providing communities is essential for making informed management decisions.

Furthermore, as we move towards new management paradigms, such as carbon farming, there is a pressing need to explore innovative business models that take advantage of carbon credit trading. At the same time, research efforts should deepen the development of nitrification and/or denitrification inhibitors, especially in terms of their association with increased use of fertilizers or organic soil conditioners. Under certain conditions, these practices may inadvertently aggravate greenhouse gas emissions, particularly nitrogen oxides. To mitigate these emissions, it is promising to investigate the potential of irrigation with water saturated with nanobubbles of various gases. This exploration encompasses several facets, such as preventing hypoxic or anoxic soil conditions that favor greenhouse gas emissions, assessing their impact on crop root physiology and soil microbial populations, and elucidating their ability to generate reactive oxygen species and their potential role in controlling soil pathogens. The use of new-generation sensors to monitor the nutritional and water status of the crop and the development of mathematical models for the real-time processing of data will be promising for increasing efficiency in the field of nutrition, fertilization, and soil management in horticultural crops.

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List of Contributions

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