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Davey Jones,
Bangor University, United Kingdom

*CORRESPONDENCE
Renato de Mello Prado
rmprado@fcav.unesp.br

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Editorial: New advances of silicon in the soil-plant system

Renato de Mello Prado[1]*, Krishan K. Verma[2] and Hassan Etesami[3]

[1]Department of Agricultural Production Sciences, São Paulo State University (UNESP), Faculty of Agricultural and Veterinary Sciences, Jaboticabal, Brazil, [2]Sugarcane Research Institute, Guangxi Academy of Agricultural Sciences, Nanning, Guangxi, China, [3]Department of Soil Science, University of Tehran, Tehran, Iran

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Editorial on the Research Topic
New advances of silicon in the soil-plant system

Silicon (Si) is increasingly recognized as a beneficial element that significantly enhances crop growth and productivity, particularly in the face of various abiotic and biotic stresses. Its role in protecting plants under stress conditions, as well as improving overall plant adaptability, has garnered considerable attention from researchers and agronomists alike. Notably, recent studies have demonstrated that Si can provide benefits even in the absence of stress, suggesting its potential to enhance plant nutrition and productivity in a sustainable manner (Prado, 2023; Verma et al., 2023). By mitigating the adverse effects of stress and promoting growth, Si contributes to sustainable agricultural practices that align with the need for environmentally friendly farming solutions (Prado et al., 2024). Nutritional disorders in crops are prevalent across various regions globally, and Si has been shown to enhance tolerance against deficiencies (Alves et al., 2024; Teixeira et al.; Silva et al., 2021; Teixeira et al., 2021) as well as against toxicity (Alves et al., 2023; Sousa Júnior et al., 2022; Barreto et al., 2022). This dual capacity makes Si a critical component for improving plant health and agricultural resilience.

As the impacts of climate change intensify, factors such as drought, salinity, and cold stress pose significant threats to plant vitality. These stressors, compounded by inadequate agricultural practices and the rising costs of fertilizers, highlight the urgent need to adopt strategies that enhance crop productivity while minimizing such challenges, particularly in field crops (Verma et al., 2024). Over the last two decades, there has been a notable increase in interest from the scientific community regarding the role of Si in soil and plant systems. Research findings thus far have been promising, indicating that Si can effectively mitigate various stresses and bolster agricultural resilience in a changing climate, with significant advancements in our understanding of the mechanisms involved in soil-plant interactions.

In this dedicated Research Topic, we have curated a collection of studies that delve into the multifaceted role of Si in enhancing soil-plant dynamics. One significant contribution is the work by Teixeira et al., which focuses on the role of Si in energy cane. Given its potential for renewable energy production, energy cane is crucial for sustainable agricultural practices. However, the study highlights challenges posed by iron deficiency in alkaline soils restricting growth. The authors demonstrate that Si enhances iron absorption, thereby improving nutritional efficiency and photosynthesis, ultimately leading to increased biomass production. The research suggests that Si can be strategically utilized to bolster growth and nutrition in energy cane, particularly in iron-deficient environments.

Water deficit is another critical stress impacting food security, compromising essential physiological and biochemical processes in plants. The study by Saja-Garbarz et al. explores how Si regulates water absorption in rapeseed roots facing drought stress and identifies the antioxidant components involved in combating stress-induced reactive oxygen species (ROS) generation. Their findings indicate that Si not only improves water balance in rapeseed under drought conditions but also enhances catalase activity, thereby reducing oxidative stress in the roots.

Further expanding the narrative on Si's benefits, research has also investigated its application in field crops that do not naturally accumulate this element, such as common beans. According to Teixeira et al., Si supplementation in irrigated common bean systems improves water use efficiency while simultaneously enhancing nutritional uptake, thus increasing the species' tolerance to water-limited environments. Their recommendations for applying stabilized sodium silicate in varying irrigation conditions (6 kg/ha, 7 kg/ha, and 8 kg/ha for adequate, moderate, and severe water deficits, respectively) provide a practical framework for optimizing crop management strategies.

The role of the soil microbiome in supporting agricultural ecosystems cannot be understated, as it influences processes such as organic matter decomposition, nutrient cycling, and plant growth promotion. Environmental stresses, however, often disrupt this sensitive balance. Etesami conducts a comprehensive review addressing how Si can enhance the resilience of the soil microbiome. The author discusses several mechanisms by which Si fosters microbiome stability, including improvement in soil pH, enhancement of nutrient and water availability, alteration of root exudation patterns, and stimulation of key microbial groups' abundance and diversity. This insight underscores Si's potential to contribute to the sustainability and productivity of agricultural systems while maintaining soil health.

In summary, Si emerges as a pivotal element in enhancing plant resilience and productivity, particularly in the context of stress conditions exacerbated by climate change. The studies compiled in the Research Topic showcase Si's multifaceted roles in various crops and highlight its potential applications for improving agricultural practices. As we look toward the future, several key areas warrant further exploration:

More in-depth research is needed to elucidate the specific physiological and biochemical pathways through which Si exerts its effects on different crops under various environmental conditions. Large-scale field trials assessing the efficacy of Si applications across diverse cropping systems and stress conditions will help validate laboratory findings and facilitate the integration of Si into practical agricultural practices. Investigating the interactions between Si and soil microbiota will deepen our understanding of how Si can enhance soil health and promote beneficial microbial communities. Research aimed at identifying and developing crop varieties with enhanced Si uptake and utilization will be essential for maximizing the benefits of this element. Exploring the synergistic effects of Si with organic amendments or other biostimulants can lead to the development of more sustainable and environmentally friendly agricultural practices. By pursuing these avenues of research, we can unlock the full potential of Si in the soil-plant system, contributing to enhanced food security and sustainable agricultural practices in an increasingly challenging global landscape.

Author contributions

RP: Writing – original draft, Writing – review & editing. KV: Writing – review & editing. HE: Writing – review & editing.

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