Chapter 13
Summary and Perspectives

13.1 Summary

Chapters in this book summarize the current knowledge inherent to the importance of Si nutrition for plant growth and development, resistance to biotic and abiotic stress and yield production and quality. The readers should refer to the individual chapters for information on past, current and future research linking Si with soils, plants and fertilizers. In general, the chapters are closely connected thereby offering a comprehensive discussion about the specific topics while avoiding repetition.

The first chapter addresses the most important historical points and general introduction to Si research worldwide. Chapter 2 critically reviews the current analytical methods used for determination of Si in a wide variety of materials including soils, plants and fertilizers. Chapter 3 is more soil oriented and includes environmental chemistry of Si and its bioavailability for crops. Chapter 4 provides an overview of Si uptake and transport by higher plants highlighting the most recent achievements in cloning and characterization of different types of Si transporter in different plant species and plant tissues. Chapters 5, 6, 7, and 8 cover the broad issue of the complex role of Si in enhancing plant resistance and/or tolerance to abiotic stresses (e.g. mineral excess and nutrient deficiency, salinity, drought, low temperature, UV radiation and flooding) and suggest the possible mechanisms of Si-mediated antioxidative defence in plants. Chapters 9 and 10 review the role of Si against biotic stress in plants, focusing on physical, biochemical and molecular components of Si-mediated plant defence and priming. Chapter 11 deals with the effect of Si on growth, development, biomass production and yield quality of a wide range of crops. Chapter 12 examines the sources of Si in agriculture focusing on the manufacturing and application of the commercially most important environmentally friendly silicate fertilizers.

Y. Liang et al., *Silicon in Agriculture*, DOI 10.1007/978-94-017-9978-2_13

13.2 Perspectives

Recent advancements concerning uptake, transport and accumulation of Si in higher plants have broadened our understanding of the beneficial effects of this element. Accordingly, it is now well established that Si accumulation in plants is attributed to an effective uptake system mediated not only by passive diffusion but also by specific transporters. Although the regulation of the expression level of Lsi transporters has been clearly elucidated in high (e.g. rice, barley and maize) and moderate (e.g. pumpkin and soybean) Si-accumulating species, the whole picture of how these genes are regulated in many other agronomically important crop species and cultivars, and in Si-excluding species in particular, remains to be further elucidated. The work on cloning of genes involved in Si uptake and transport from other crop species should be continued with special focus on the identification and characterization of novel Si transporters.

Silicon supply and its subsequent accumulation in plants could be exploited as a strategy to improve crop health and productivity in stressful environments. However, little information is available on the response of Si transporters to plant stresses. More investigations are therefore needed to establish whether there is a relationship between Si transporters and the benefits of Si to plants subjected to multiple stresses. Finally, a comprehensive understanding of Si transport is important to draw novel breeding and sustainable crop management strategies to enhance productivity of crops growing under ever-increasingly stressful environmental conditions as a consequence of global climate change.

Recent studies have revealed the active role of Si in priming plants for a better defence response against biotic stress possibly through SA, JA, ethylene and/or ROS signalling pathways. However, whether and how Si acts as a secondary messenger in priming plants in response to biotic and perhaps abiotic stresses is still uncertain. Moreover, information is still scant on the metabolically active roles of Si in plants under abiotic stress conditions, particularly on the molecular aspects of Si-mediated nutrient and water use efficiency.

Combining different state-of-the-art analytical techniques (e.g. ICP-MS, XPS, AFM), He et al. (2013, 2015) have recently demonstrated that most of Si is naturally present in the cell walls as Si-hemicellulose complex rather than intra- or extracellular silica deposits. Therefore, such organic matrix-bound Si may play a significant role in maintaining cellular integrity and structure of the walls, thereby shedding more light on the biochemical and structural role of Si in preserving cell shape and mechanical properties as well as in defence against abiotic and biotic stress. On the other hand, the essentiality of Si for higher plants has not been confirmed yet. One of the main reasons is that a Si-free environment cannot be created currently due to technical problems as Si contamination from purified water, chemicals and dust cannot be avoided. It seems to suggest that progress in research on Si nutrition depends on the adoption of the cutting-edge technologies and advanced instruments.

Overall, further research directions should focus on accumulating more convincing evidence to unveil the molecular mechanisms of Si involved in plant resistance or tolerance to biotic and abiotic stresses as well as in the regulation of sensing, signal transduction pathways and gene expression involved in biosynthesis of key compounds related to plant growth.

References

He CW, Wang LJ, Liu J, Liu X, Li XL, Ma J, Lin YJ, Xu FS. Evidence for 'silicon' within the cell walls of suspension-cultured rice cells. New Phytol. 2013;200:700–9.

He CW, Ma J, Wang LJ. A hemicellulose-bound form of silicon with potential to improve the mechanical properties and regeneration of the cell wall of rice. New Phytol. 2015;206:1051–62