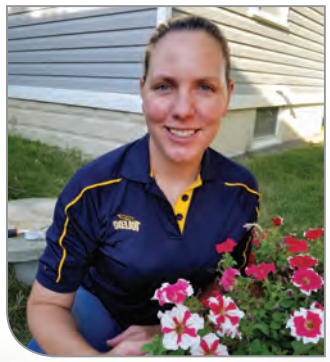
BY PETER KONJOIAN AND WENDY ZELLNER

Silicon Nutrition: Misconceptions and Advancing Knowledge



Peter Konjoian is president of Konjoian's Horticulture Education Services Inc. His career spans four decades as a commercial grower, researcher and consultant. Wendy Zellner is a research associate professor at the University of Toledo. Konjoian can be reached at peterkfes@comcast.net.

Joining me is Wendy Zellner, research associate professor at the University of Toledo. Wendy received her Ph.D. from the University of Toledo in 2012 with a focus in cellular and molecular biology. She was then hired as a postdoctoral research plant physiologist with the USDA-Agriculture Research Services, where she secured industry funding for her research. Following the postdoctoral position, she returned to the University of Toledo to continue her work in understanding silicon as a plant nutrient at the cellular level.

Peter: Wendy, you've described several misconceptions to me that need to be explained to better understand the benefit silicon has on crop performance. Please correct the record regarding our knowledge of this element.

Wendy: Three main misconceptions when it comes to silicon are:

1. Silicon is only a nutrient for certain plants.
2. All silicon fertilizers or sources are similar in providing the nutrient to plants.
3. A high concentration of silicon is needed to have an effect.

To begin, all plants benefit from silicon. A small group of plants contain high concentrations of silicon in their leaves (mainly grains and grasses, some cucurbits and an even smaller number of floriculture plants, such as zinnia and sunflower). Most plants have low concentrations of silicon in their leaves relative to the grains, but, in the presence of silicon, they still grow better when challenged with disease or environmental stress (droughts, floods, heat waves, frosts and nutrient imbalances).

Peter: Time out, please. Most commercial growers are familiar with the phrase "essential element" or "essential nutrient" when discussing plant nutrition. You state that all plants benefit from silicon, but do they require it to complete their life cycle? Is it an essential element or more of a complementary nutrient?

Wendy: Currently, we are not able to completely rid a growing system of silicon, so we are not able to fully understand what role (if any) silicon has for developmental processes, such as reproduction. Based on the current definition for an essential nutrient, silicon can not be deemed essential or nonessential. Bloom and Epstein tried to address this by adjusting the definition of essentiality in 2005; however, some researchers, even in the silicon field, still refute silicon's essentiality in most plants.

Prior to the 1940s, the necessity of silicon for plants was well known and the use of silicon-containing materials was common for certain plants, such as sugar beets. As our agricultural lands have been overworked, this single nutrient has not been incorporated back into the growing systems and thus leaves the plants more susceptible to disease and environmental stress.

Peter: I'd say thanks for that clarification Wendy, but it sounds like we still have a lot to learn before we can definitively state whether it's essential or not. Perhaps it's best, for now, to think in terms of theory versus practice. In theory we haven't proven that silicon is an essential nutrient, but in practice your statement that all plants benefit from silicon can guide us. Let's move on to the next misconception.

Wendy: Secondly, not all silicon fertilizers labeled for sale in the U.S. contain the proper form of plant-available silicon, and even materials from the same process or source (i.e., industrial slag or mined minerals such as azomite) can vary greatly in their silicon content and availability. For instance, I just finished a study looking at two azomite sources and found that one had a relatively high concentration of plant-available silicon, while the other had almost none. The labeling and testing of domestic silicon-containing fertilizers is still being developed and can be confusing for the end user.

Peter: Growers are quite adept at sifting through product categories with the help of reputable manufacturers and other trusted sources to find high quality and ignore poor. Coconut coir products come to mind; quality coir products are leached to remove salts while cheap products are not.

With this misconception in mind, have you done enough research to tell growers what types of silicon products they should look for and which types they should avoid? Can you say with confidence that if a grower has tried a silicon product and not seen its touted benefits that it could have been the product and not her or his growing practices?

Wendy: That is a difficult question to answer. The most pronounced effects of silicon are seen when stress is present. If the grower did not experience any issues that growing season, there would be no visual differences between the silicon-fed and non-treated plants. In addition, there were products in the past that supplied little-to-no plant available silicon. These types of products use data from silicon research to make unsubstantiated claims about the benefits of using their fertilizers. I would

suggest talking with other growers, researchers and/or consultants when researching a product to see how well it has worked for them in their growing practices. If a product does not work to your satisfaction, I would try another.

Peter: I have heard it stated that because glass contains silicon it shouldn't be used in the laboratory for analyses of growing media and plant tissue. Any truth to this and, if so, how are labs conducting their analyses?

Wendy: That is correct. When labs analyze for silicon, all material and digestion solutions are made, mixed and maintained in plasticware to avoid contamination from the glass bottles. In my studies, I've found that even when we grow plants with ultra-purified water, we still have a significant amount of silicon that can be detected in leaves and roots of the control plants. This shows how well plants can accumulate trace amounts of the nutrient from their environment to concentrate in specific tissue.

Peter: Your last misconception deals with the amount of silicon needed by plants to yield benefits. How is our knowledge advancing on this front?

Wendy: It has been assumed that high concentrations of silicon application will lead to more protection. My research has shown that values as low as 30-ppm silicon were able to protect plants. Most fertilizers are recommended at rates of 100 ppm or higher (some foliar products suggest using silicon at 1,000 ppm). High silicon concentrations can lead to nutrient deficiencies in plants grown in already deficient environments or media.

Peter: You mentioned that agricultural soils are being overworked and silicon levels are being depleted. What about greenhouse and indoor hydroponic production, how should silicon be managed in these systems?

Wendy: Peat and other soilless media components lack the parent material that contributes appreciable amounts of silicon to the growing plants. Hydroponics, in the case of deep water or nutrient film technology, provide even less silicon. Incorporation of the correct silicon fertilizer to these programs will likely help reduce mildews, insects and other abiotic stress that might be encountered in an enclosed growing environment.

Peter: What objectives are you currently studying in your silicon research program?

Wendy: Currently, I am researching the release rates of silicon from a wide variety of silicon fertilizers available here in the U.S. as well as a few products from the U.K. Figure 1 shows tomatoes subjected to salt stress and the beneficial effect

Figure 1. Basil plants subjected to salt stress; top is control, bottom is silicon treated.

silicon had on their health. In addition, I am using my cellular and molecular background to try and identify proteins and enzymes that directly interact with silicon in order to provide evidence of the nutrient's essentiality in plants. We also continue to show the benefits of silicon in low foliar accumulator species to both diseases and environmental stress that includes heavy metals and drought tolerance.

Peter: Concluding, you've debunked misconceptions about silicon's effect on crop production and helped us understand how this topic of plant nutrition is advancing. Please leave us with a couple practical suggestions on how growers can begin capitalizing on our current level of understanding of silicon and start using it to increase their profitability.

Wendy: Growers can rest assured that researchers have shown silicon's ability to protect plants. My best advice would be to just start using it in their growing practice. I would suggest trying products side by side to determine what type works best in their conditions and which gives the best results. Like any trial, don't use plants that can withstand stress and pressure, use those that are harder to grow or more susceptible to mildews or insects. These will give a better indication if silicon-addition will benefit their growing system. If those products don't work, talk with others who have used them to see if they have suggestions. The more information we share with one another, the more we will be able to understand how to take advantage of this stress-fighting nutrient.

Lastly, one of the amazing things about silicon is that you can never add too much for the plants. For instance, if different varieties of a crop are being grown and some have a higher requirement for silicon than others, all plants can be treated with a higher dose without having to worry about any toxicity in the lower accumulating plants.

Since silicon is naturally abundant on earth, plants have evolved elaborate mechanisms to ensure regulation of the nutrient into and throughout the plant at specific times in their life cycle. This means that there are no silicon-toxicity levels. However, too much soluble-silicon in the growing medium can chelate out other nutrients, such as zinc, and lead to nutrient deficiencies, which has been reported when exceptionally high concentrations of silicon were supplied as weekly drenches. As long as we stay within the recommended rates of the product, this should never be seen.

Peter: Thank you Wendy, we appreciate you sharing your extensive silicon experience with us. gpn