From Forest Nursery Notes, Summer 2011

43. Impact of silicon on plant growth. Cavins, T., Marek, S., and Kamenidou, S. Greenhouse Management and Production 30(6):20-25. 2010.

Fertilization

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Impact of SILICON on plant growth

Silicon has the potential to be used in the production of floriculture crops to increase flower and stem size, accelerate flowering and improve resistance to stresses including drought.

Ever wonder why plants sometime seem to grow better in the ground than in a container? There are a lot of things that contribute to the growth differences, but we decided to investigate whether nutrient levels played a role.

When comparing a field soil to a greenhouse substrate, there is a notable difference in the level of some nutrients. One of these nutrients is silicon so we looked at the effects this minor element might have on floriculture plants if it was added to a greenhouse substrate.

Silicon (Si) is a non-essential nutrient for most plants. However, in field crops it is known to affect plant growth and quality, photosynthesis, transpiration and enhance plant resistance to stresses such as drought. In floriculture production, most plants are grown in soilless substrates consisting primarily of peat moss or pine bark. In these substrates the silicon concentration is limited and its supplementation might be beneficial.

Growth enhancement

We conducted a series of studies to determine if supplemental silicon has a place in greenhouse production. Our first study included the cut flowers *Zinnia elegans* 'Oklahoma Formula Mix', *Helianthus annuus* 'Ring of Fire' and Gerbera 'Acapella'. Various concentrations of silicon were incorporated into a peat-based substrate using a potassium silicate powder ($KSiO_3$); rice hull ash, which is a natural by-product with

Increased stem diameter of *Helianthus annuus* with silicon supplementation. Potassium silicate powder incorporated into the growing medium (right) vs. silicon untreated plant (left).

high silicon content (20 percent SiO_2); or five weekly substrate drenches of soluble potassium silicate ($KSiO_3$). Five weekly foliar applications of sodium silicate (Na_2SiO_3) were also made until runoff (Table 1).

The silicon concentration increased in all plant species that received supplemental silicon treatments. Table 1 shows the increase in silicon concentrations in helianthus leaf tissue along with the increase in stem diameter. The silicon concentration and deposition in plant tissue (leaf versus stem and flower) varied among species indicating that different species may take up different amounts of silicon. Also, silicon deposition varies in different plant tissues. Depending on silicon source and rate, several plant traits improved when supplemental silicon was applied.

Thick straight stems were evident with helianthus and zinnia. In gerbera, flower diameter increased with sodium silicate foliar sprays. Early flowering occurred with optimum silicon treatments along with increased flower quality compared to untreated controls for each of the species.

Table 1. Sources and rates of silicon applied to *Helianthus annuus* and silicon tissue concentration.

Silicon source	Application method	Silicon rate	Silicon applied (mg/pot)	Leaf	Silicon concentration (ppm)_Stem	Flower	Apical stem diameter (mm)
None	None	0	0	4,294	2,839	3,156	6.1
g/m							
Rice hulls 20% SiO	Media Incorporation	33 66 100	50 100 150	4,904 5,603* 6,723*	3,050* 3,125* 3,276*	3,773 3,898* 4,361*	6.3 6.3 6.9*
KSiO flakes	Media Incorporation	70 140 280	100 200 400	7,016** 6,627** 6,503**	3,379** 3,339** 3,339**	4,023* 4,013* 4,316**	6.6 7.1** 7.6**
mg/L							
KSiO	5 weekly drenches	50 100 200	75 150 300	11110** 12616** 15397**	2,978 3,741** 4,224**	4,300** 4,254** 5,058**	7.1** 7.1** 8.4**

Values with * were deemed as a significant increase versus the control by statistical analysis.

Silicon rate recommendations

One of the keys to being able to make silicon application recommendations is to establish sufficient substrate and plant silicon tissue levels. Guidelines for acceptable tissue and substrate levels are not yet established for floriculture crops.

Helianthus annuus 'Ring of Fire' was used to investigate the relationship of silicon tissue and substrate content. Rice hull ash, $KSiO_3$ weekly drenches and $KSiO_3$ flake substrate incorporation were used as silicon sources (Table 2). Results were similar to the first study. Plants exhibited increased flower and stem diameter and increased stem dry weight when they received supplemental silicon.

A positive correlation between leaf silicon concentration and saturated media extract soilless substrate samples was observed. The correlation indicates the potential for using leaf samples to establish acceptable silicon concentrations for soilless floriculture crop production. Leaf tissue values of silicon that correspond with optimum plant performance are listed in Table 2.

Reducing transpiration

Other aspects of silicon fertilization that have gained interest are increased drought resistance and increased flower diameter. A potential cause for both of these benefits is the reduction in water lost by plants through evapotranspiration. Reduction of transpiration rate (or increase of leaf resistance) has been attributed to silicon. Most silicon studies have used agricultural crops and the effects were accelerated with increased environmental stresses like drought and metal toxicity.

Reduction of the transpiration rate could further benefit floriculture crop

Table 2. Silicon source and concentrations applied to *Helianthus annuus* and the correlation factor when comparing to saturated media extract values.

Silicon source	Application method	Silicon rate mg/L	Silicon applied (mg/pot)	Leaf silicon concentration (ppm)	Saturated media extract concentration
KSiO	5 weekly drenches	0 25 50 75	0 37.5 75 112.5	4,253 4,816 5,208 5,882	30 33 33 66
KSiO Flakes	Media incorporation	0 140 190 240	0 200 270 340	4,253 5,015 5,663 5,859	30 54 62 43
Rice hulls 20% SiO	Media incorporation	0 90 130 170	0 135 195 255	4,253 4,638 4,561 5,829	30 33 42 43

r=0.75

production. We conducted a study on the effect of supplemental silicon on stomatal conductance, which is the mechanism plants use to open and close "water vapor" valves. Under normal greenhouse conditions, leaf resistance (reduction of transpiration) increased with a high rate of sodium silicate foliar sprays. This study didn't support an active role of silicon in stomata movement but there is an indication that sodium silicate foliar spray applications can act as a film-forming anti-transpirant that increases leaf resistance.

Further research

The results of studies on the physical aspects related to silicon supplementation are encouraging. We continue to explore optimum rates as high rates of many silicon sources can cause nutrient imbalances and a substrate pH shift. However, by using moderate rates growth enhancements were still achieved and no issues with growth and development were observed.

Because of the alkaline nature of many silicon supplements, it is not recommended to mix soluble forms with fertilizer solutions as the resulting high pH will likely cause precipitation of nutrients. The rates of silicon supplements used in our studies did not have any dramatic or residual effects on substrate pH. However, if growing conditions exist with high alkaline water or high limestone rates in the substrate then issues could arise.

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Sodium silicate foliar sprays at 50 milligrams per liter silicon increased flower diameter and height of gerbera (right in both photos) compared to silicon-untreated plants (left).

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Photo by David Kuack

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Greenhouse Management & Production, formerly GMPro, (USPS 013549) is published monthly. One-year subscription rates: Free to qualified retailers in the United States. Non-Qualified U.S. subscriptions are $96 in the United States; $120 for delivery outside the U.S.; U.S. funds drawn on a U.S. bank required for all foreign subscriptions. Single copy rate: $8. plus postage while supplies last. Periodicals postage paid at Richfield, Ohio, and additional mailing offices. Postmaster: Send address changes to **Greenhouse Management & Production**, 4020 Kinross Lakes Parkway, Suite 201, Richfield, Ohio 44286. Canada Post: Publications Mail Agreement #40612608. Canada Returns to be sent to Bleuchip International, P.O. Box 25542, London, ON N6C 6B2