# Detection, Distribution, and Quantification of Silicon in Floriculture Crops Utilizing Three Distinct Analytical Methods

Silicon (Si) is not considered an essential plant nutrient, as most plant species can complete their life cycle without its presence. The presence of Si in plants has been shown to improve dry mass and yield, enhance pollination, and increase disease resistance. Si can have beneficial effects when not taken up in appreciable amounts, such as a reduced incidence of micronutrient and metal toxicity. Little is known about how silicon may benefit floriculture crop production. Further study of the benefits of Si in plants requires reliable methods of detection and quantification. Several of these methods were examined for their effectiveness.

**Electron Beam Analysis**

Electron beam analysis (EBA) is the use of scanning electron microscopy with energy dispersive X-ray analysis. EBA is a relatively expensive method and not readily available to most laboratories. EBA is an effective tool for detecting the presence of Si and determining its location in the plant, but is unable to quantify the Si. EBA requires a high tissue concentration (200 to 300 mg $kg^{-1}$) to easily locate deposits, making this method only useful for species that accumulate significant amounts of Si (Fig. 1). Occasionally there will be no difference in the surface features of plants with Si and those without, making it more difficult to localize the silicon with in the plant. Failure to locate Si using this technique does not necessarily indicate lack of Si uptake by that plant because of the localized nature of detection.

Figure 1.Scanning electron micrograph (top) and the corresponding spectrograph (bottom) of verbena trichomes with Si treatment.

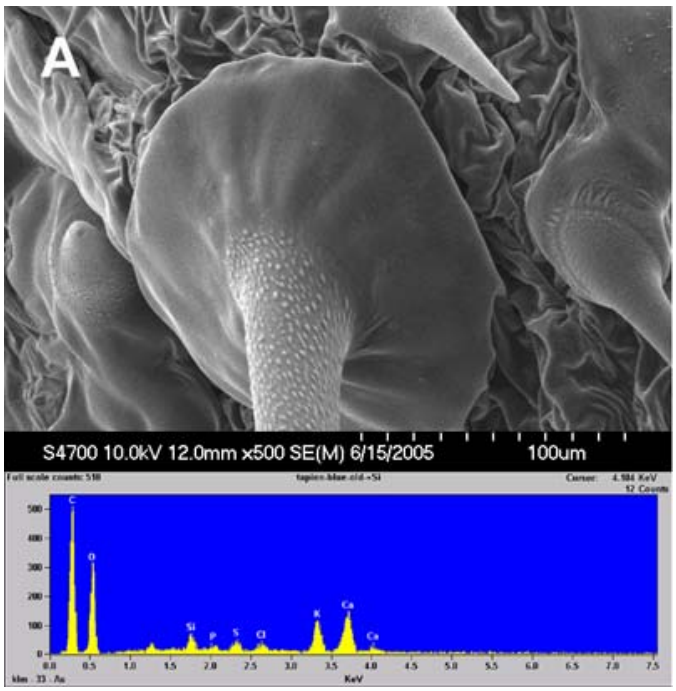


Table 1.Si detection, distribution, and concentration in mature verbena leaves using EBA, ICP-OES, and colorimetry methods.

| EBA | | ICP-OES | Colorimetric |
|---|---|---|---|
| Si Detected | Location | Leaf Si Content +Si (mg $kg^{-1}$) | Leaf Si Content +Si (mg $kg^{-1}$) |
| Yes | Leaf trichomes & margins | 8417.0 | 8225.5 |

**Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES)**

The ICP-OES method originally called for plant material to be digested either in sodium hydroxide (NaOH) or hydrofluoric acid (HF). The use of HF is hazardous, and NaOH use resulted in frequent replacement of microwave digestion tubes ($250 to $500 each) and ICP-OES torches ($350 to $500). To avoid these issues, a new method of digestion was developed. It was determined that potassium hydroxide (KOH) would minimize the damage to the digestion tubes and ICP-OES torch. Thorough testing of this method validated its effectiveness in quantifying tissue Si. Readings were within 80 mg $kg^{-1}$ of the standard (4400 mg $kg^{-1}$).

**Colorimetry**

The use of colorimetry (reacting agents to produce a color that corresponds with the concentration of the substance of interest) is a well established, inexpensive technique for quantifying Si and other elements in plant tissue. In a multi-step process, plant tissue is digested and mixed with reagents to produce a blue solution that is then measured for absorbance at 650nm. The absorbance of the mixture is then compared against a standard calibration curve of known Si concentrations previously prepared with the same method. This method yielded similar Si concentrations to those of the ICP-OES method. Only three species deviated substantially between these two quantification methods.

As the use of Si to assist in alleviating biotic and abiotic stresses increases; reliable methods for detecting the presence, distribution, and quantity of Si in plants are becoming more important. The EBA method is a reliable tool for localization of Si, but requires a high tissue concentration and expensive equipment to do so. The ICP-OES and colorimetric methods are two viable quantification techniques for Si in plants that yield similar results. While the colorimetric method is the less expensive method of the two, the ICP-OES method had less variance in its data and allowed for more automation in its performance.

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