Exploring the Mechanisms Involved in Silicon-Mediated Resistance to Herbivorous Insects and Plant Pathogens.

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PEPS 410

Sustainable Plant & Soil Health Management

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Introduction

HAWAI'I Neotropica GROWN WITH ALOHA

NEOTROPICA
HAWAII TROPICAL FLOWER + PLANT GUIDE

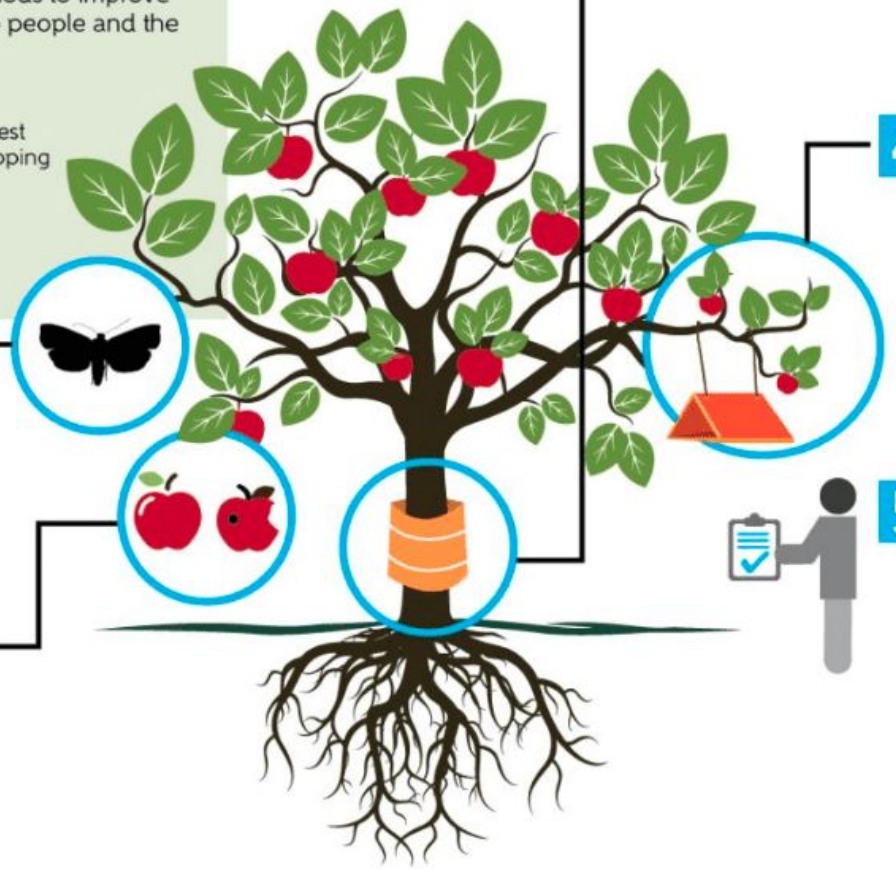
Integrated Pest Management

What is IPM?

Integrated Pest Management is a science-based approach that combines a variety of techniques. By studying their life cycles and how pests interact with the environment, IPM professionals can manage pests with the most current methods to improve management, lower costs, and reduce risks to people and the environment.

IPM tools include:

- Alter surroundings
- Add beneficial insects/ organisms
- Grow plants that resist pests
- Disrupt development of pest
- Prevention of pest problem developing
- Disrupt insect behaviors
- Use pesticides



1 IDENTIFY/ MONITOR

Determine the causal agent and its abundance (contact your local extension agent for help).

2 EVALUATE

The results from monitoring will help to answer the questions: Is the pest causing damage? Do we need to act? As pest numbers increase toward the economic threshold further treatments may be necessary.

3 PREVENT

Some pest problems can be prevented by using resistant plants, planting early, rotating crops, using barriers against climbing pests, sanitation, and sealing cracks in buildings.

4 ACTION

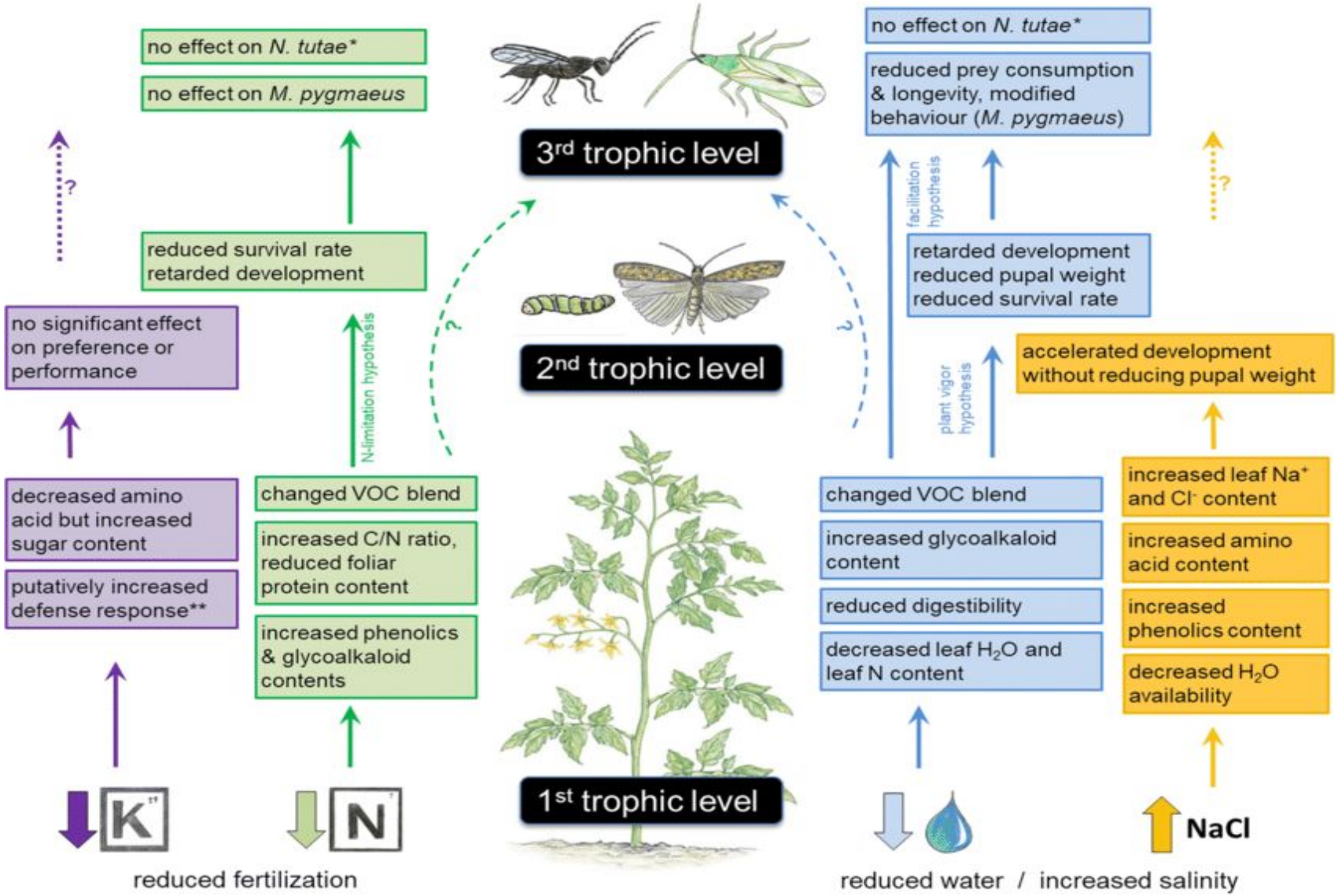
IPM uses multiple tools to reduce pests below an economically damaging level. A careful selection of preventive and curative treatments will reduce reliance on any one tactic and increase likelihood of success.

5 MONITOR

Continue to monitor the pest population. If it remains low or decreases, further treatments may not be necessary, but if it increases and exceeds the action threshold, another IPM tool should be used.

https://piedmontmastergardeners.org/article/integrated-pest-management/

Bottom-Up Strategies



(Han, P., Desneux, N., Becker, C. *et al.* 2019). https://doi.org/10.1007/s10340-018-1066-x

Photo by Joanna Bloese

Product: Mainstay Si by Redox

GUARANTEED ANALYSIS

Calcium (Ca).....10%
Also contains non-plant food ingredient
Silicon Dioxide (SiO_2).....22%

WHY MainstaySi?

CALCIUM & SILICON NUTRITION

Mainstay Si is specifically formulated to provide efficient calcium and silicon nutrition. Silicon enhances the proper uptake and organization of calcium for cell wall structure.

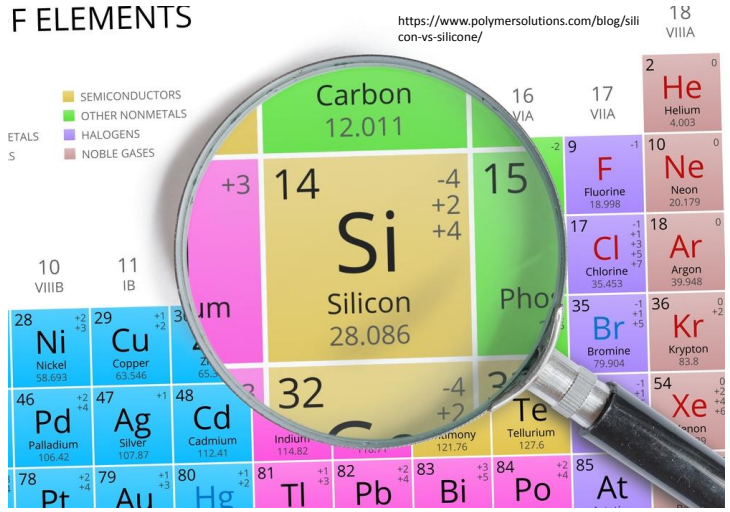
ABIOTIC STRESS DEFENSE

Lack of calcium and silicon nutrition leads to abiotic stress and cell wall degradation. **Mainstay Si** is unique in its ability to improve Abiotic Stress Defense and increase cell wall strength.

PRODUCT USAGE

Abiotic Stress Defense	Apply 0.5-3 gals./acre as a soil application or 0.25-1.5 gals./acre as a foliar application during early-season cell division/development. Repeat every 1 to 2 weeks.
Plant Nutrition	Apply 0.5-3 gals./acre as a soil application or 0.125-1.5 gals./acre as a foliar application during the growing season. Repeat every 1 to 2 weeks.
Fruit Firmness	Apply 0.5-3 gals./acre as a soil application or 0.25-1.5 gals./acre as a foliar application during early-season cell division/development. Repeat every 1 to 2 weeks.
Cell Wall Strength	Apply 0.5-3 gals./acre as a soil application or 0.125-1.5 gals./acre as a foliar application during early-season cell division/development. Repeat every 1 to 2 weeks.
Drought Stress	Apply 0.25-0.5 gals./acre as a soil application or 0.25-1.5 gals./acre as a foliar application during periods of reduced water availability and higher temperatures. Repeat every 1 to 2 weeks.

https://waterdamagerestorations.org/small-leaf-mold-polymer-clay-mold-pmc-mold-glass-mold-craft-mold-embellishment-silicone-mold/



https://www.qsiquartz.com/properties-fused-silica/

Different Formulations of Silicon Fertilizers

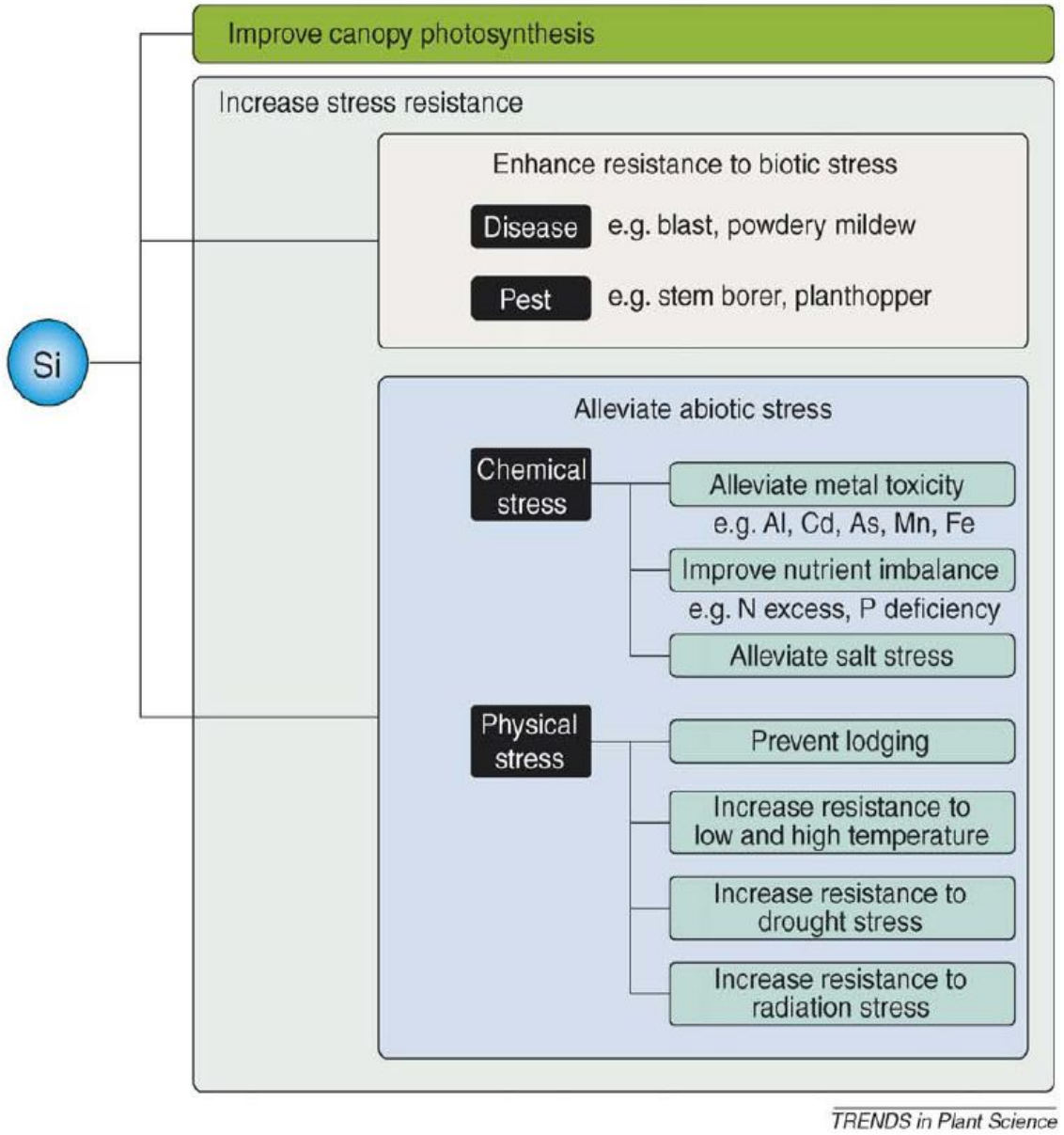
Silicon sources:

- Calcium Silicate ($CaSiO_3$)
- Sodium Silicate (Na2SiO3)
- Rice hull ash (soil amendment)
- Fly ash (soil amendment)
- Potassium Silicate (K2SiO3)

- Silicic acid, $Si(OH)_4$, is the bioavailable form of silicon in soil solution that is taken up by plant roots

History of Silicon

- Silicon (Si) is the second most abundant element after oxygen in soil.
- Silicon dioxide comprises 50–70% of the soil mass.
- As a consequence, most plants rooting in soil contain some Si in their tissues.
- Silicon can provide many benefits in mediating plant stress.



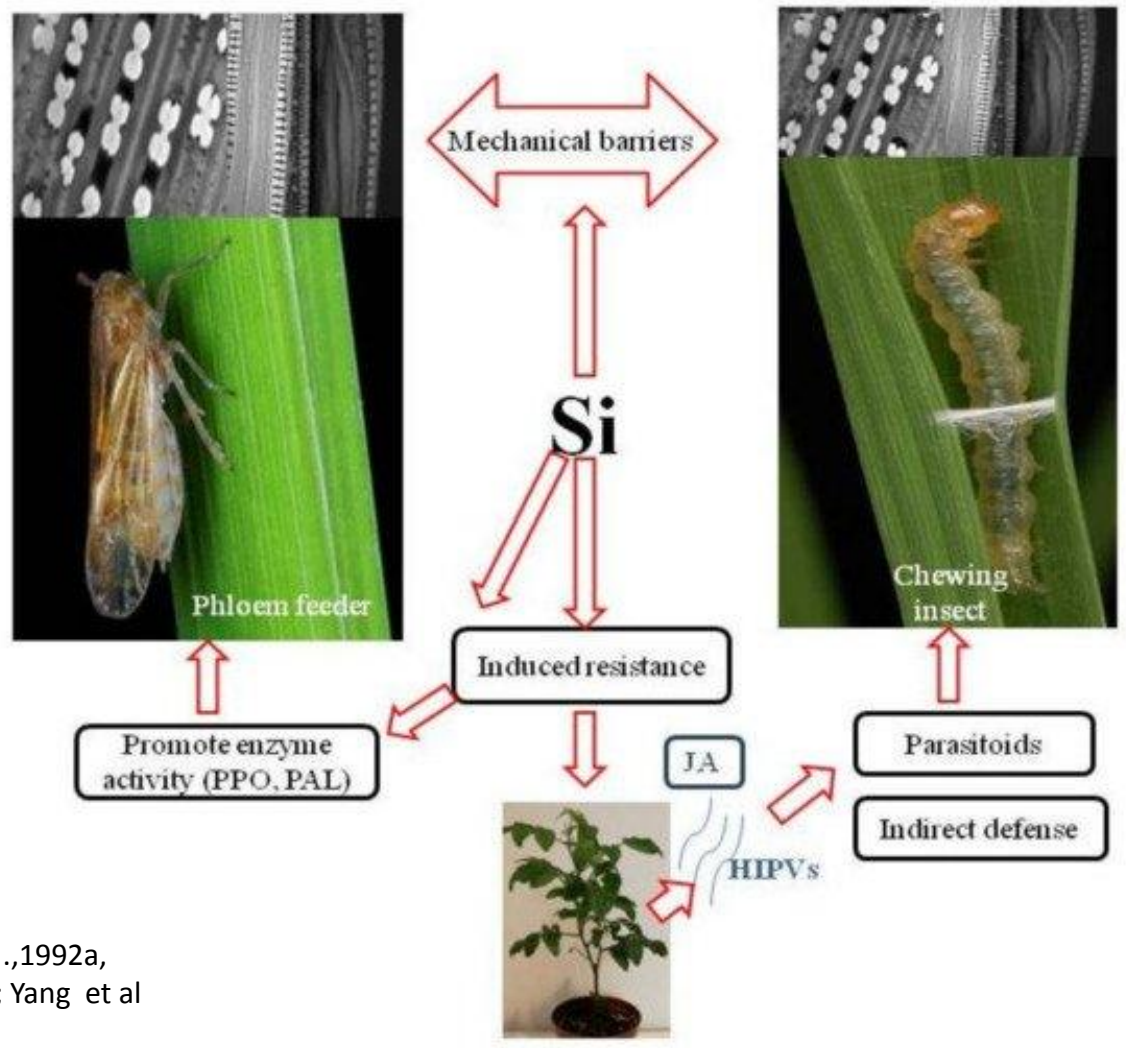
(Epstein, 1999; J.F. and Takahashi,2002; Richmond and Sussman, 2003)

(Alhousari and Greger, 2018)

Role of Si in Plant Protection

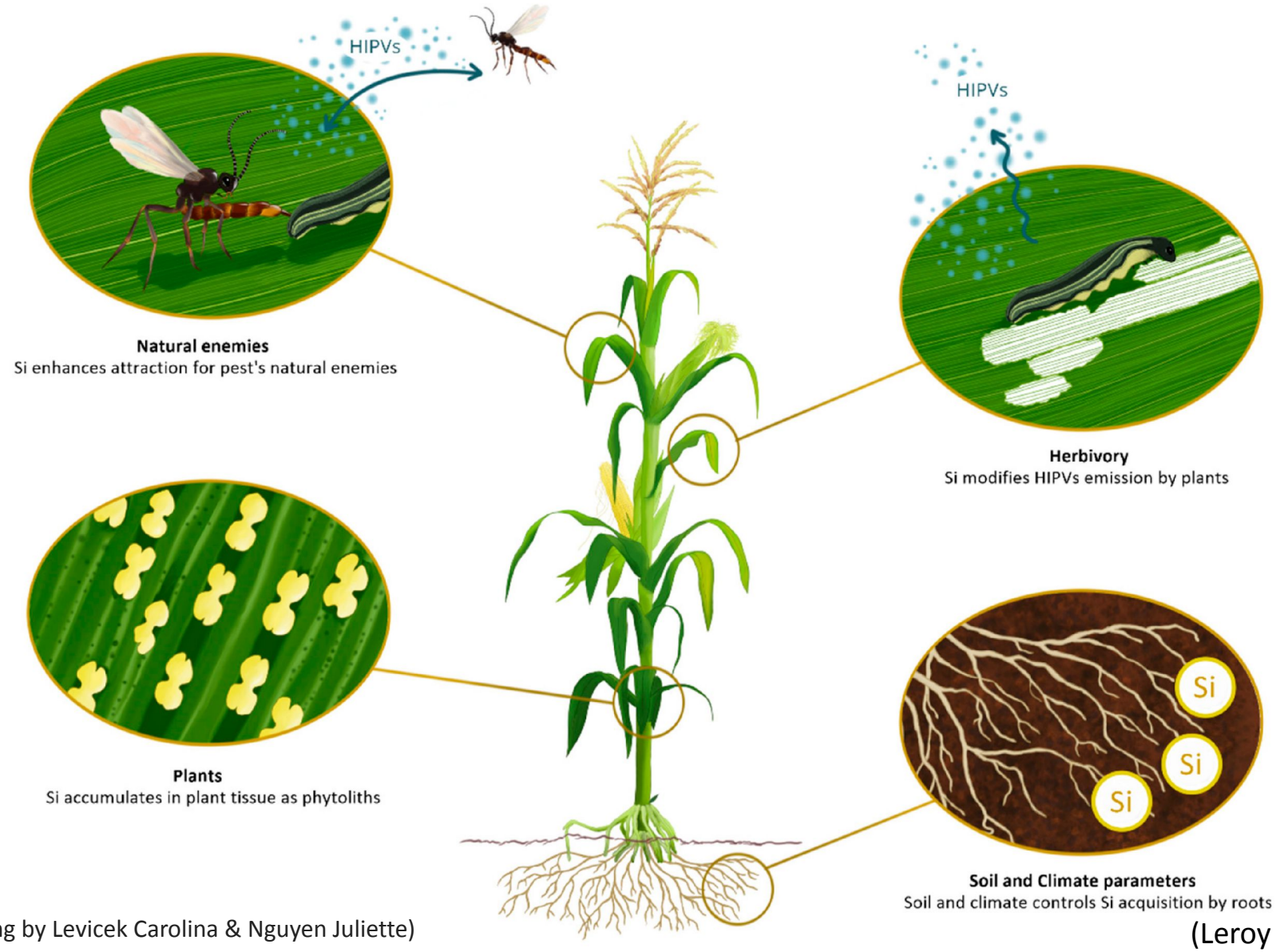
- The mechanisms by which Si provides protection against plant pests and disease are still not fully understood.

- However recent research suggests Si acts as both a physical barrier in cell walls, and is related to specific plant defense reactions.



(Epstein, 1994; Liang & Sun, 2002; Yoshida et al ., 1962; Carver et al ., 1987; Cherif et al .,1992a, 1992b, 1994; Fawe et al ., 1998, 2001; Bélanger et al ., 2003; Rodrigues et al ., 2003, 2004; Yang et al .,2003).

Si as a Plant Resistance Inducer



(Drawing by Levicek Carolina & Nguyen Juliette)

(Leroy et al., 2019)

Direct Defenses

The arrangement and distribution of silicified microstructures, together with their pattern and location in plant tissues, were considered more effective at conferring resistance than was their actual Si content, effectively delaying plant penetration by insects and thereby decreasing plant susceptibility to herbivore insect damage.

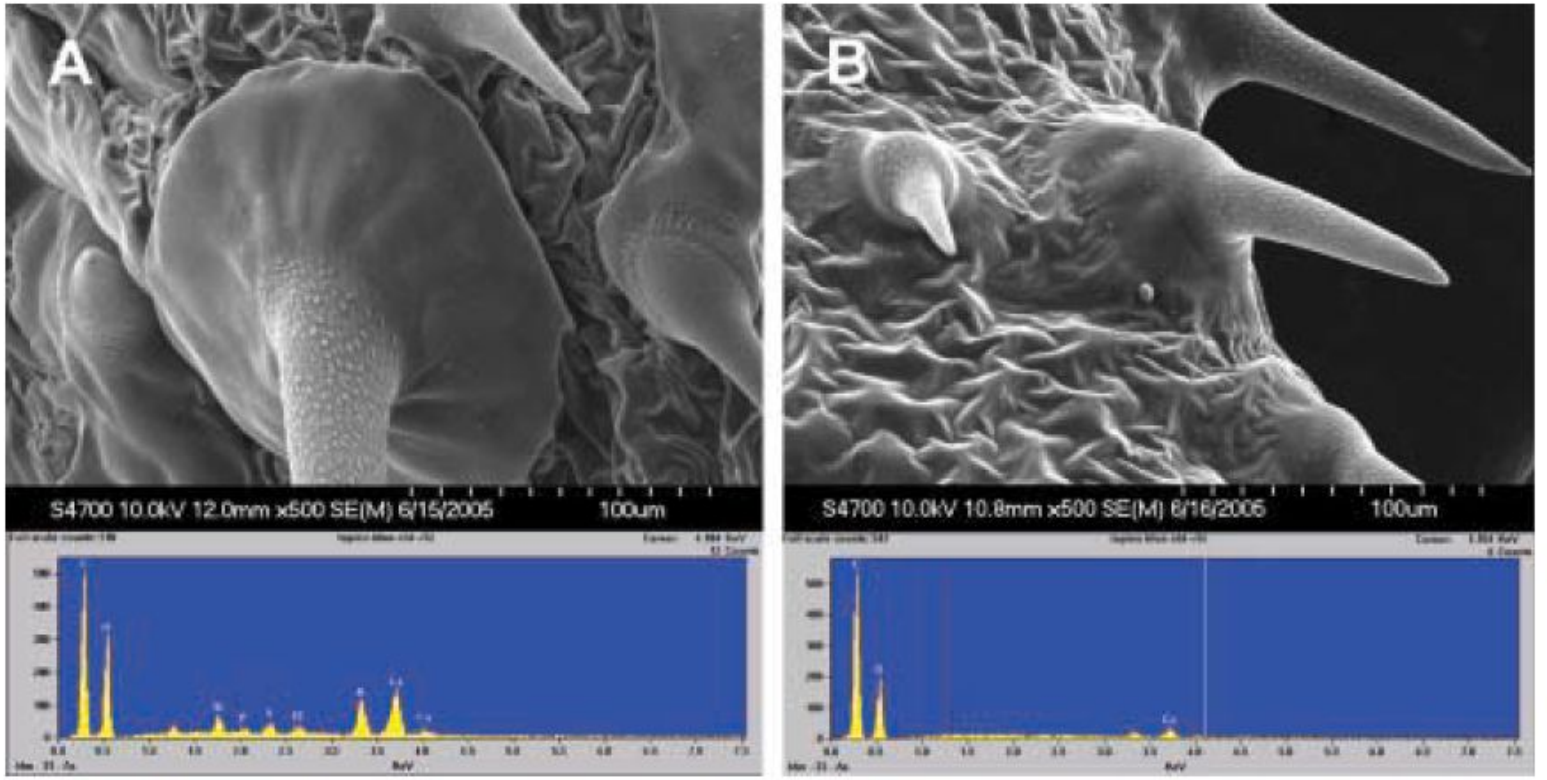
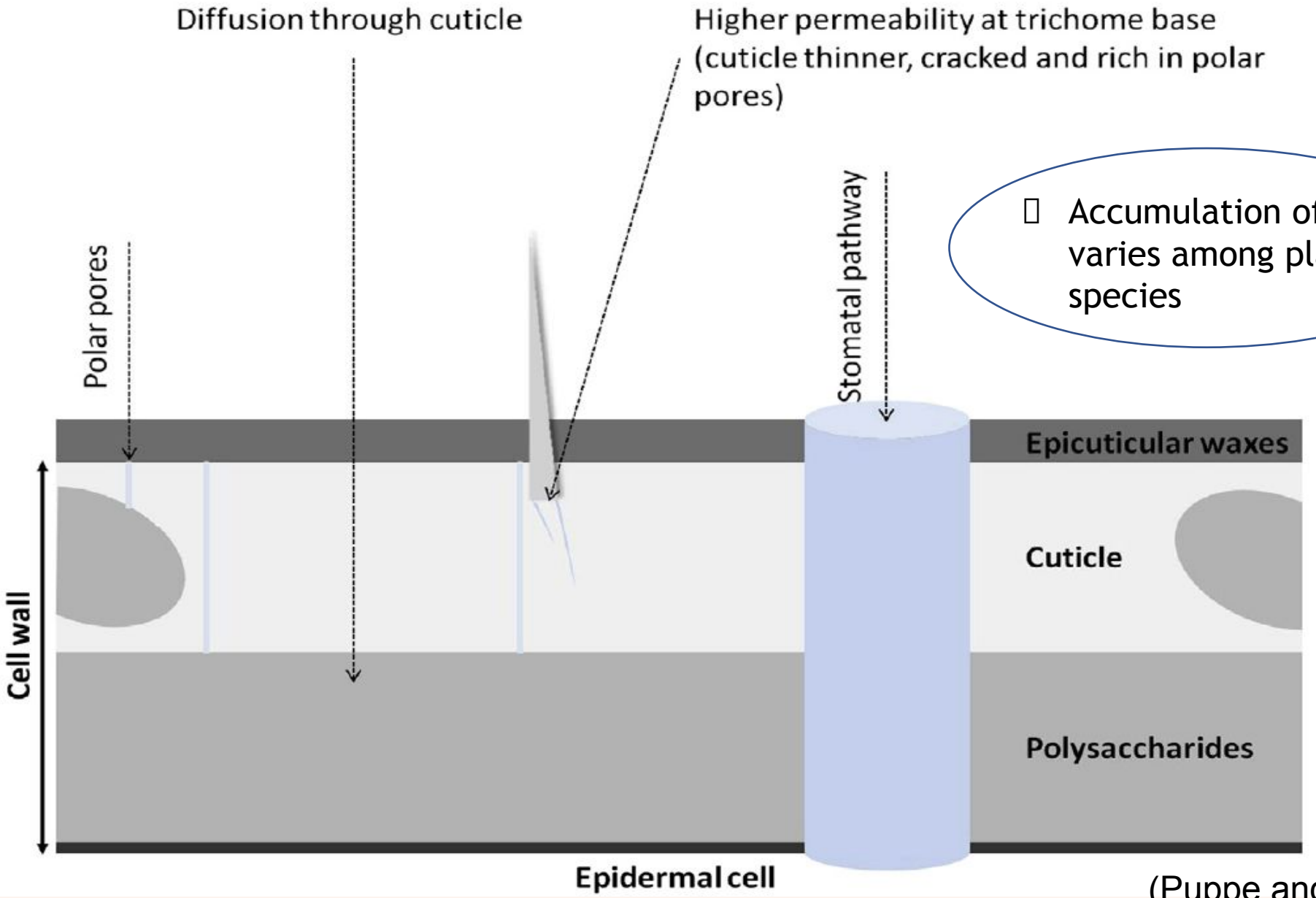


Figure 1. Scanning electron micrographs (top) and the corresponding spectrographs (bottom) of verbena trichomes with (A) and without (B) Si treatment. The Si-fed verbena contained Si and other elements within the base of each trichome. Si-fed verbena contained about 0.8% dry weight of Si based on both ICP-OES and colorimetric determinations.

(Frantz et al, 2008)



- Accumulation of Si varies among plant species

(Puppe and Sommer, 2018)

Silicon Experiments

Objectives:

- Assess silicon accumulation of key ornamental crops.
- Assess affects of silicon accumulation on crop specific pests and pest complexes.
- Carry out production scale test of silicon fertilizers (future work).


Photo credit: Arnold Hara – Anthurium thrips

https://www.agric.wa.gov.au/citrus/mites-citrus?page=0%2C2


Photo by Joanna Bloese

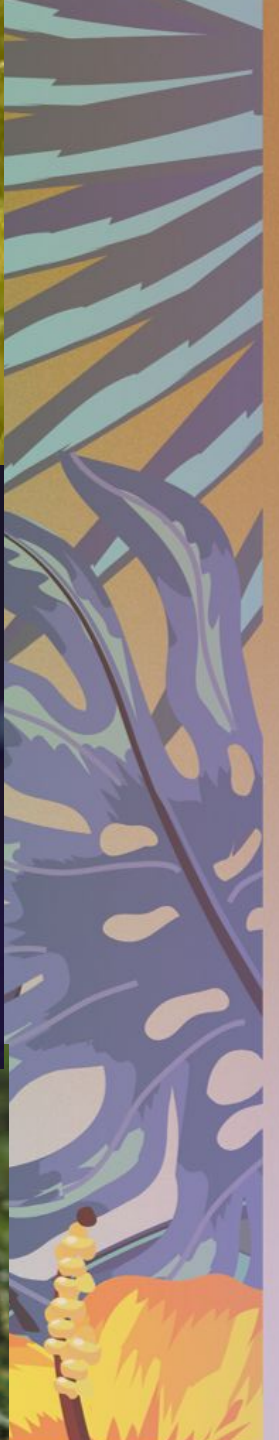

https://wimastergardener.org/article/katydids/


Extento.Hawaii.edu

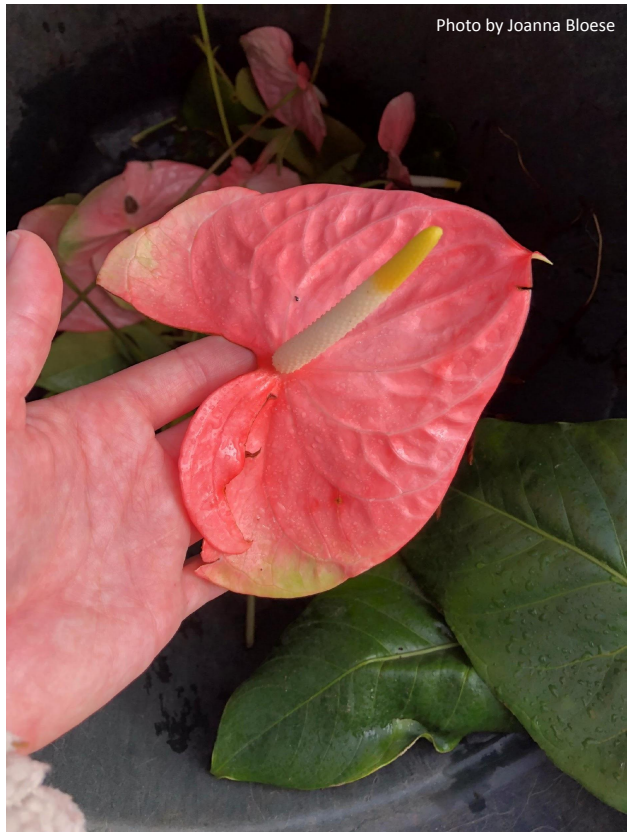

Photo by Ryan Porter

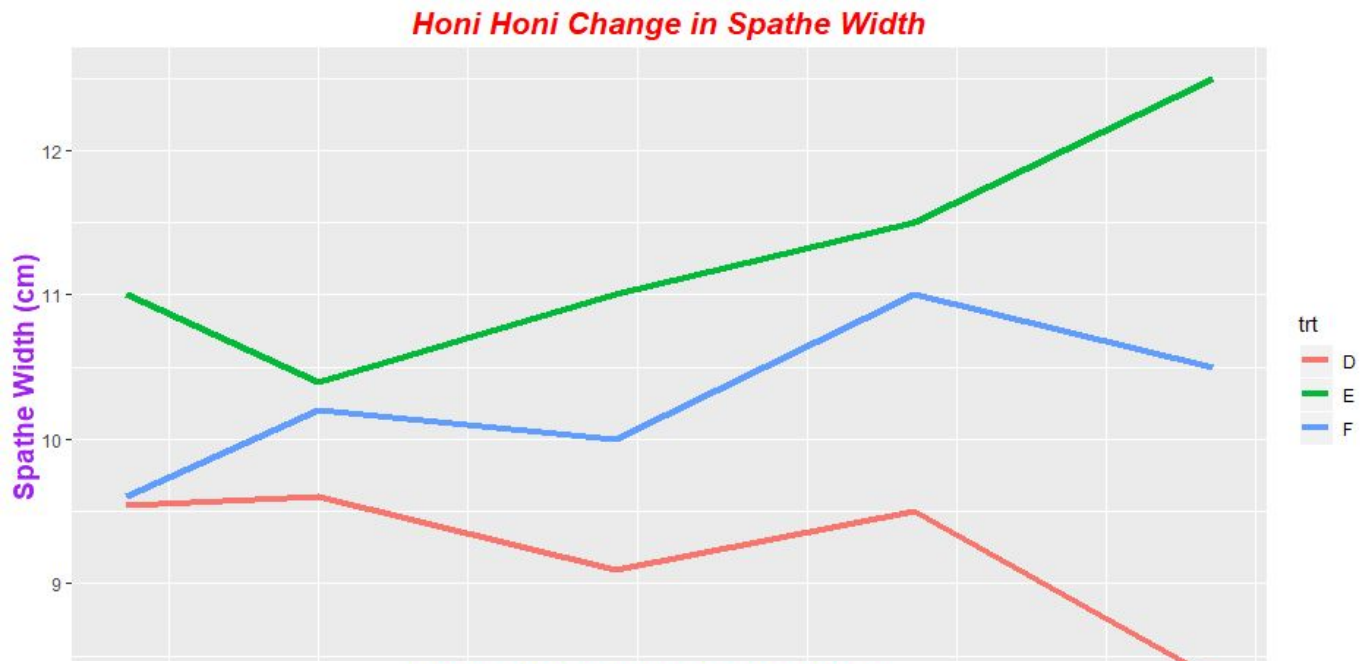

https://hawaiinaturejournal.weebly.com/hawaii-plants-and-animals-in-the-backyard-and-beyond/make-like-a-tree-and-leave-katydids

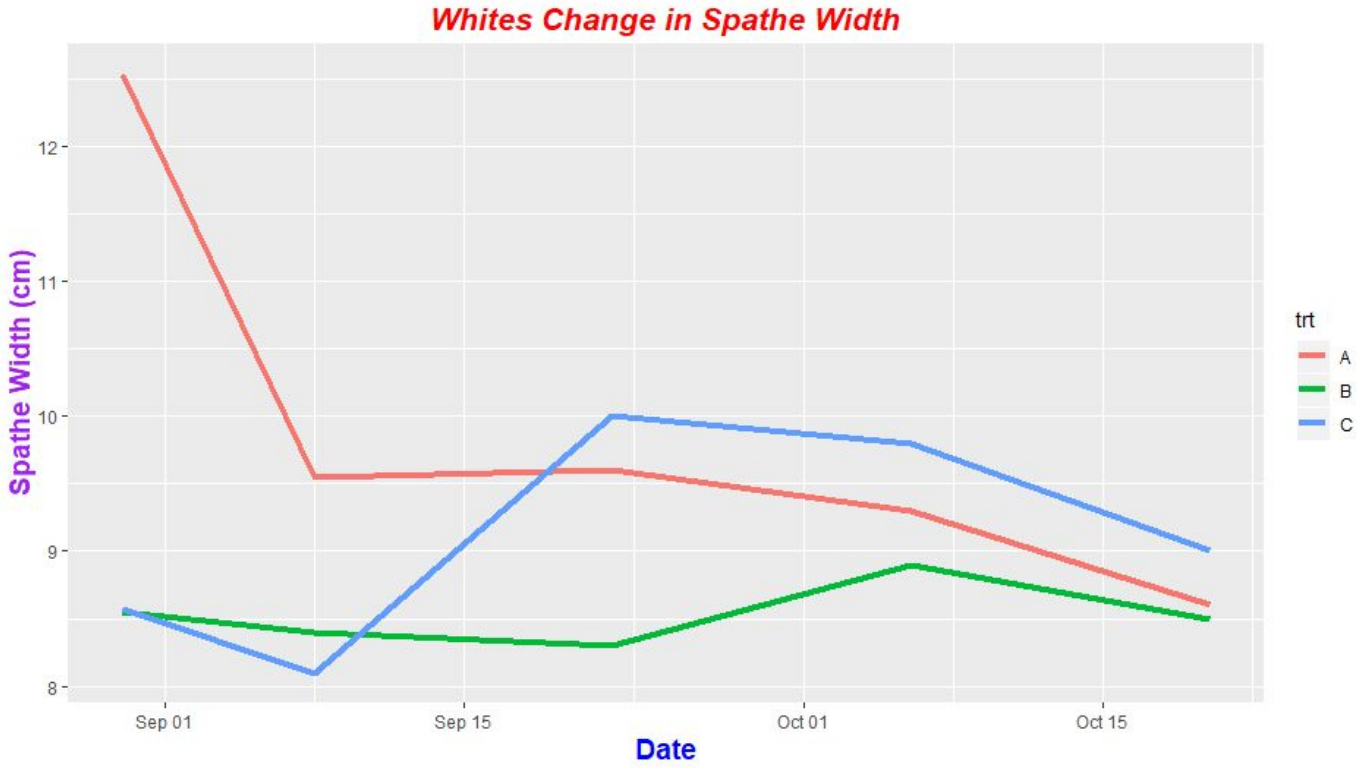

Photo credit: Arnold Hara – Melon Thrips



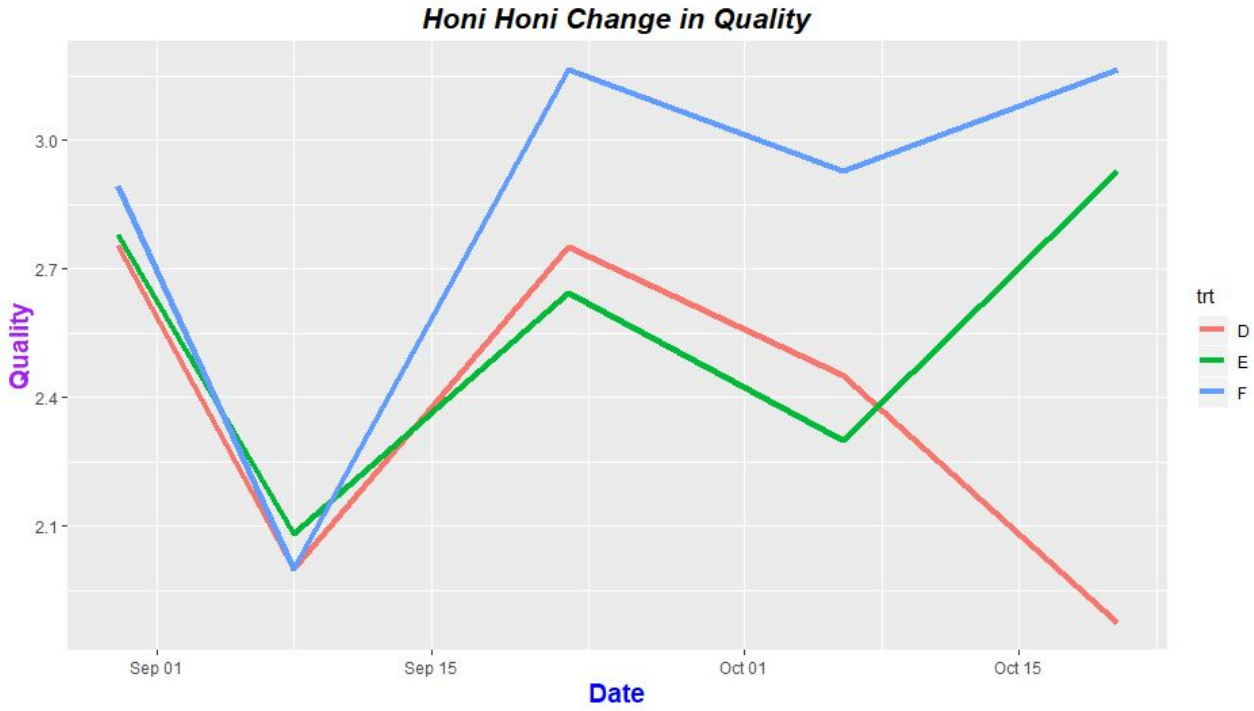
Treatment Effects on Spathe Width

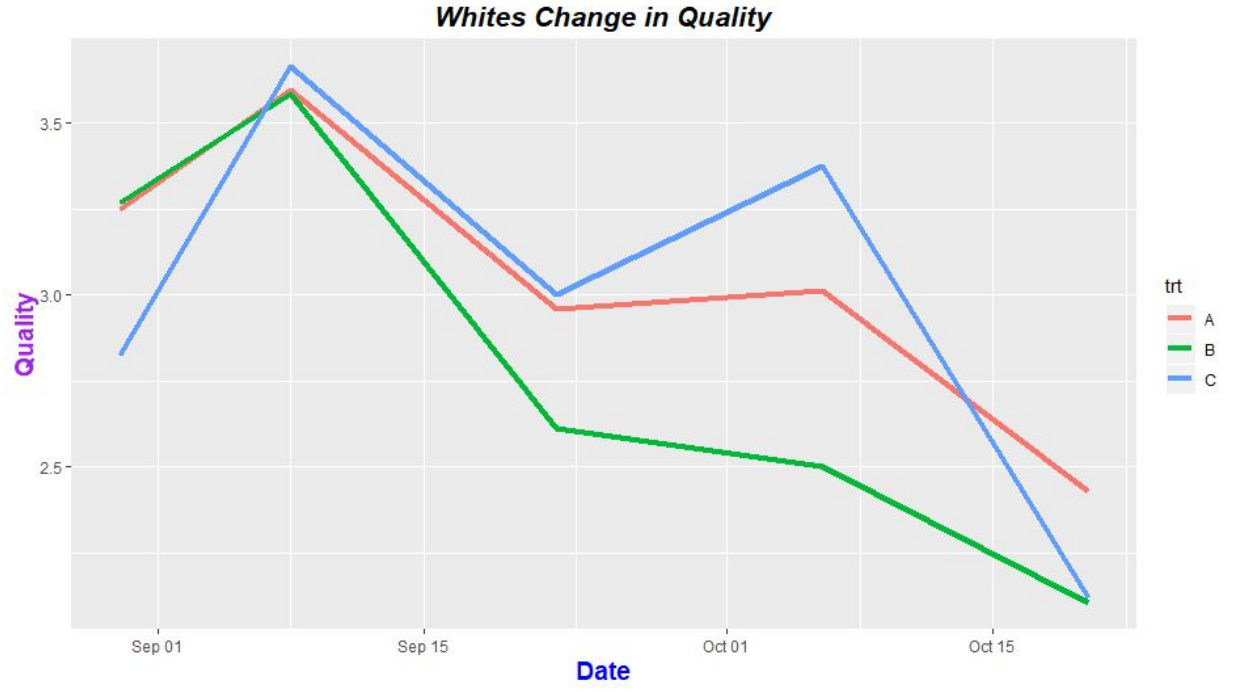


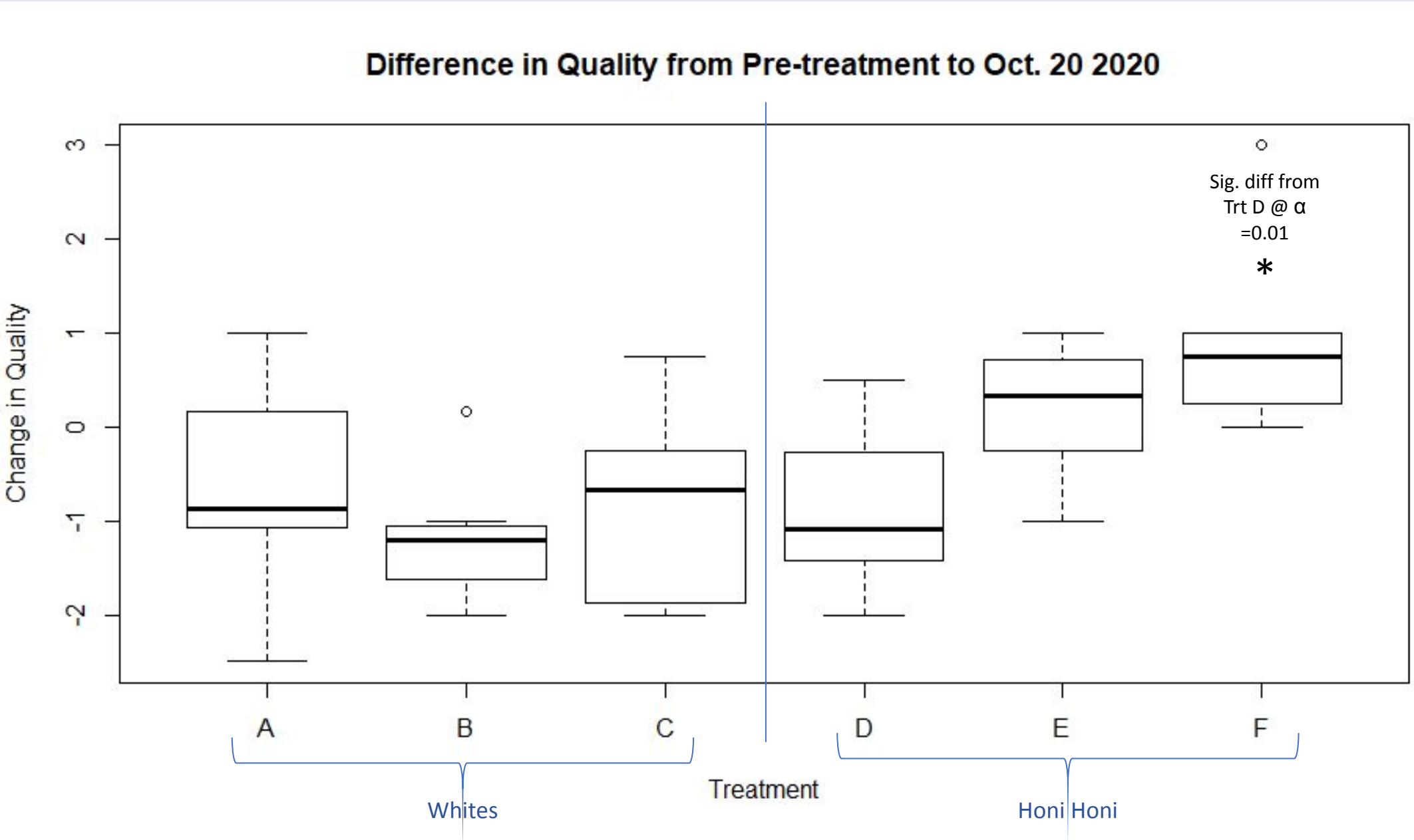




Treatment Effects on Quality

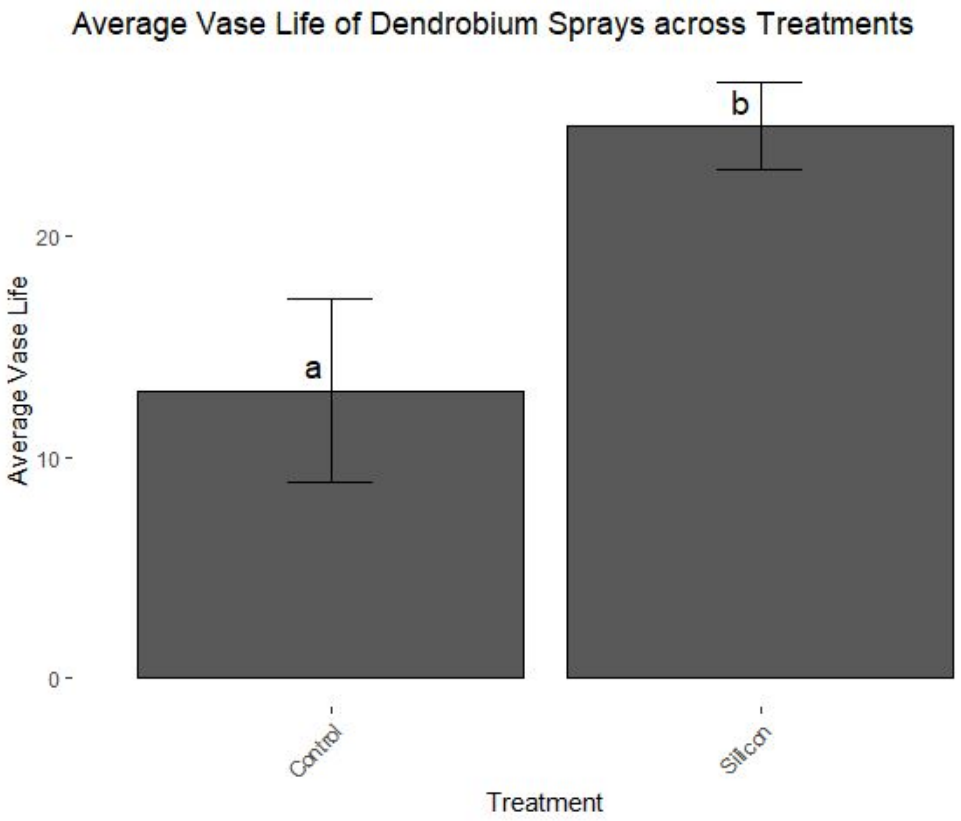


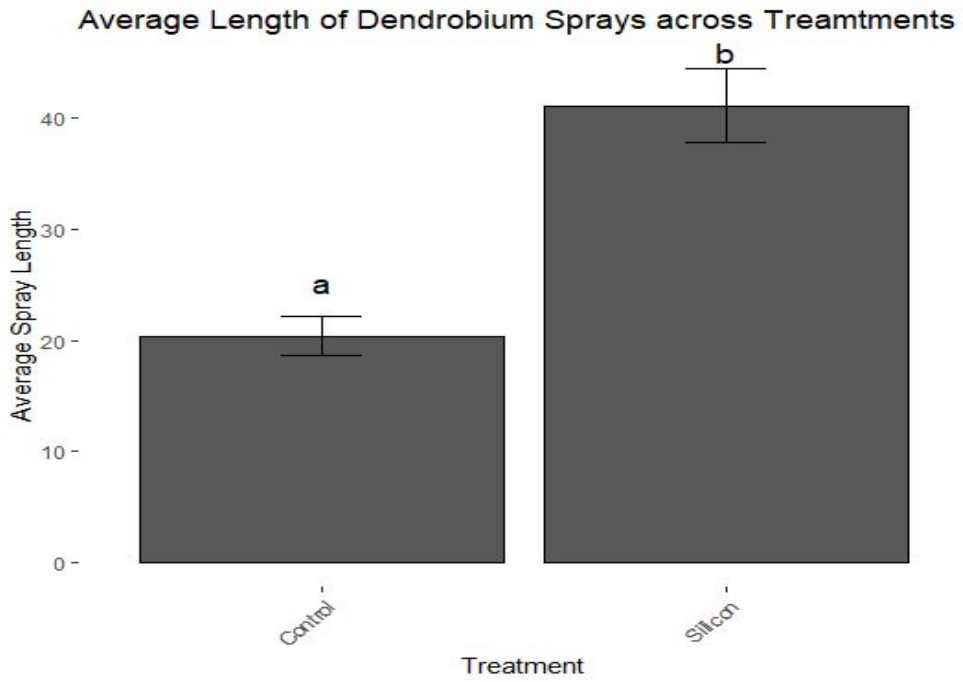



Difference in Quality from Pre-treatment to Oct. 20 2020
Change in Quality
3
2
1
0
-1
-2
Sig. diff from
Trt D @ α
=0.01
*
A
B
C
D
E
F
Treatment
Whites
Honi Honi

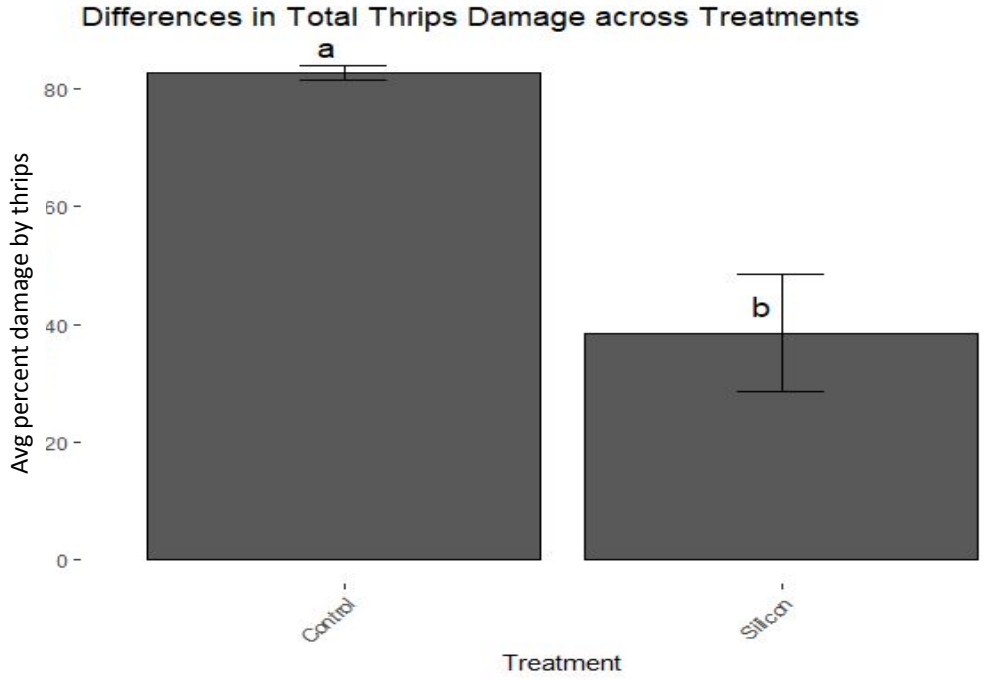
Soluble Si Fertilizer Trial in Orchids

Dendrobium Preliminary Results





Lmm w/ repeated measure P <.0001



Conclusion

- Silicon soluble fertilizers are a promising form of IPM and exhibit effective management among a variety of pests and diseases by acting as a physical barrier and by enhancing plant SAR.

- Possible option for Si to be incorporated into an IPM program for dendrobiums and anthuriums.

- Exploiting plant resistance can represent an economically and ecologically efficient approach to Integrated Pest Management (IPM).