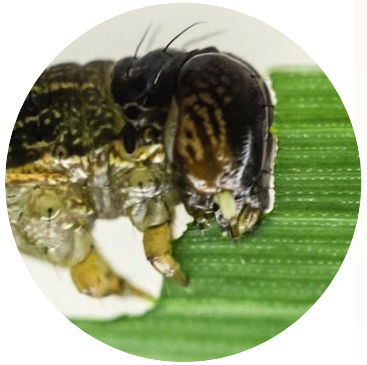
PennState

Plant mineral defense against insect herbivores

Flor E. Acevedo, Michelle Peiffer, Gary Felton

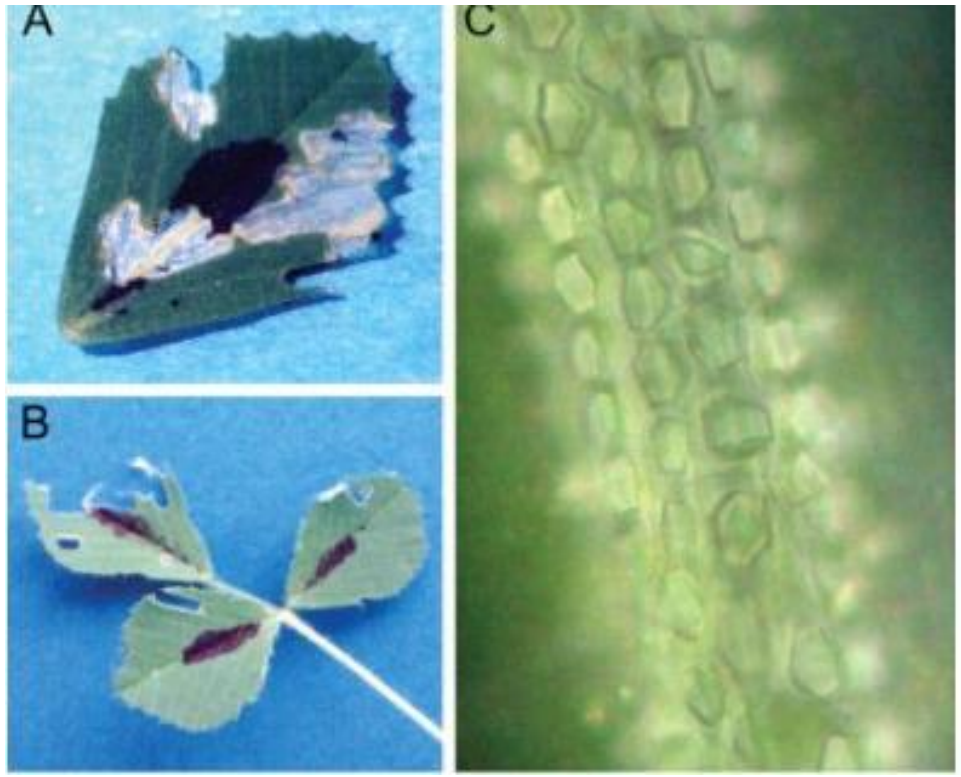
Introduction

Plants uptake minerals from the soil. Animals get essential minerals from plants.

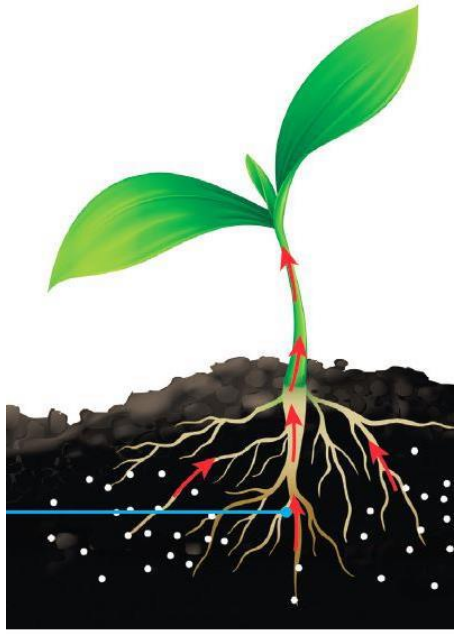


Introduction

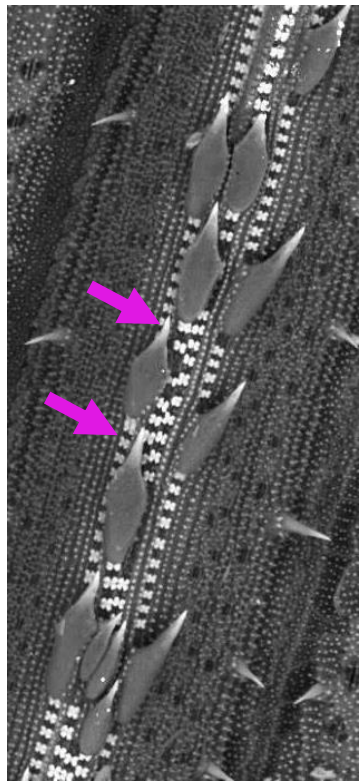
Plant mineral defense



Calcium oxalate crystals in *Medicago truncatula*
Korth *et al*., 2006



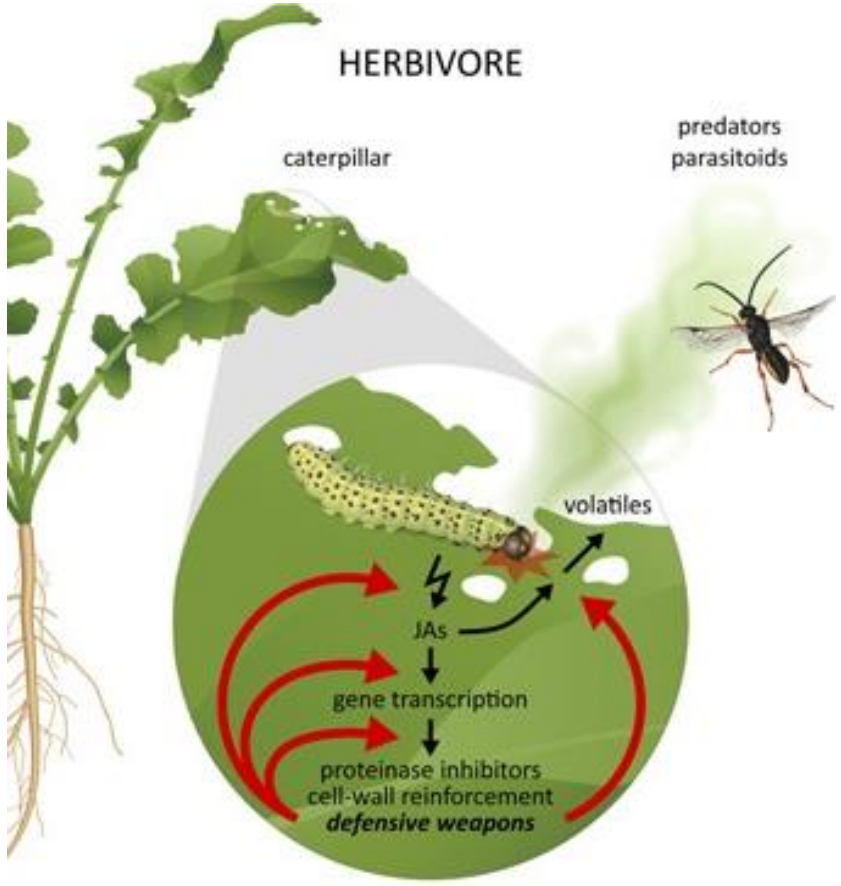
www.wolftrax.com



Silicon bodies in *Oryza sativa*
Acevedo, 2016

Introduction

Herbivore induced plant defenses



Maag *et al*., 2015

Si

Priming of jasmonate-mediated antiherbivore defense responses in rice by silicon

Mao Ye[a,b], Yuanyuan Song[a,b], Jun Long[a,b], Ruilong Wang[a,b], Scott R. Baerson[c], Zhiqiang Pan[c], Keyan Zhu-Salzman[d], Jiefen Xie[b], Kunzheng Cai[b], Shiming Luo[b], and Rensen Zeng[a,b,1]

Silicon amendment is involved in the induction of plant defense responses to a phloem feeder

Lang Yang[1,2], Yongqiang Han[3], Pei Li[1,2], Fei Li[1,2], Shahbaz Ali[1,2] & Maolin Hou[1,2]

Silicon Supplementation Alters the Composition of Herbivore Induced Plant Volatiles and Enhances Attraction of Parasitoids to Infested Rice Plants

*Jian Liu[1,2,3,4], Jiwei Zhu[1,2,3], Pengjun Zhang[5], Liwei Han[1,2,3], Olivia L. Reynolds[1,2,6], Rensen Zeng[7], Jinhong Wu[1,2,3], Yue Shao[1,2,3], Minsheng You[1,2,3] and Geoff M. Gurr[1,2,3,4]**

Hypotheses

1) Insect herbivory modifies leaf mineral composition.

2) Silicon supplementation increases herbivore induced defenses in high and low Si-accumulator plants.

Model system

Spodoptera frugiperda

Maize

High silicon-accumulator

Soybean

http://www.croplife.com

Moderate silicon-accumulator

Tomato

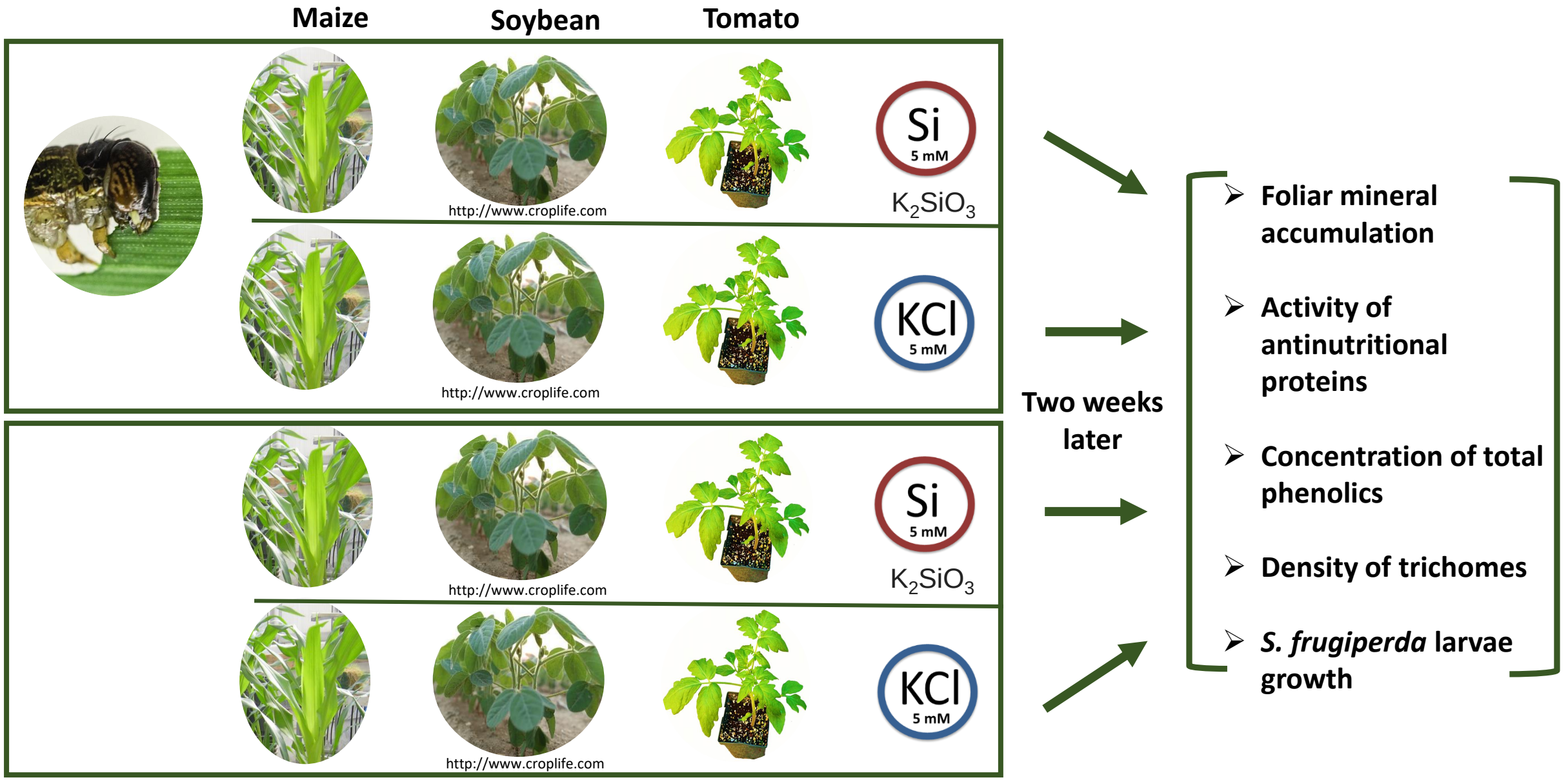
Non-silicon accumulator

Objectives

1) To determine changes in plant mineral composition after herbivore attack.

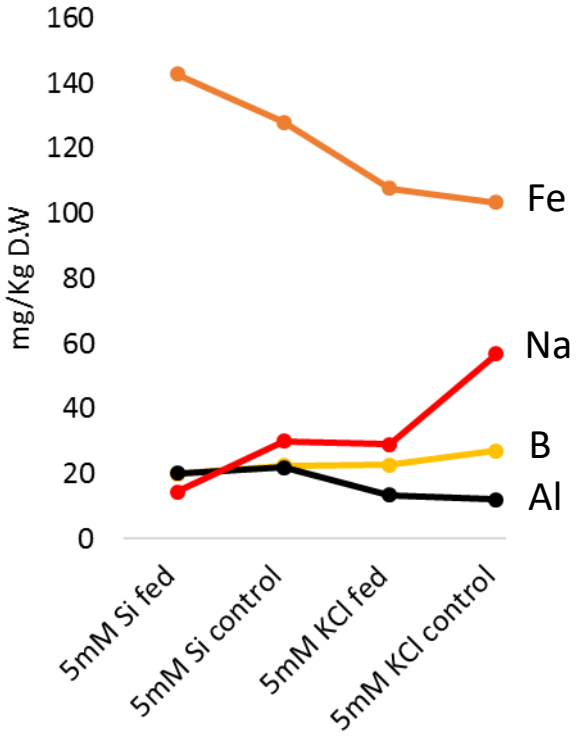
2) To test the effect of silicon (Si) supplementation on plant defense responses against insect herbivores.

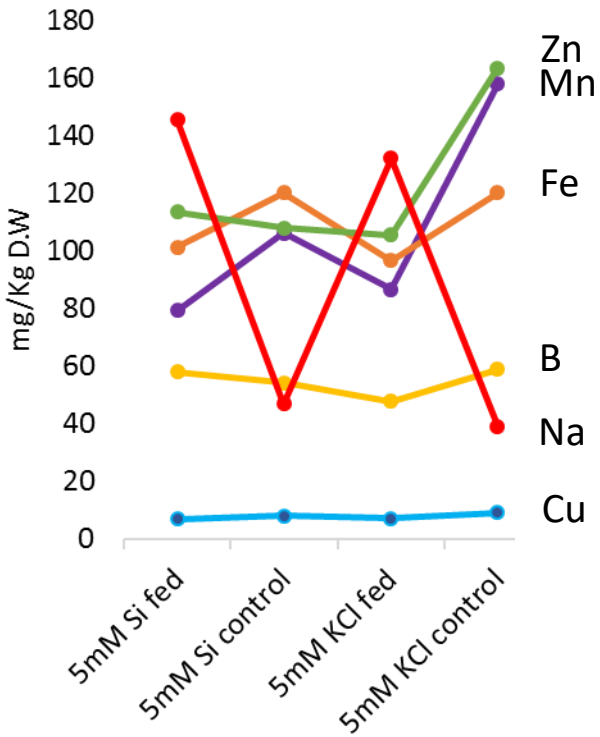
Methods

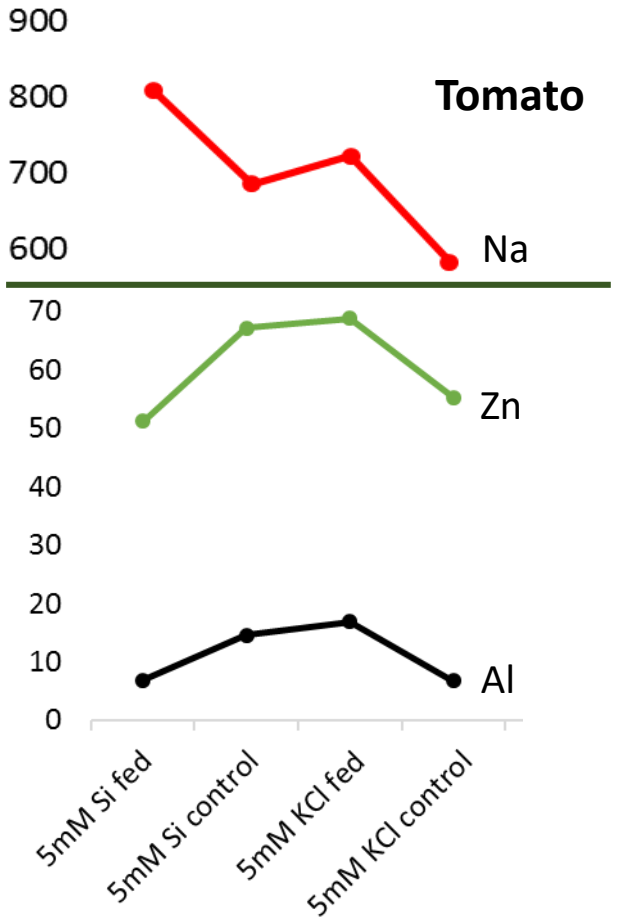

Maize
Soybean
Tomato
Si
5 mM
K_2SiO_3
KCl
5 mM
http://www.croplife.com
Two weeks later
Foliar mineral accumulation
Activity of antinutritional proteins
Concentration of total phenolics
Density of trichomes
S. frugiperda larvae growth

Results

Insect herbivory and silicon supplementation modify leaf mineral composition.

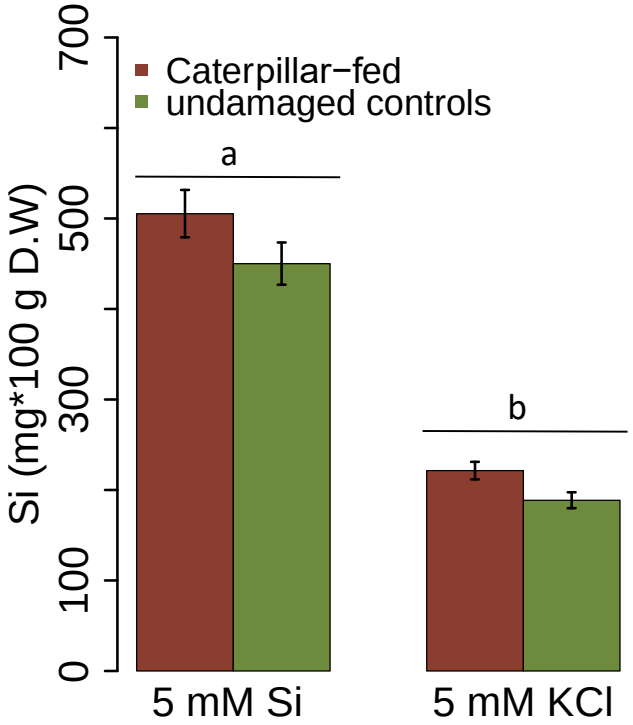






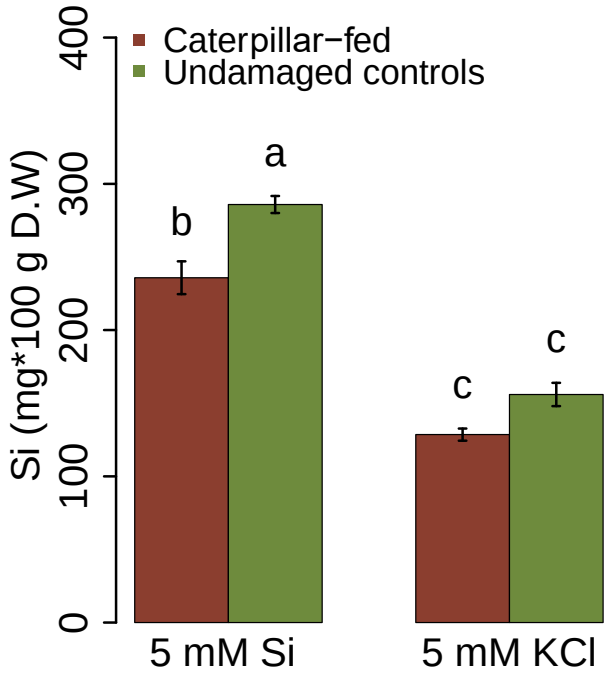
Silicon-supplemented plants accumulated greater amount of this element in their leaves compared with non Si-supplemented controls.

Maize



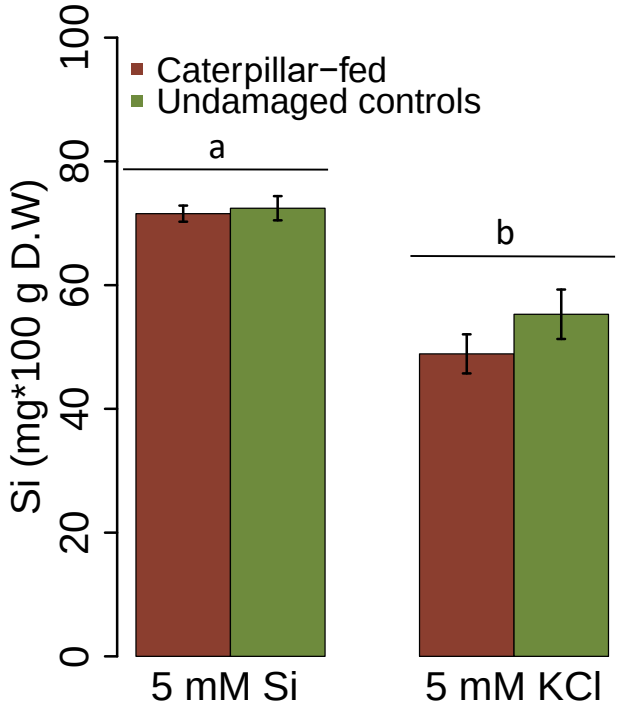
Trt1 (Si/KCl) F = 30.61, $p < 0.001$
Trt2 (cat/und) F = 4,51, $p = 0.037$

Soybean



Trt1 (Si/KCl) F = 0,21, $p = 0.082$
Trt2 (cat/und) F = 5,33, $p = 0.022$

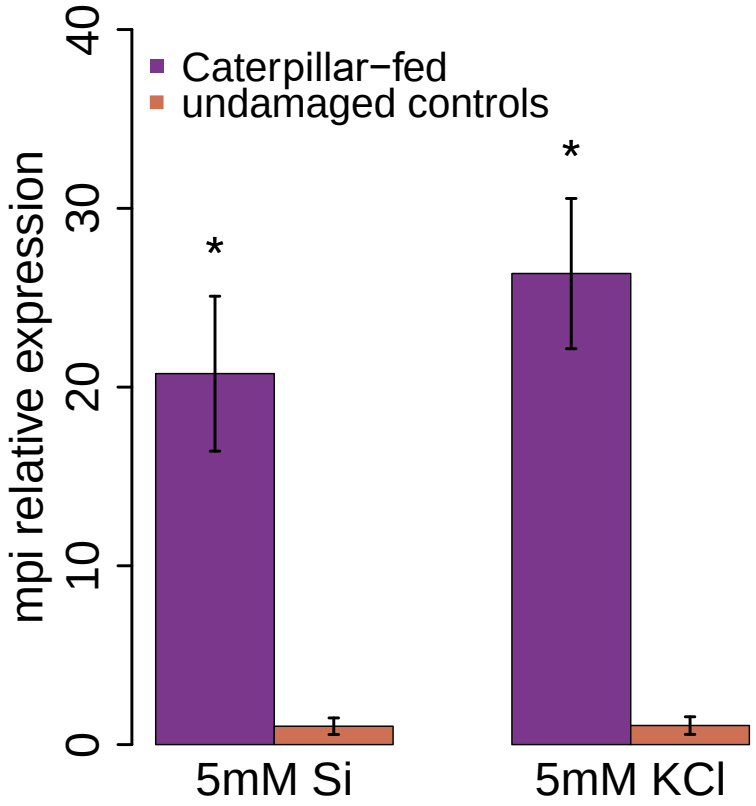
Tomato



Trt1 (Si/KCl) F = 0,81, $p = 0.49$
Trt2 (cat/und) F = 30,55, $p < 0.001$

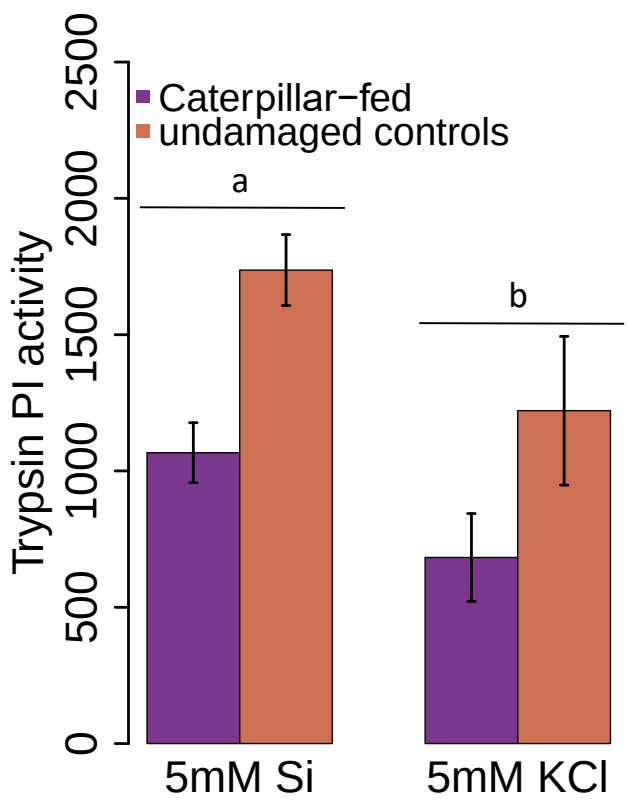
Silicon supplementation increased production of peroxidase in tomato, and protease inhibitors in soybean.

Maize (*mpi*)



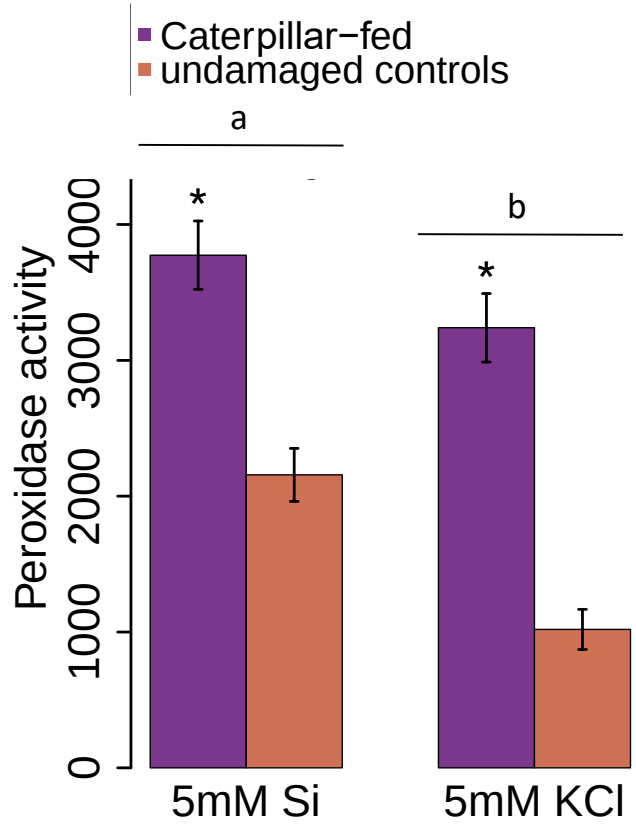
Trt1 (Si/KCl) F = 1,24, p = 0.307
Trt2 (cat/und) F = 291,8, p < 0,001

Soybean (Trypsin PI)



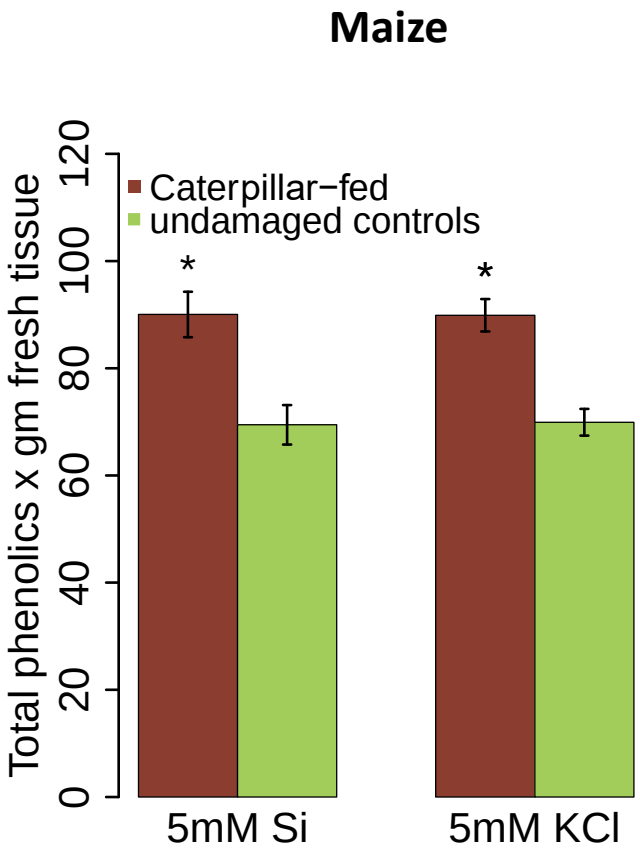
Trt1 (Si/KCl) F = 4,24, p = 0.008
Trt2 (cat/und) F = 0,07, p = 0.792

Tomato (POX)

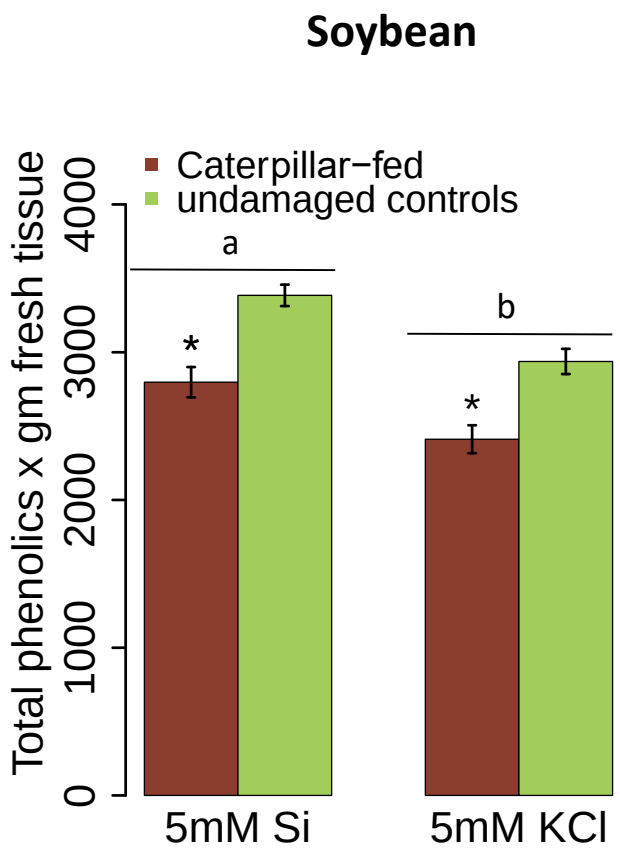


Trt1 (Si/KCl) F = 5,92, p < 0.001
Trt2 (cat/und) F = 139,3, p < 0.001

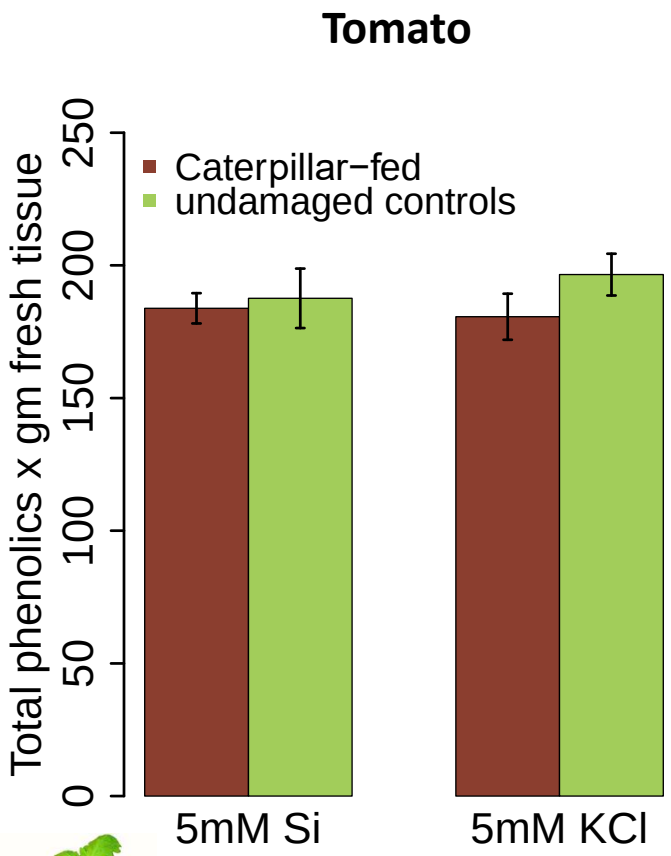
Silicon supplementation and herbivory affected the concentration of total phenolics in soybean and maize.



Trt1 (Si/KCl) F = 1,09, p = 0.36
Trt2 (cat/und) F = 33,88, p < 0,001

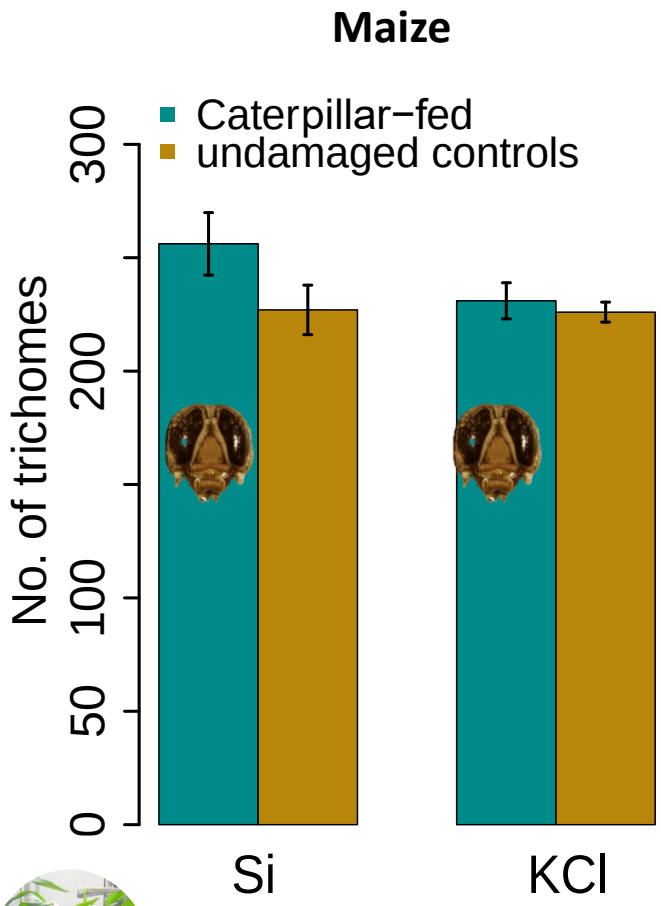


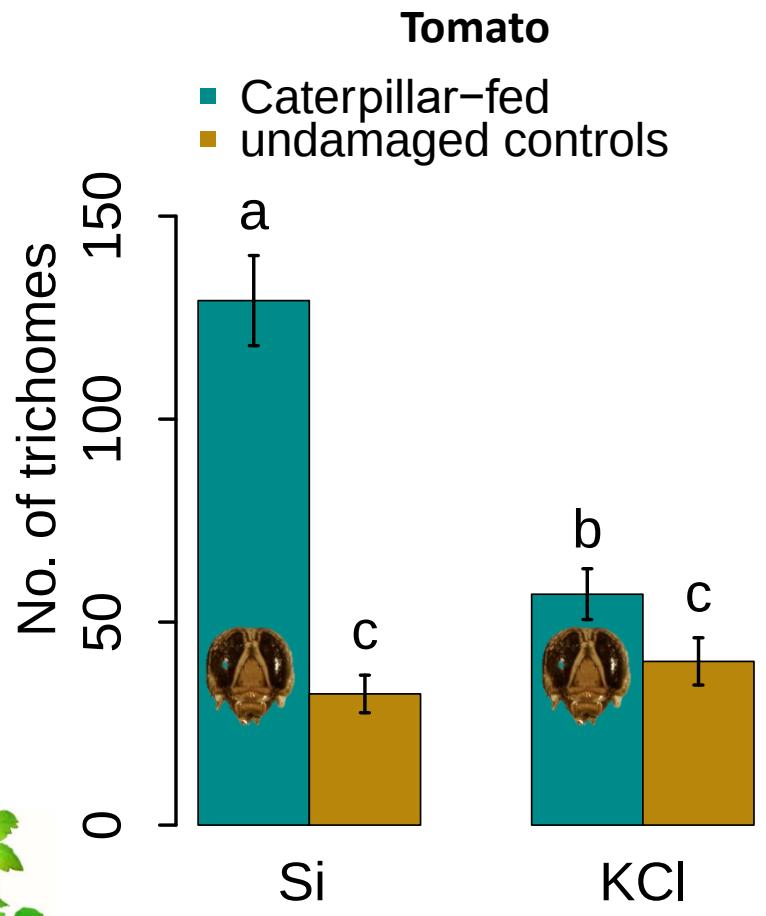
Trt1 (Si/KCl) F = 11,19, p < 0,001
Trt2 (cat/und) F = 21,41, p < 0,001



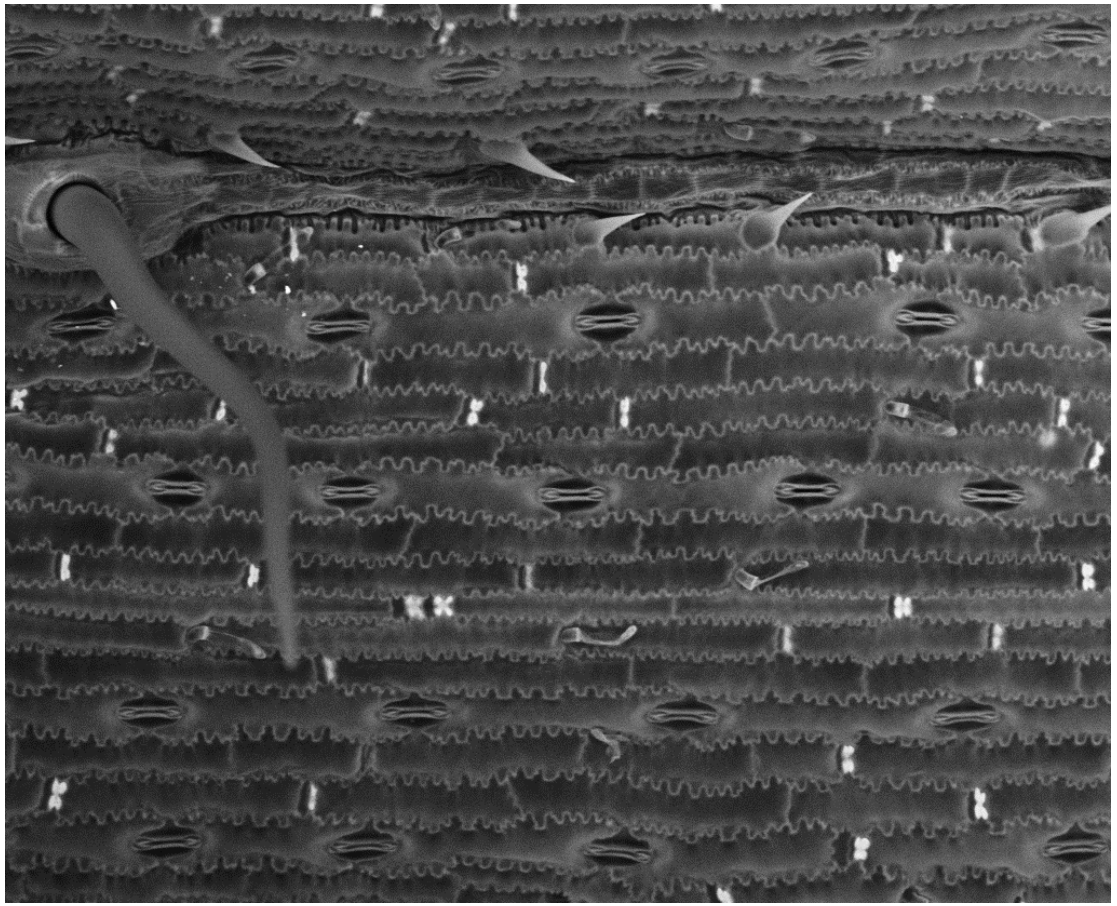
Trt1 (Si/KCl) F = 0,38, p = 0,765
Trt2 (cat/und) F = 3,47, p = 0,066

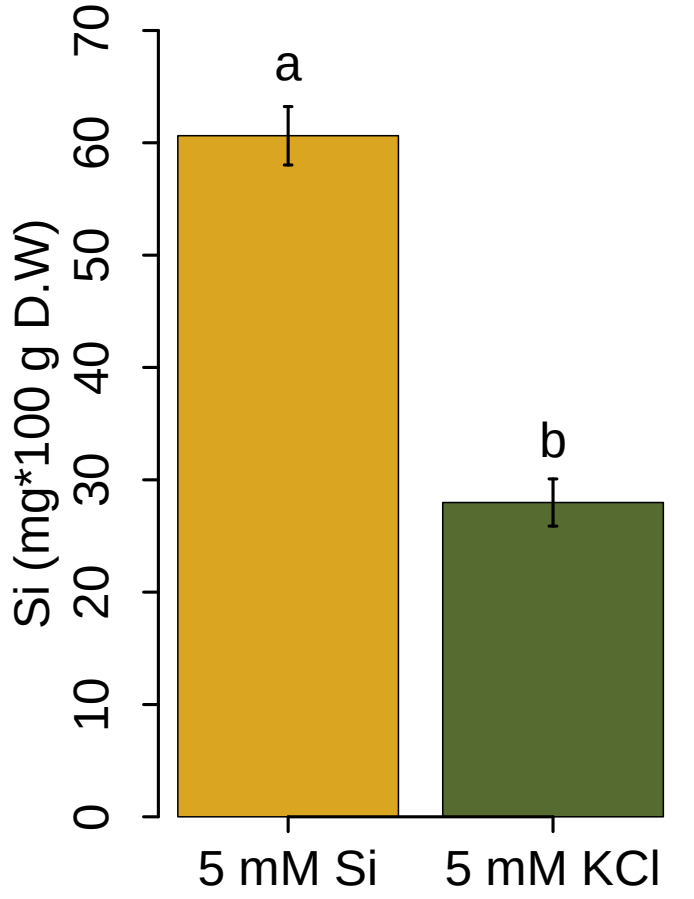
Silicon supplementation and herbivory increased production of trichomes in tomato.





Maize plants supplemented with silicon accumulated greater amount of this element in their trichomes.

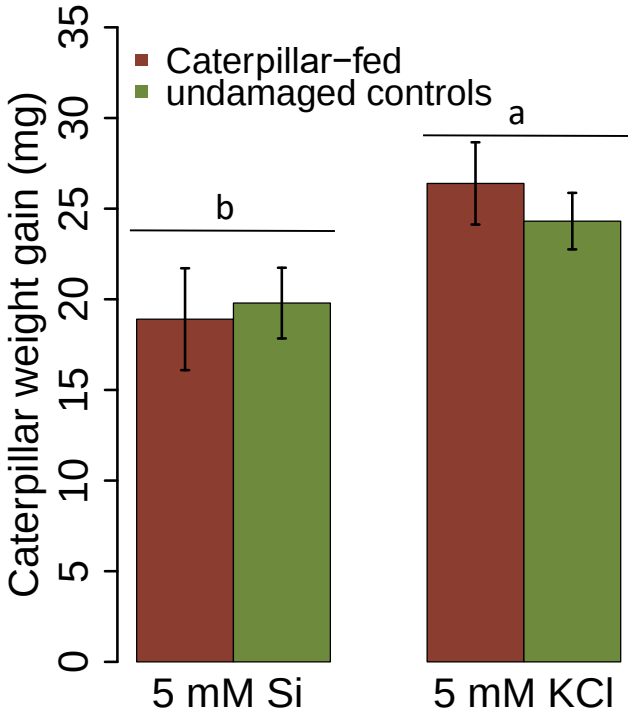




t = -9,85, *p* = 0,000, *df* =5, n = 4

Larvae fed on Si-supplemented plants previously exposed to herbivory gained less weight than controls.

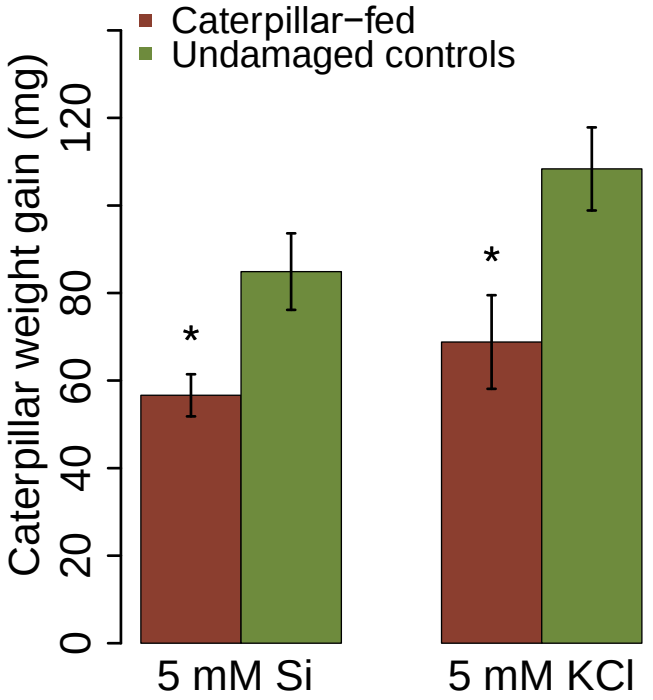
Maize



Trt1 (Si/KCl) F = 30.61, $p < 0.001$

Trt2 (cat/und) F = 4,51, $p = 0.037$

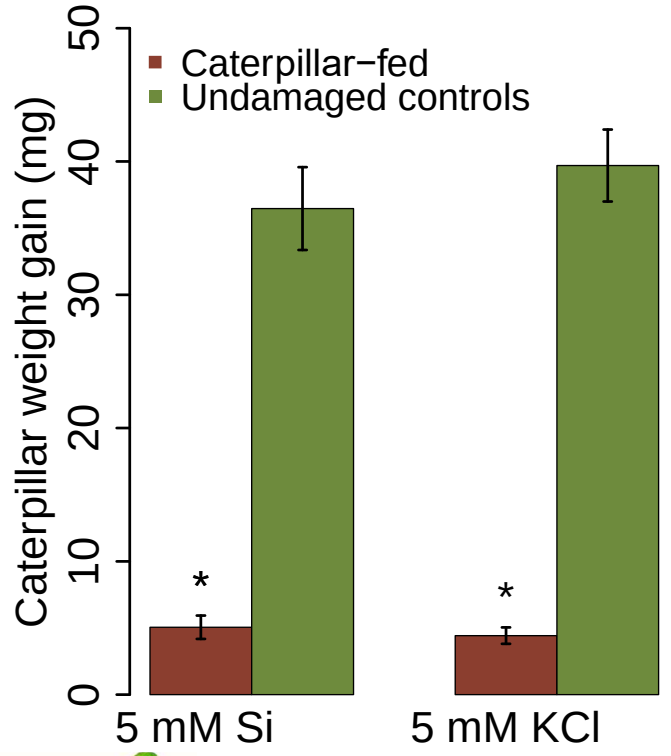
Soybean



Trt1 (Si/KCl) F = 0,21, $p = 0.082$

Trt2 (cat/und) F = 5,33, $p = 0.022$

Tomato



Trt1 (Si/KCl) F = 0,81, $p = 0.49$

Trt2 (cat/und) F = 30,55, $p < 0.001$

Hypotheses

1) Insect herbivory modifies leaf mineral composition.

Plant	Fe	Al	Na	Mn	Ca	Mg	Cu	B	Zn	Si
Maize	↑	↓	↓	–	↑	–	–	–	–	–
Soybean	↓	–	–	↓	–	↑	↓	↓	↓	↓
Tomato	–	↓	↑	–	↓	–	–	–	–	–

Hypotheses

1) Insect herbivory modifies leaf mineral composition.

Plant	Fe	Al	Na	Mn	Ca	Mg	Cu	B	Zn	Si
Maize	↑	↓	↓	–	↑	–	–	–	–	–
Soybean	↓	–	–	↓	–	↑	↓	↓	↓	↓
Tomato	–	↓	↑	–	↓	–	–	–	–	–

2) Silicon supplementation increases herbivore induced defenses in high and low Si-accumulator plants.

Si 5 mM

Plant	*mpi*		POX		Trypsin PI		Phenolics		No. Trichomes		Cat. Weight gain	
	Si 5 mM		Si 5 mM		Si 5 mM		Si 5 mM		Si 5 mM		Si 5 mM	
Maize	–	↑	–	–	–	–	–	↑	–	–	↓	–
Soybean			–	↑	↑	↓	↑	↓	?		–	–
Tomato			↑	↑	–	↑	–	–	↑	↑	–	↓

Conclusions

Silicon supplementation

Art work: Nick Sloff

Acknowledgements

Felton and Luthe labs

PennState

SARE
Sustainable Agriculture
Research & Education

USDA

FULBRIGHT
COLOMBIA

REPÚBLICA DE COLOMBIA

COLCIENCIAS
Departamento Administrativo de Ciencia, Tecnología e Innovación