NYWGF RESEARCH - FINAL REPORT

Funding for fiscal year: 2021-2023

SECTION 1:

Project title: Effect of silicon on grapevine health

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New Research ☒ **Continued Research** ☐

Amount Funded **$** 10,515

SECTION 2:

Project Summary Impact Statement:

Many plant species uptake and accumulate silica in their tissues. In many of them, silicon increases plant resistance to insects and pathogens by enhancing the plant's physical and chemical defenses. *Vitis vinifera* is known to contain specialized silicon transporters, and there is experimental evidence of its ability to accumulate up to 2% of silicon in their leaves. But the ability of *Vitis labrusca* to accumulate silicon is unknown. This proposal aimed to determine the ability of three different grape cultivars to accumulate silicon in different tissues, and to determine the effect of silicon supplementation on grapevine health, leaf biomass and mineral uptake. The results of this study could help determine the benefits of supplementing grapevines with silicon.

Objectives:

1) To determine the ability of three different grape cultivars to accumulate silicon in different tissues.
2) To test the effect of silicon supplementation on grapevine health.
3) To determine the effect of silicon supplementation on plant biomass and mineral uptake.

Materials & Methods:

Methods for objective 1: To determine the ability of three different grape cultivars to accumulate silicon in different tissues. Canes of Concord, Niagara and Cabernet Franc vines (grafted in rootstock 3309) were purchased and planted in pots at the Lake Erie Grape Research and Extension Center located in North East, PA in summer 2021. The growing media was a combination of topsoil, peat moss, and perlite at a 1:1:1 ratio, and each vine was fertilized with 5gr of the slow release Osmocote plus. A total of 20 vines were grown for each cultivar at the beginning of the growing season; ten of them were supplemented with a solution of 2mM of calcium metasicate (approximate composition of 48.28% CaO, 51.72% SiO_2) whereas the other ten vines were controls supplemented with calcium oxide (these supplements were added during the growing season of 2022, each vine received a total of 3 liters of each solution spread in six applications of 500 ml each). Nearing the end of the growing season, samples of leaves, petioles and roots were extracted from the plants, dehydrated through serial dilutions of ethanol, critical point dried with liquid CO_2 and visualized using the Energy Dispersive X-ray Spectroscopy (EDS) technique in a Scanning Electron Microscope. The EDS technique was used for visualizing the distribution of minerals in different tissues.

Methods for objective 2: To test the effect of silicon supplementation on grapevine health. Canes of Concord, Niagara and Cabernet Franc vines were purchased and planted as indicated above (see methods for objective 1). Ten vines per cultivar were supplemented with a solution of 2mM of calcium silicate whereas the other 10 vines were controls supplemented with lime. All the vines were assessed for relative resistance and susceptibility to the four major fungal diseases in the Lake Erie Region; powdery and downy mildew, black rot, and Phomopsis cane and leaf spot. Vines were exposed to ambient levels of inoculum from the vineyard. The disease levels that develop among the varieties were rated in leaves and shoot internodes. Disease incidence (percentage of leaves/shoot internodes) and severity (percent area of leaves/shoot internodes) were determined for all vines. Severity was rated using the Barratt-Horsfall scale and converted to percentage of area infected using Elanco conversion tables. For assessing resistance to insects, the vines were exposed to naturally occurring populations present in the Lake Erie Region. The vines shoots were periodically inspected (at least every other day during the growing season) to record the number of insects and their damage.

Methods for objective 3: To determine the effect of silicon supplementation on plant biomass and mineral uptake. To measure the biomass, we used the same vines grown for objective 1. For each vine, we separated leaves, oven-dried them until constant weight in paper bags and then weighted then in a scale. Additionally, one sample of leaves per vine was ground for mineral analyses. The concentration of N, P, K, Ca, Mg, Mn, Fe, Cu, B, Al, Zn, Na, and S was measured at the Penn State Ag analytical services lab https://agsci.psu.edu/aasl/plant-analysis/plant-tissue-total-analysis

Data analysis

Differences in plant biomass, and concentration of different minerals between treatments were analyzed with t-tests (alpha = 0.05).

Results/Outcomes/Next Steps:

Ability of grape cultivars to accumulate silicon in different tissues.

Leaves, stems, and roots of Concord, Niagara and Cabernet Franc vines were cut out of the plants in late September (2022), prepared as indicated in the methods section, and used for visualizing silicon particles with the EDS technique in a Scanning Electron Microscope (SEM). We found silicon particles on leaves but not in stems or roots of all cultivars tested (Figure 1). Silicon seems to be coming out through pearl glands and deposited as dust particles on the epidermis of the leaves. Grape leaves don't have silica cells (structures in the epidermis of the leaves to contain silica) like those present in other plant species, instead silica is ejected through pearl glands and spread on the leaf epidermis (Figure 2). Silicon particles were not found in stems or roots of the cultivars tested in this study (Figure 3).

Effect of silicon supplementation on grapevine health.

There were no natural insect infestations detected during the growing season of 2022. We were hoping to see Japanese beetle infestations, but we didn't get any this year. However, grapes did get infected with diseases. The week of July 21 of 2022 we observed vines infected with powdery mildew. Our disease ratings were as follows: 100% infection (100% incidence) with powdery mildew in Cab Franc, Niagara and Concord grapevines. This means that all vines had at least one leaf infected with the pathogen. The severity of the disease was different for cultivars. We took 4 infected leaves and rate the percent of infection per leaf using the Barrat/Horsfall rating system, Concord and Niagara had a severity of 2.34%, whereas Cab Franc had a severity of 81.25%. We did not find differences in disease severity among treatments.

Effect of silicon supplementation on plant leaf biomass and mineral uptake

In late September of 2022, we harvested all the leaves and petioles from the potted vines, dried them in an oven and weighed them to determine the effect of silicon supplementation on leaf biomass. From these, 15 gr of dry leaves with petioles were used to determine mineral composition. Leaf biomass was not affected by silicon supplementation on any of the grapevine cultivars tested in this study (Concord: $t = 1.13$, df = 14, P-value =0.277; Niagara: $t = 1.58$, df = 28, P-value =0.126; Cabernet Franc: $t = 0.83$, df = 30, P-value =0.412; Figure 4). Likewise, silicon supplementation did not affect the concentration of minerals in leaves and petioles of any of the grape cultivars tested in this study (Table 1).

Technology Transfer Plan:

The results of this study will be published in a peer-reviewed scientific journal and will be disseminated to growers in extension meetings.

Attachments:

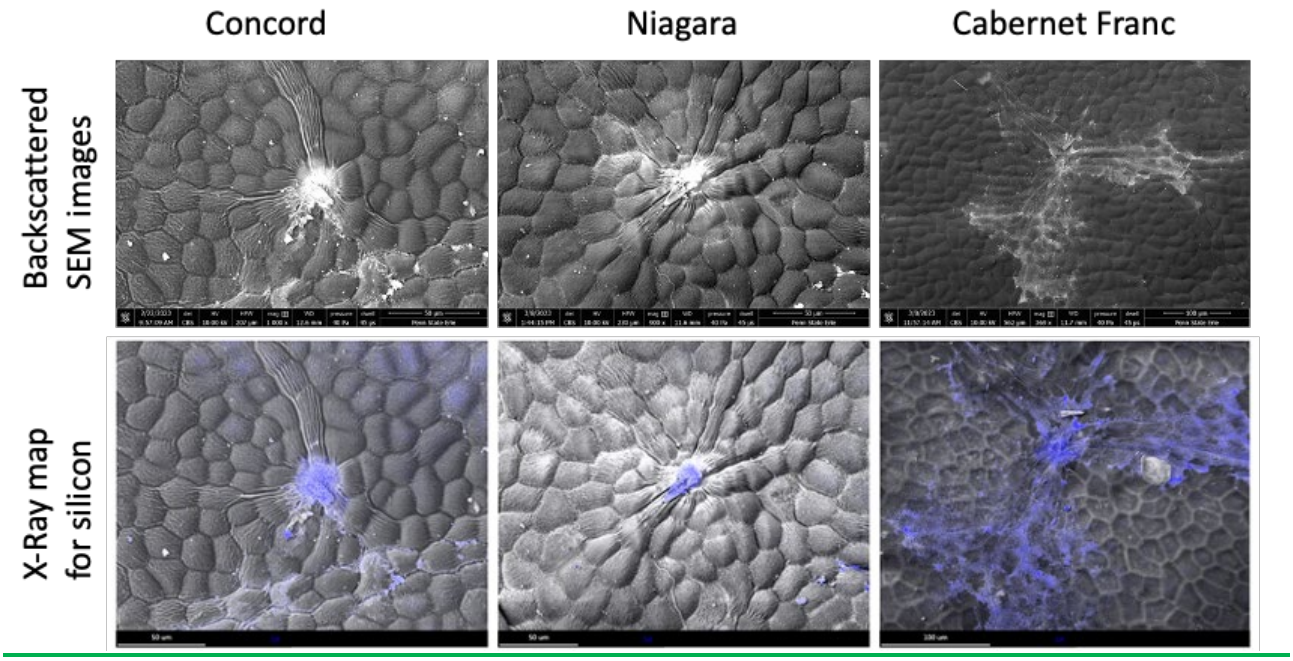

Figure 1. Deposition of silicon on leaves of Concord, Niagara, and Cabernet Franc. In the top backscattered electron images, the deposition of silicon can be visualized in white color. The lower images are x-ray maps of the distribution of silicon colored in blue.

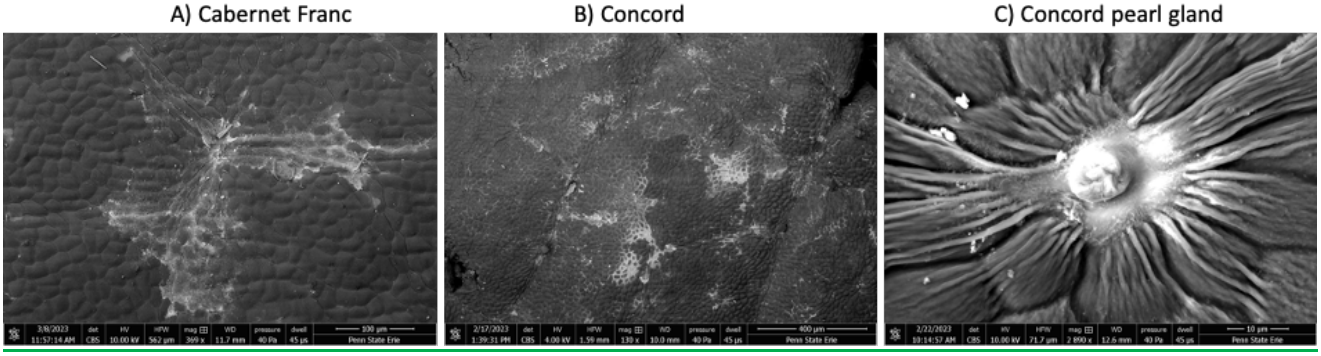

Figure 2. Backscattered electron images that illustrate the deposition of silicon on Cabernet Franc and Concord leaves. In A & B the silicon deposition can be visualized in white color over the epidermis of the leaves. Detail of a pearl gland in a Concord leaf that mobilizes silicon is depicted in C.

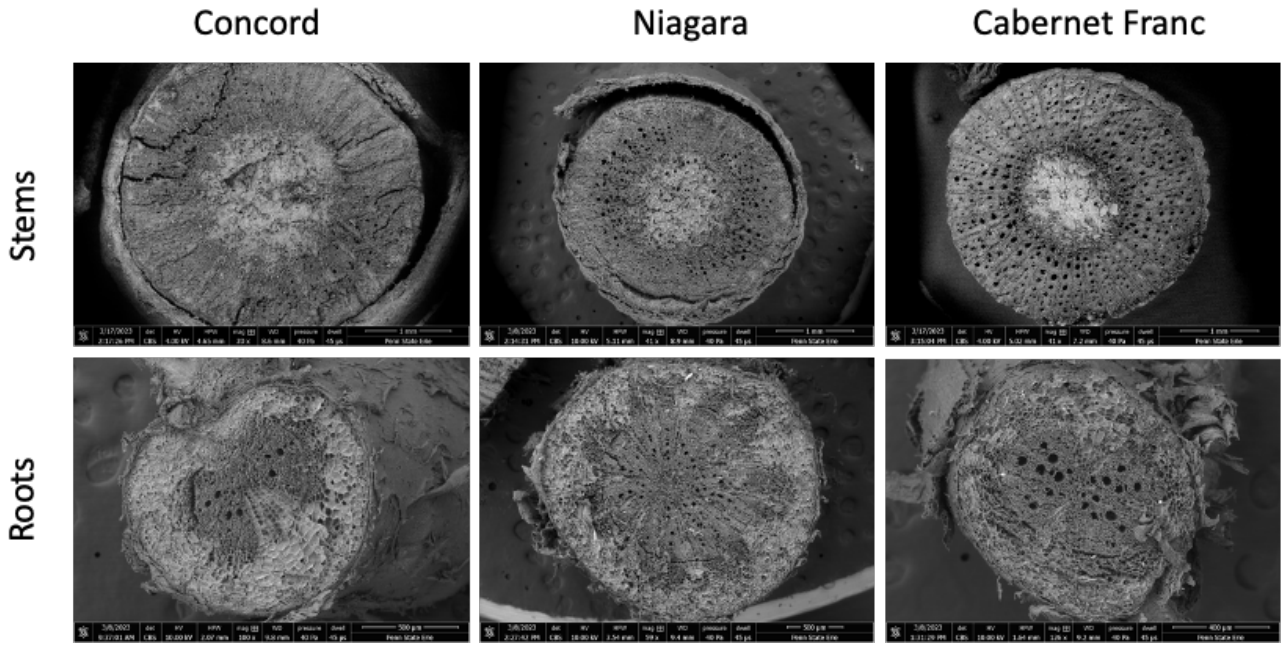

Figure 3. Backscattered electron images of stems and roots from Concord, Niagara and Cabernet Franc grapevines showing no presence of silicon particles.

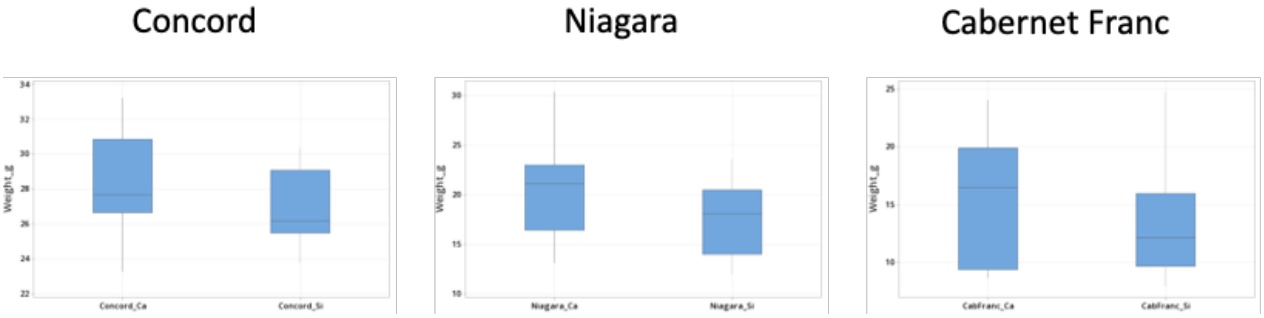

Figure 4. Dry weight of leaves and petioles from Concord, Niagara, and Cabernet Franc grapevines supplemented with either lime (Calcium Oxide CaO) or silicon (Calcium metasilicate CaSiO3).

Table 1. Average concentration of minerals in leaves and petioles from Concord, Niagara, and Cabernet Franc grapevines supplemented with either silicon or lime.

		N	P	K	Ca	Mg	S	Mn	Fe	Cu	B	Al	Zn	Na
Cultivar	treatment	%	%					mg/kg						
Concord	Si	1.79	0.37	1.45	0.86	0.16	0.11	84.89	36.49	4.19	33.65	9.46	11.15	882.80
Concord	CaO	1.72	0.40	1.34	0.95	0.18	0.10	98.19	35 .81	4.14	30.02	9.04	12.04	753.90
Niagara	Si	1.92	0.55	1.60	1.43	0.26	0.13	101.75	57.49	6.58	27.50	17.04	15.47	462.70
Niagara	CaO	1.93	0.41	1.37	1.16	0.27	0.13	136.7	52.89	5.85	27.5	14.31	14.99	577
Cab Franc	Si	1.56	0.37	1.90	1.56	0.26	0.16	77.67	49.2	5.95	43.07	9.98	23.24	682.1
Cab Franc	CaO	1.78	0.39	2.00	1.63	0.24	0.16	88.81	58.98	6.42	39.88	9.62	23.62	647.5

SECTION 3:

Project summary and objectives:

Many plant species uptake and accumulate silicon in their tissues. In many of them, silicon increases plant resistance to insects and pathogens, these plants benefit from silicon supplementation applied to the roots or

as a foliar spray. The benefits of applying silicon to grapevines is not well supported. Thus, this proposal aimed to 1) determine the ability of Concord, Niagara, and Cabernet Franc to accumulate silicon in different tissues, 2) test the effect of silicon supplementation on grapevine health, and 3) to determine the effect of silicon supplementation on leaf dry weight and mineral uptake in potted vines.

Importance of research to the NY wine industry:

This proposal helps determine if silicon supplementation could be helpful in vineyards.

Project Results/next steps:

Concord, Niagara, and Cabernet franc uptake and accumulate silica in leaves after its application to the roots. Silicon supplementation did not affect the uptake of other nutrients from the soil and did not influence the dry weight of grapevine leaves. Unfortunately, under our experimental conditions, we didn't find a positive effect of silicon in protecting potted vines against powdery and downy mildew. More research could help us understand the role that silicon supplementation may have in grapevine protection against various stressors.

Supporting attachments:

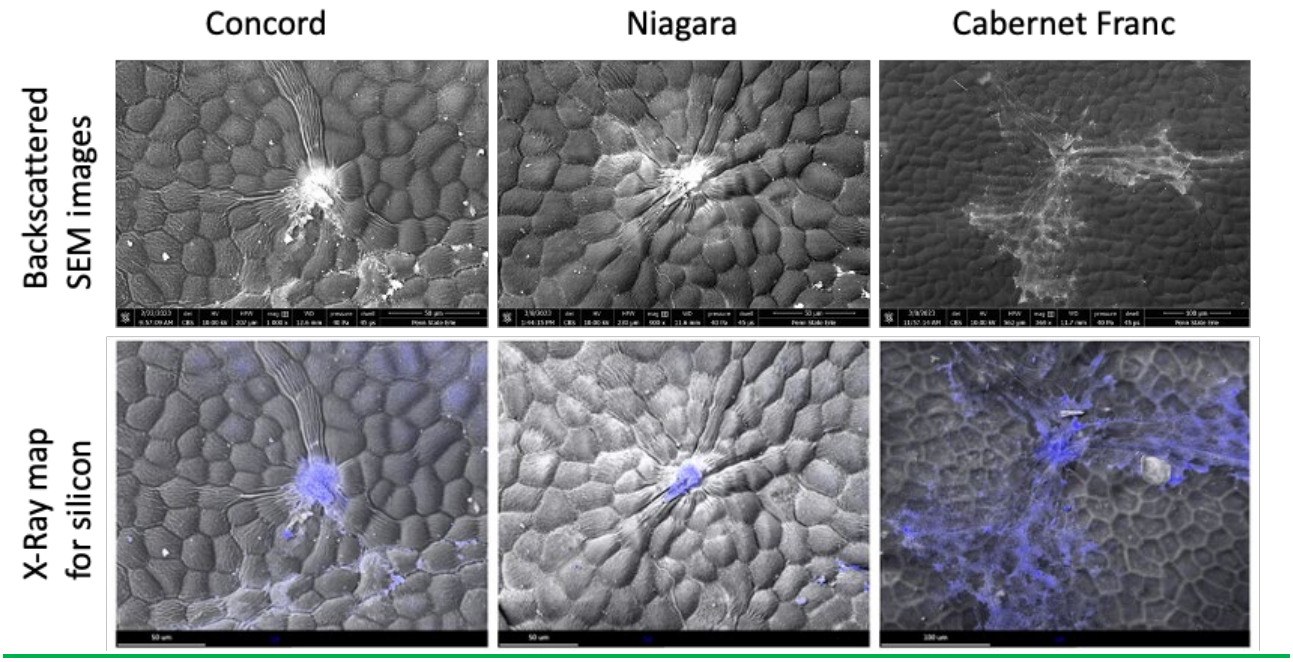

Figure 1. Deposition of silicon on leaves of Concord, Niagara, and Cabernet Franc. In the top images, the deposition of silicon can be visualized in white color. The lower images are x-ray maps of the distribution of silicon colored in blue.