Bioavailable silicon: release rate from additives & substrates

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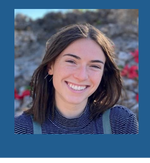


Introduction

Liquid fertilization is often used to supply silicon (Si) (Boldt & Altland, 2021), but Si is minimally soluble. Media components that provide a steady release of Si are valuable.

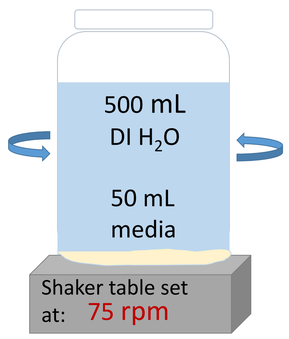
There are many options for Si media amendments, but Si release rate is not well characterized.

Our objective was to quantify Si release from media components to achieve a steady-state Si release as mono-silicic acid (H_4SiO_4) over time.

Methods

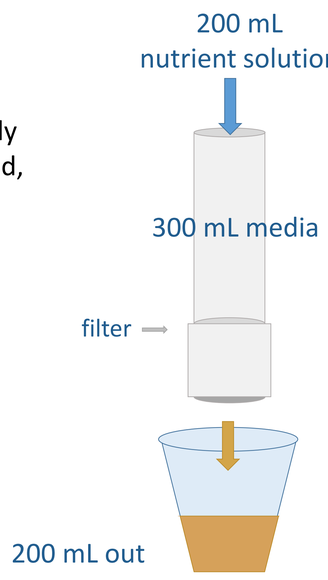
Release in water

-50 mL media or additive added to 500 mL DI water.
-Sample filtered and diluted; DI water replaced weekly.
-Heteropoly blue method to measure mono-silicic acid in solution (Eaton et al., 2005). Comparison with ICP-OES was 96.5 +/- 3% STDEV.



Release in media

-Flushed twice weekly
-Leachate was filtered, and diluted for colorimetric measurement.
-Leachate pH measured.



LaMotte® silica low range test kit (3664-SC) and colorimeter were used.

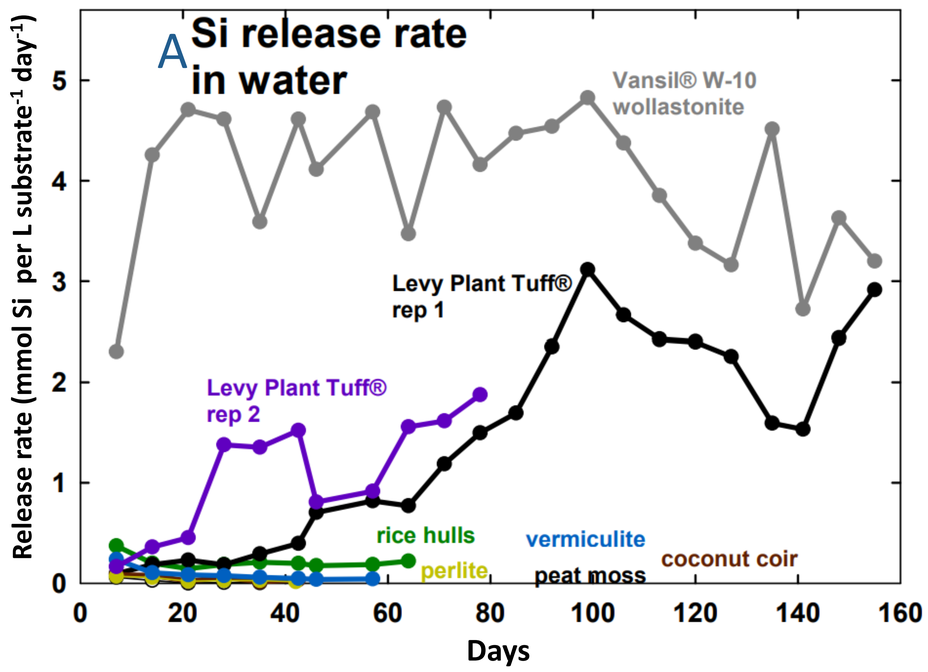


Fig. A (right): Release rate of Si in water from twelve Si amendments and substrates were tested (nine graphed). Media components with steady Si release rates were terminated after 60 days. Levy Plant Tuff® is variable in particle size.

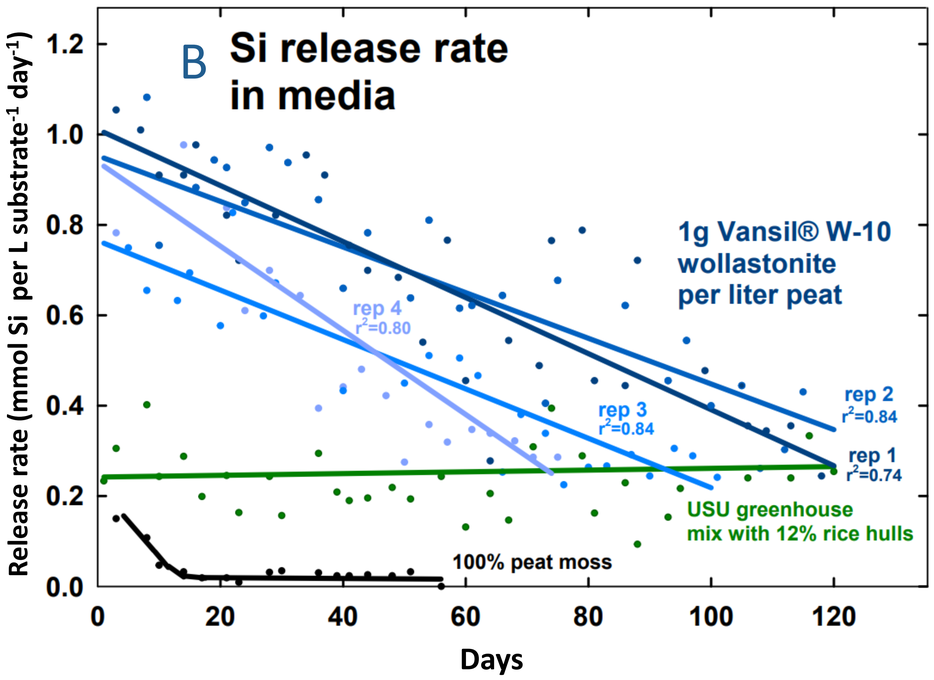


Fig. B (left): Release rate of Si from peat-based media with Si amendments. USU greenhouse mix is comprised of 75% peat moss, 13% vermiculite, 12% rice hulls, wetting agent, and hydrated lime to adjust pH to 6.0.

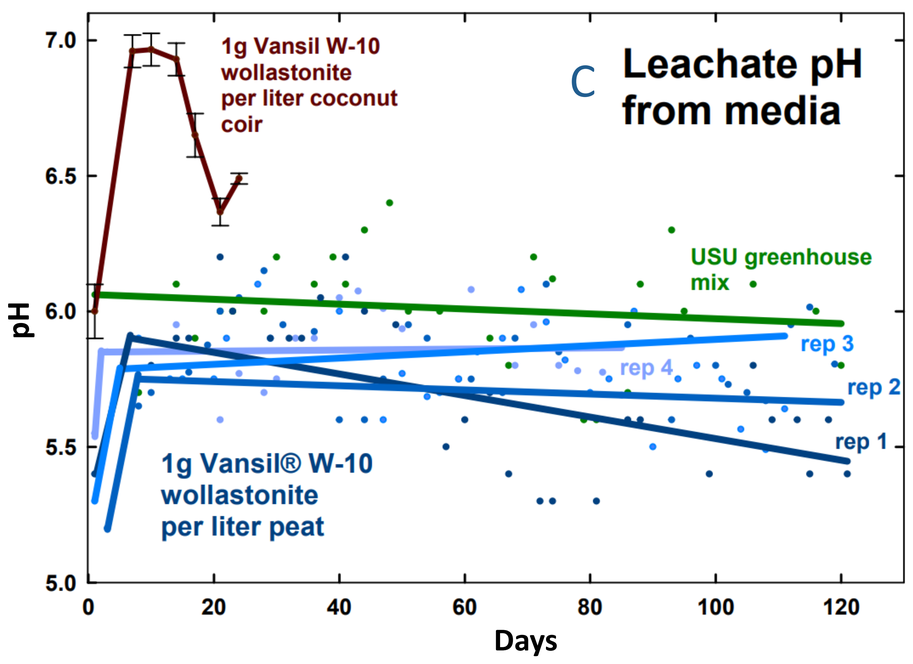


Fig. C (right): The dissolution of wollastonite (Vansil® W-10) increased pH by about 0.5 units in peat-based media and 1.0 unit in 3 replicates of coconut coir-based media over the first 7 days.

Results

Release in water	Avg. mmol Si per day	
Substrates or additives	per liter	per kg
Vansil® W-10 wollastonite:	**4.23**	**5.26**
Levy Plant Tuff® rep 1:	1.48	0.75
Levy Plant Tuff® rep 2:	1.09	0.57
Rice hulls:	0.21	1.53
NaturalDE® diatomaceous earth:	0.31	0.86
Axis® diatomaceous earth:	0.26	0.59
Vermiculite:	0.06	0.41
Sandstix® play sand:	0.08	0.05
Ottawa sand:	0.03	0.02
BDH® sand (30-40 mesh):	0.03	0.02
Coconut coir:	0.05	0.39
Perlite:	0.02	0.12
Peat:	0.01	0.08

-Levy Plant Tuff® started releasing rapidly after 20 to 40 days, but caused an alkaline pH (~10.3; data not presented).

Release in media

- 1 g wollastonite per liter peat had a release rate 4x greater than 12% rice hulls, but decreased over time.
- Wollastonite ($CaSiO_3$) dissolution increases pH as it reacts with water:

$$CaSiO_3 + 3H_2O \rightarrow Ca^{2+} + H_4SiO_4 + 2OH^-$$

- It is unknown why the pH of peat and coconut coir-based media with wollastonite did not increase over time.
- Analysis of basil and sunflower grown for 6 weeks with 1.17g wollastonite per liter of media indicated no biologically important increases in leaf concentration of nine heavy metals.

Conclusions

- Rice hulls steadily released Si in both water and media.
- Wollastonite had the highest release rate, and caused an increase in media pH in the first week.
- Peat, coconut coir, perlite, and vermiculite minimally released Si.
- Diatomaceous earth products are expensive and release similarly to rice hulls.
- Levy PlantTuff® had an inconsistent release rate.

Literature Cited

Boldt, Jennifer K. and James E. Altland. "Petunia (*Petunia ×Hybrida*) Cultivars Vary in Silicon Accumulation and Distribution." *HortScience*, vol. 56, no. 3, 19 Jan. 2021, pp. 305–312., doi:10.21273/hortsci15486-20.
Eaton, Andrew D., and Franson Mary Ann H. Standard Methods for the Examination of Water & Wastewater: Centennial Edition. 21st ed., American Public Health Association, 2005.

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