Phytolith stock of a 26-yr volcanic ash soil in Tarlac, Philippines

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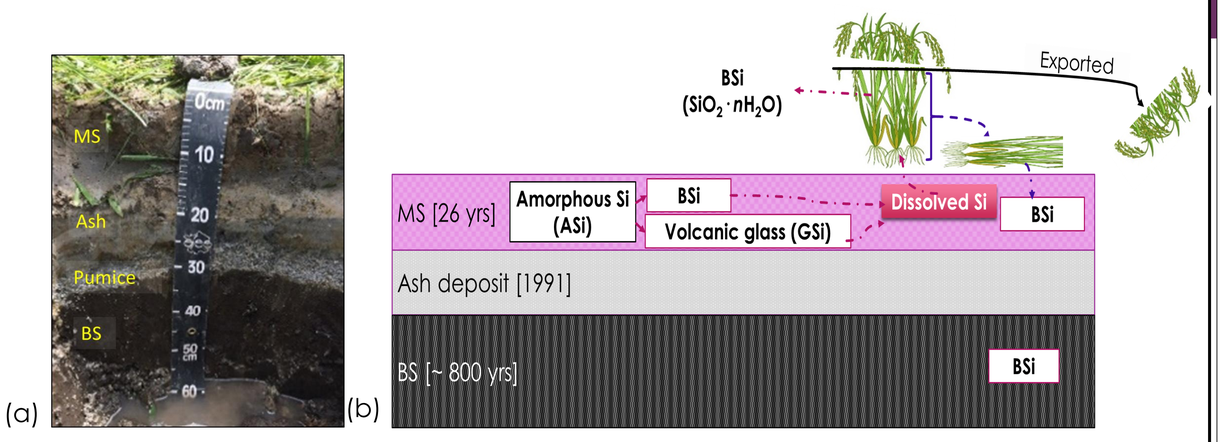
Introduction

- The impact of soil burial by tephra (< 2 mm) on silicon (Si) biogeochemical cycle in the soil-plant system is not well known.
- Silicon improves rice resistance to biotic and abiotic stresses. Rice is a well-known accumulator of BSi.
- The study focuses on phytoliths (BSi) in a rice-cultivated area affected by the 1991 eruption of Mt. Pinatubo, Philippines.
- We compare the BSi content in *(i)* the modern soil (MS) that has been developing from the 1991 dacitic ash deposit and cultivated with rice for 12 years (2005-2017), and *(ii)* the older (~ 800 yrs) volcanic ash soil (BS) that was buried by the deposit and cultivated with rice from 1979 to 1991 (Fig. 1).



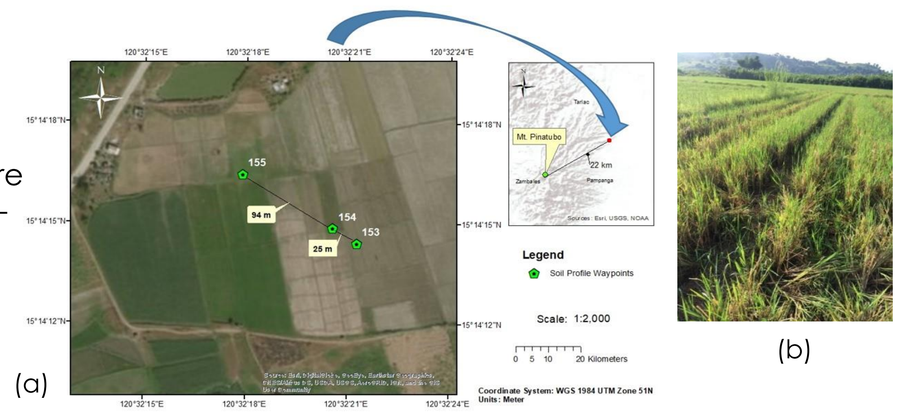
(a) (b)

Figure 1. Photo of a typical soil profile (a) and sketch of BSi cycle 26 years after 1991 Pinatubo eruption (b)

Materials and Methods

1 Sampling

Three soil profiles and rice straw samples were collected from an ash-affected irrigated rice soil (Fig. 2).



(a) (b)

Figure 2. Location map of the sampling site (a) and rice sheath biomass left after harvesting (b)

2 Laboratory extractions

Soil → ASi (BSi + [1]GSi) extraction from soil's silt-size fraction through densimetric separation using heavy liquid (Na-polytungstate)

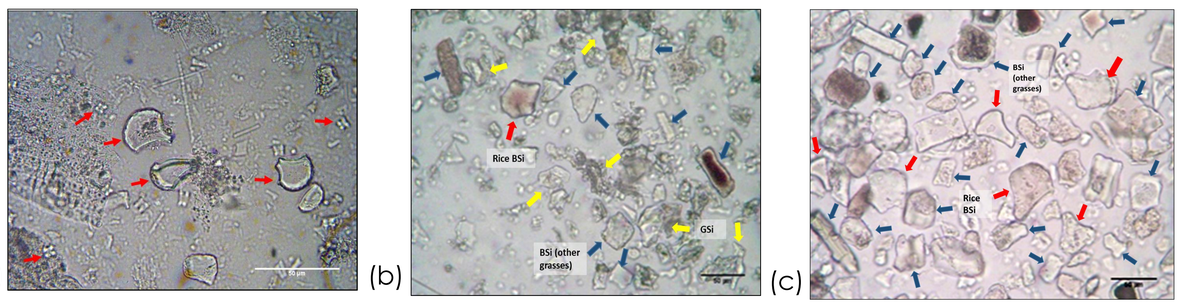
Plant tissue → BSi extraction from rice sheath biomass through digestion at 120°C using HNO_3 and H_2O_2 (70:30 vol.)

Microscopic observation of phytolith assemblage → Estimation of percent abundance (Hodgson, 1978) and weight equivalence

[1]GSi was also extracted due to similar density (≤ 2.3 g cm^{-3}) as BSi

Results

- Average phytolith content of rice sheath biomass is 13 % (dry matter wt.).
- Rice BSi morphologies observed were sheet element dumbbells with scooped ends (~ 10 µm), and rice cuneiform (fan-shaped) bulliform (~ 40 µm) (Fig. 3).



(a) (b) (c)

Figure 3. BSi assemblage in rice sheath (a), MS (b), and BS (c)

- BS has higher ASi (BSi + GSi) at 294 g m^{-2} compared to MS (56 g m^{-2}).
- Abundance of rice BSi in MS (0.9 %) and BS (1.0 %) are comparable, however, MS has higher GSi (70 %) and lower total BSi, consisting of rice BSi plus BSi from other grasses, (60 %) than BS with 7 % GSi and 96 % total BSi (Fig. 4).

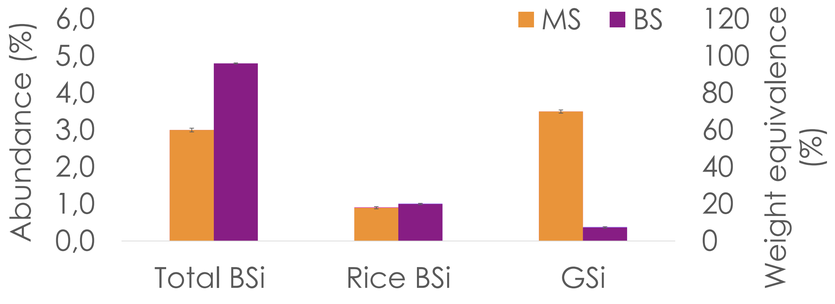


Figure 4. Average abundance and weight equivalence of BSi and GSi in MS and BS

Discussion

- The predicted rice BSi content in the MS and BS were 30-56 and 2-6 times higher, respectively, compared to the measured rice BSi (Table 1).

$$[2]\text{Predicted BSi stock (g m}^{-2}) = \frac{\text{Rice biomass returned to soil (g m}^{-2})}{\text{Rice BSi content (\%)}}$$

[2]Assumptions:

- ✓ % Biomass recycled back to the soil: 70 % (mainly rice sheath)
- ✓ Moisture content of rice biomass: 37 %
- ✓ Biomass incorporated (dry matter): 91-130 g m^{-2} at 2-3 seasons yr^{-1} (MS); 52-78 g m^{-2} at 2 seasons yr^{-1} (BS)
- ✓ Dissolution rate of BSi (pH 5) is negligible (1 x 10^{-15} mol m^{-2} s^{-1} , Fraysse et al. 2006)

Table 1. Measured ASi (BSi + GSi), rice BSi and predicted BSi stocks (g m^{-2}) in a rice soil buried by ash

Horizon	Measured ASi (BSi + GSi)	[3]Measured rice BSi	[4]Predicted BSi
MS	56	12	280 / 599
BS	294	67	167 / 250

[3] Based on % abundance and weight equivalence of rice BSi from measured ASi

[4] MS: 91 g m^{-2}, 2 seasons yr^{-1} / 130 g m^{-2}, 3 seasons yr^{-1}; BS: 52 g m^{-2}, 2 seasons yr^{-1} / 78 g m^{-2}, 2 seasons yr^{-1} (BS)

Conclusions

- A high rice BSi stock is preserved in the BS which is about 6 times higher than in MS, but the reason for this is not yet known.
- The measured BSi in the MS being lower in magnitude (~ 37x) than the predicted stock may be attributed to underestimation since clay-sized and broken BSi were not accounted.
- A method to separate GSi from BSi should be developed in order to quantify the stock of BSi in young volcanic soils.

References

Fraysse, F., Pokrovsky, O.S., Schott, J., & Meunier, J.D. (2006). Surface Properties, Solubility and Dissolution Kinetics of Bamboo Phytoliths. *Geochimica et Cosmochimica Acta 70(8)*: 1939–51.

Hodgson, J M (1976). Soil survey field handbook : describing and sampling soil profiles. *Soil Survey of England*, Harpenden.