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OrganoRice

Silicon fertilization in organic rice production: its role in increasing yield and reducing heavy metals in rice

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Why silicon (Si)?

Si: >1% dw of major crops like rice (4.2%), wheat (2.5%), soybeans (1.45%), etc.

non-essential but beneficial for (graminaceous) plants:

- Increases plant resistance to abiotic and biotic stresses:
  - Drought
  - Salinity
  - Heavy metals
  - Pathogens
  - Pests
- Improve crop growth and yield, as well as nutrient use efficiency

Si in soil >30% w. but why still need Si fertilization?

- Low availability – only available form to plants is monosilicic acid (H_4SiO_4)
- Large removal after harvest

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Screening of heavy metals

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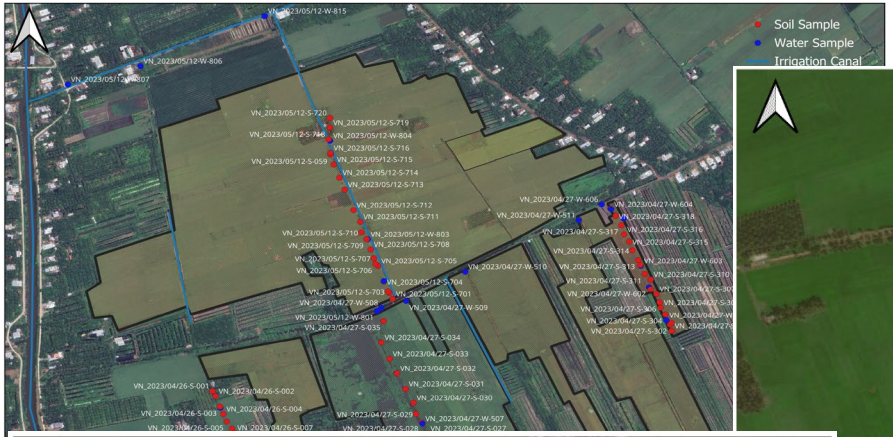

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Screening of heavy metals

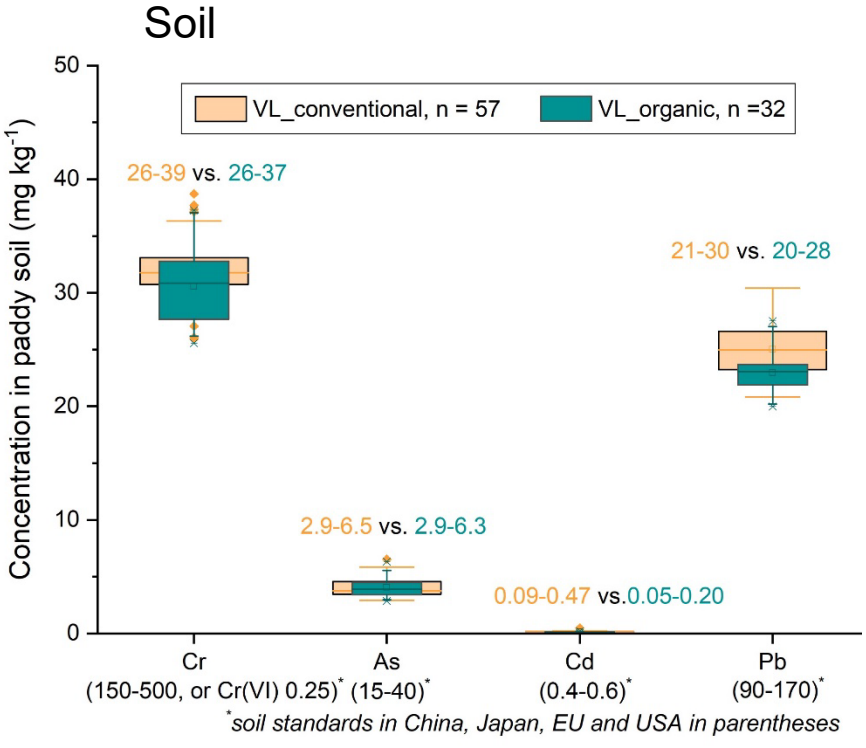

Figure 1. Concentration of heavy metals of interest in the soil of conventional (C) and organic (O) paddy fields in Vinh Long Province

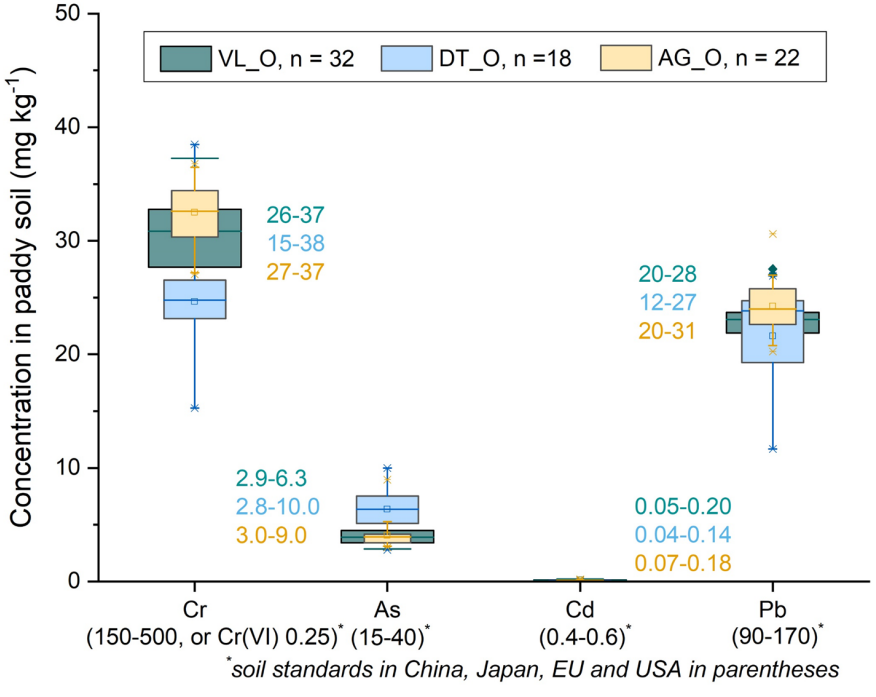

Figure 2. Concentration of heavy metals of interest in the soil of organic paddy fields in Vinh Long (VL_O), Dong Thap (DT_O), and An Giang (AG_O) Provinces

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Screening of heavy metals

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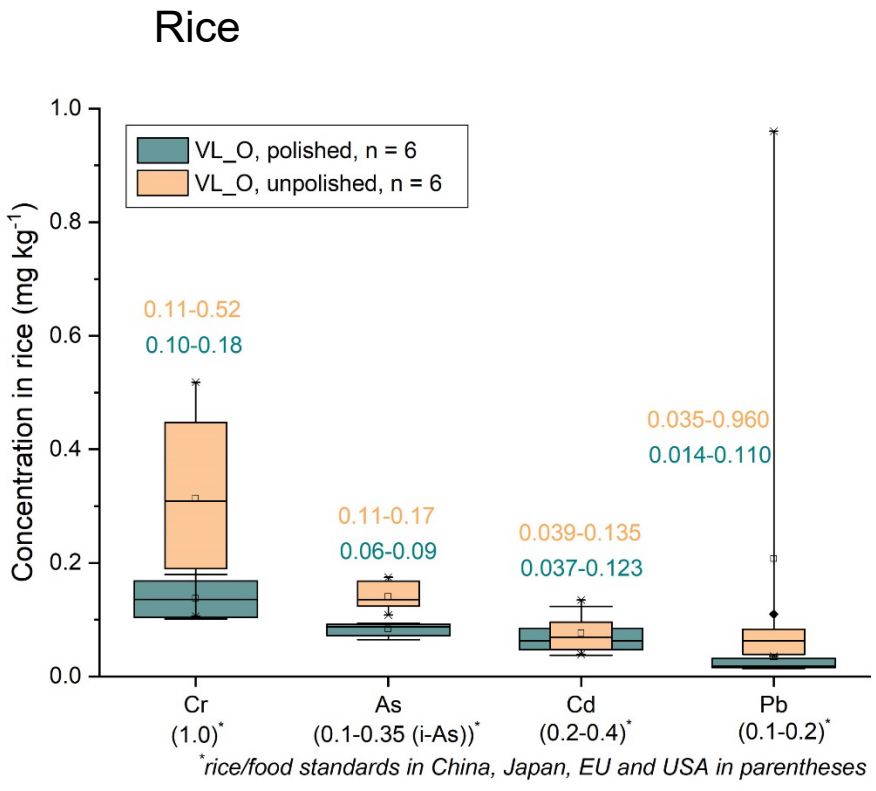

Figure 3. Concentration of heavy metals of interest in the rice products from organic paddy fields in Vinh Long Province

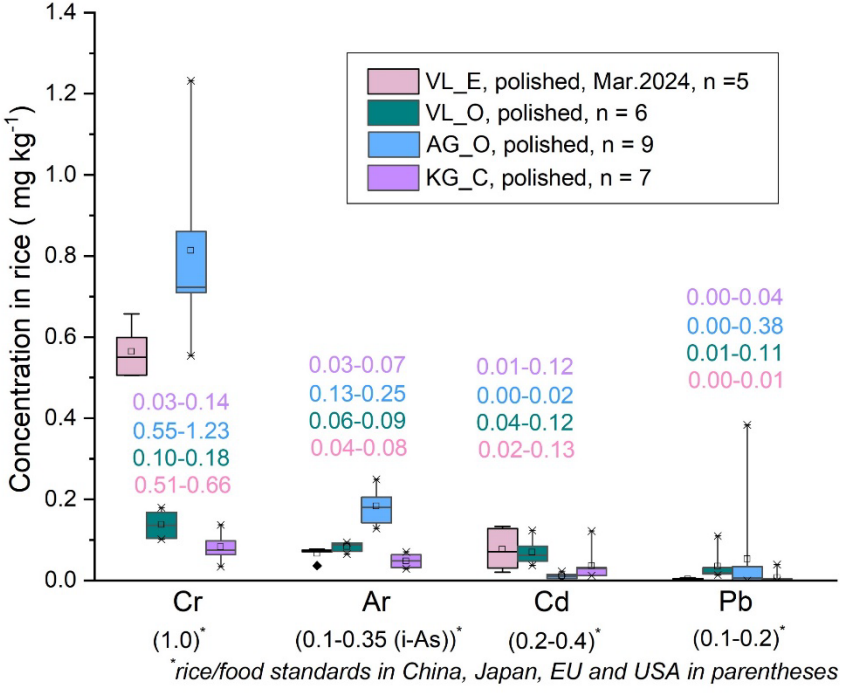

Figure 4. Concentration of heavy metals of interest in polished rice grains from conventional or organic paddy fields in Vinh Long (VL_E, VL_O), An Giang (AG_O), and Kien Giang (KG_C) Provinces

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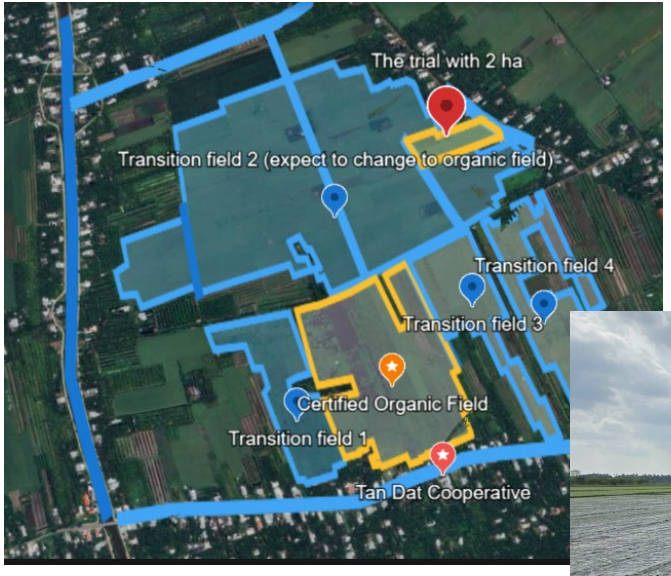
Si fertilization field trials

Vinh Long

Acknowledgement to Dr. **Dang Duy Minh and the Can Tho University team**



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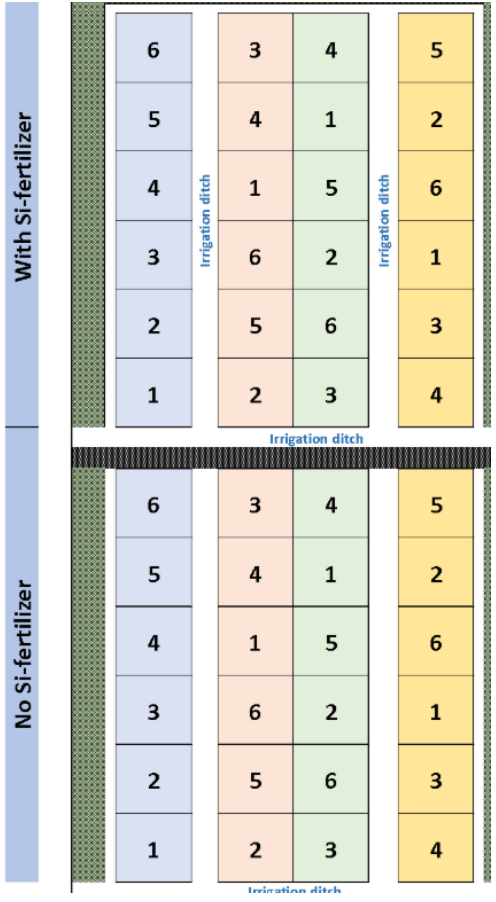
Si fertilization field trials



Organic fertilizers experimental treatments includes:

(1) Control
(2) Chicken manure compost (20 kg/1,000 m^2)
(3) Earthworm vemi-compost (50 kg/1,000m^2)
(4) Microbial Organic compost from fishery processing by-products (170 kg/1,000m^2)
(5) Organic fertilizer from crop residue (22.5 kg/1,000m^2)
(6) Seaweed extract (50-60 mL/1,000m^2) + humate (2 kg/1,000m^2)

⇒ Each treatment was carried out in 4 replicates, each replicate has an area of ~ 50 m^2.

⇒ 200 kg compost (manure and rice plant residue)/1,000m^2 applied for treatments.

⇒ Without and with Si fertilizer (300 kg/ha)

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Si fertilization field trials

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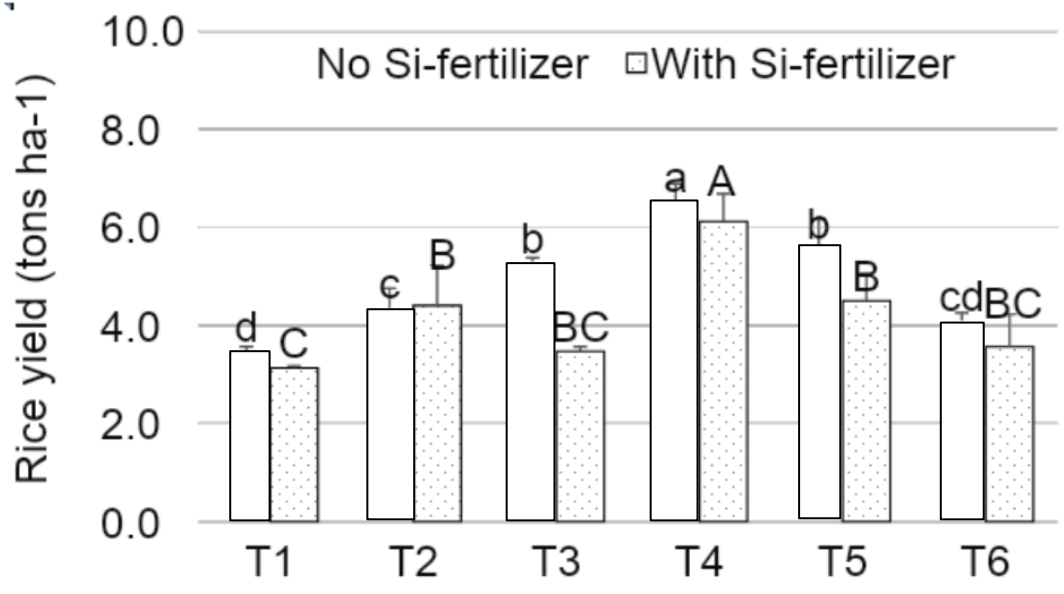
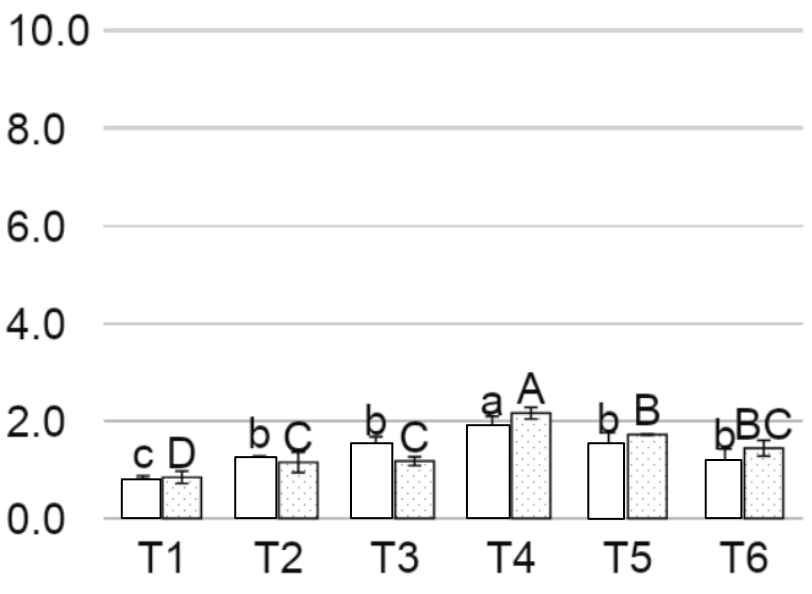
1st Crop



2nd Crop



1. *Control*
2. *Chicken manure compost*
3. *Earthworm vemi-compost*
4. *Compost from fishery processing by-products*
5. *Organic fertilizer from crop residue*
6. *Seaweed extract liquid*

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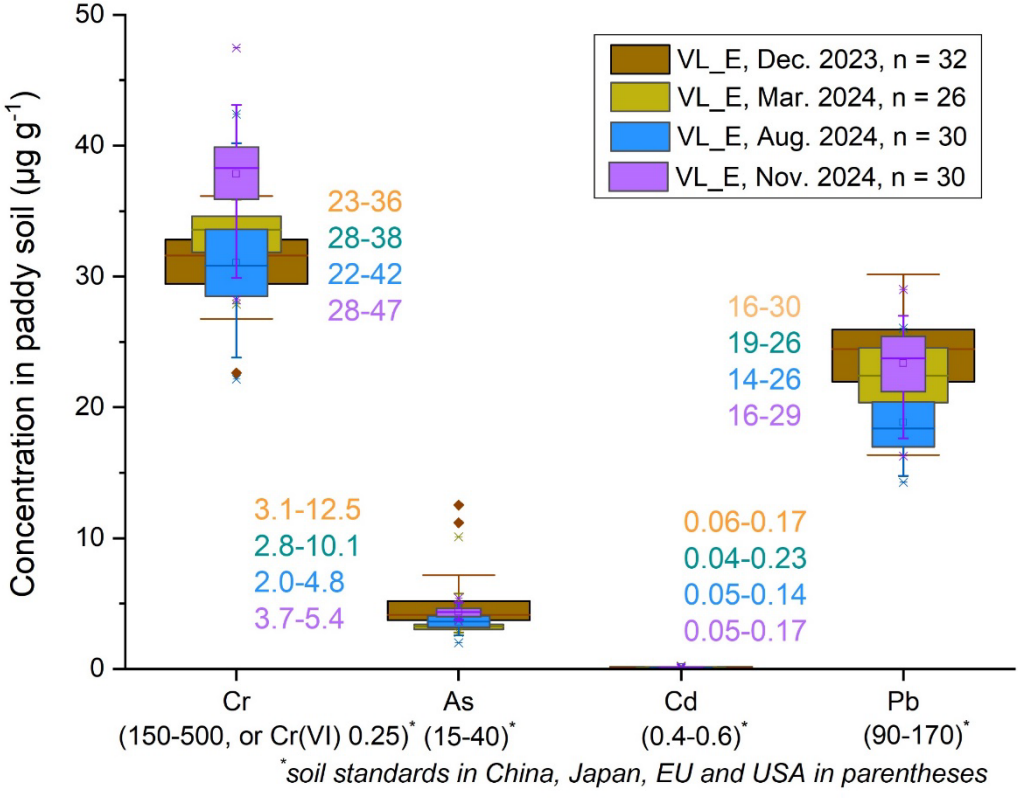
Si fertilization field trials

Soil



Mean and its SD:
As: 4.1±1.5 µg g^{-1}
Cd: 0.11±0.03 µg g^{-1}
Pd: 22±3 µg g^{-1}
Cr: 33±4 µg g^{-1}

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Si fertilization field trials

Organo Rice

Rice	As (µg g-1)	Cd (µg g-1)	Pb (µg g-1)
Control	0.17	0.006	0.11
	0.16	0.002	0.07
Chicken manure compost	0.20	0.003	0.08
	0.17	0.004	0.06
Earthworm vemi-compost	0.19	0.004	0.07
	0.16	0.004	0.04
Microbial Organic compost from fishery processing by-products	0.23	0.004	0.10
	0.20	0.002	0.07
Organic fertilizer from crop residue	0.19	0.004	0.13
	0.17	0.002	0.07
Seaweed extract + humate	0.20	0.004	0.15
	0.16	0.003	0.06

no Si

with Si

FAO/WHO/national limit Vietnam: As: 0.2 µg/g
Cd: 0.2 µg/g
Pb: 0.4 µg/g

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Where does Si go in rice?

Acknowledgement to Dr. **Dang Duy Minh and the Can Tho University team**

^{29}Si-labelling experiment in net-house, CTU

- Enriched $^{29}SiO_2$ (amophorus, abundance of ^{29}Si 99.35% vs. natural abundance 4.7%)
- Treatment: 200 mg $^{29}SiO_2$ + 4 kg soil from VL vs. no $^{29}SiO_2$
- Sampling time:
  - DAS 0: fresh mixture of $^{29}SiO_2$ and soil; day of sowing; 2 pot replicates
  - DAS 5: soil soaked with water for 5 days before transplanting the rice seedlings; 3 pot replicates
  - DAS 70: heading; 3 pot replicates
  - DAS 100: harvest; 3 pot replicates
  - DAS 100 control: soil soaked with water for 100 days without rice plants growing in
- Samples: soil, water, rice

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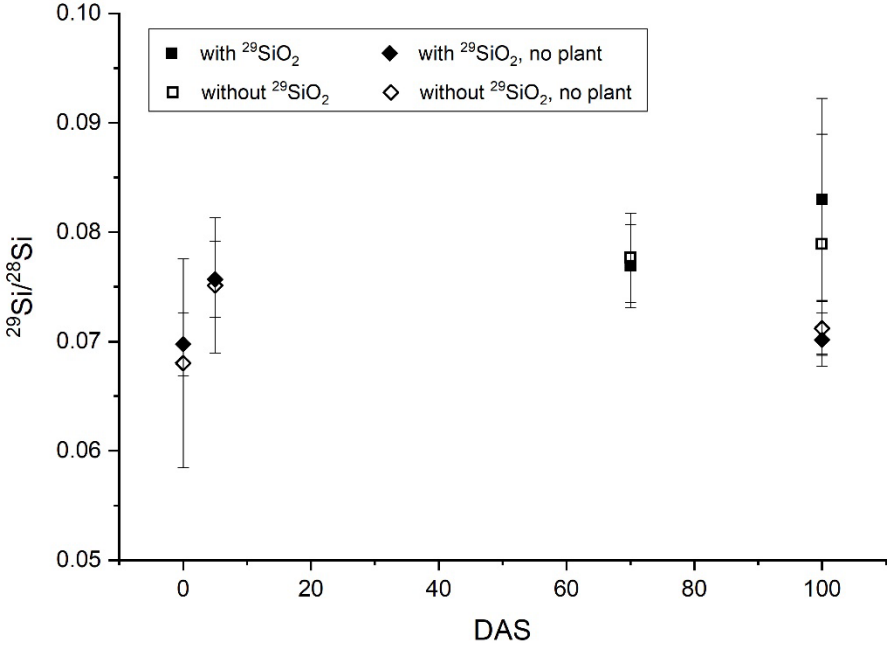
Where does Si go in rice?

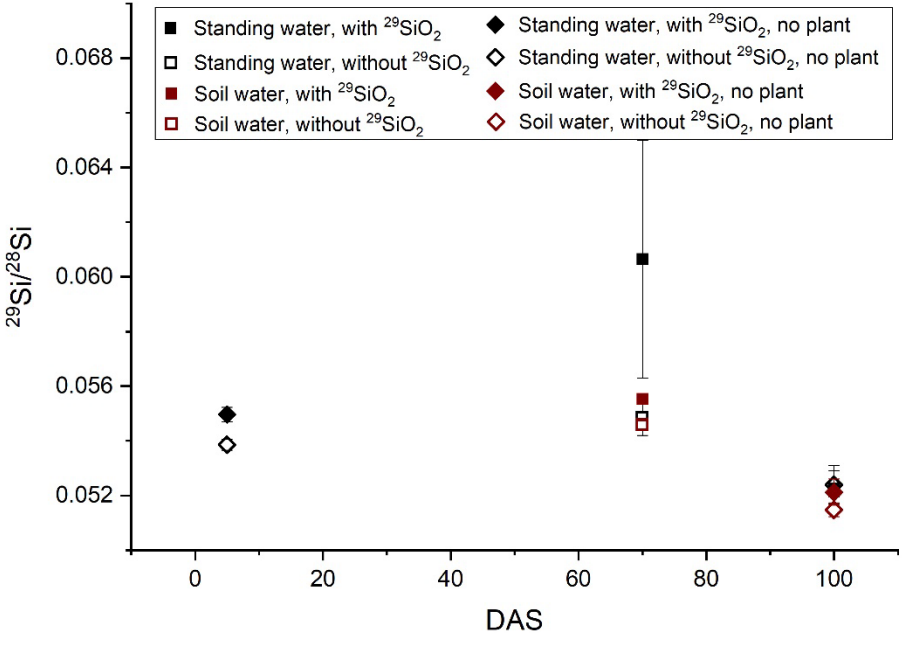
OrganoRice

Preliminary results

Soil (available pool)



Water



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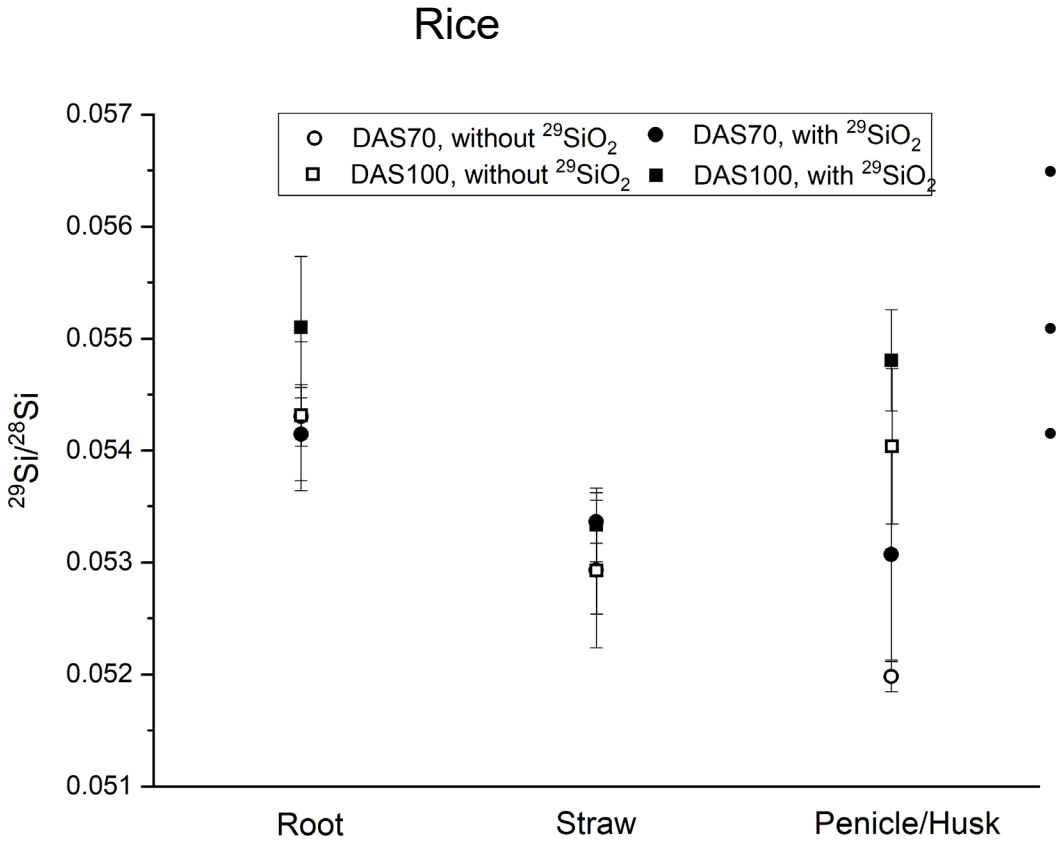
Where does Si go in rice?

Preliminary results



- Highest ^{29}Si-signals in roots and then husk
- Higher ^{29}Si-signals when mature
- Little/No Si in grain

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Learned and To learn

- ✓ The Si fertilizers applied here did not lead to yield increase, at least in the beginning
  - ➢ Insufficient efficiency of the fertilizers? Other forms and application methods?
  - ➢ Co-aplication Si-dissolving microorganisms?
  - ➢ Under what soil conditions would Si fertilization benefit on crop yields?
  - ➢ Biogeochemical processes of Si fertilizers in the paddy system?

- ✓ The Si fertilizers seemed to have reduced the contents of heavy metals in the rice grains
  - ➢ Necessity of Si fertilization in the Mekong Delta?
  - ➢ Adverse impact of added Si fertilizers on soil prosperities and heavy metal contents?

- ✓ The ^{29}Si-labelling experiment showed Si accumulation in the roots and in the husks for its protecting role
  - ➢ Uptake efficiency of Si?
  - ➢ Role of amorphous SiO_2 and other Si minerals in long-term Si availability?

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Thank You

Ear and mind open for questions and suggestions