Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.9367

Decreasing As in rice: Interactions of soil sulfate amendment and water management

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Accumulation of inorganic arsenic (iAs) and dimethylarsenate (DMA) in rice threatens human health and rice yields, respectively. While both water management and soil sulfate amendments can strongly influence the biogeochemistry of iAs and DMA in paddy soils, their mutual impact on rice grain As concentration and speciation remains unclear. In this study, we conducted a pot experiment combining two different water regimes (continuous and intermittent flooding) and soil sulfate amendments (control and +200 mg S/kg soil applied as Na_2SO_4). Porewater composition throughout the experiment, plant growth parameters (including transpiration rate and yield parameters), in-planta elemental distribution (including grain As speciation), and root iron-plaque were analyzed. We found that soil sulfate amendment substantially decreased grain iAs by 44% under intermittent flooding, while only by 25% under continuous flooding compared to the controls. Although sulfate amendment increased porewater DMA concentrations more than 10-fold under intermittent flooding, it increased grain DMA only by 43–68 % and had negligible effects on yield under both water regimes. Irrespective of sulfate amendment, continuous flooding resulted in 46–95 % more grain iAs, 258–320 % more grain DMA, and 47–55 % less yield than intermittent flooding. Thioarsenic species accounted for <5 % of total grain As in all samples. Grain iAs was not related to the porewater composition nor in-planta As sequestration but positively correlated to As in root iron-plaque ($r = 0.92$). The decoupling of DMA in grain and porewater suggests a DMA-producing/releasing process localized in the vicinity of rice roots under continuous flooding. Our results show that combining soil sulfate amendment and intermittent flooding may help secure the quantity and quality of rice produced in As-affected areas. The key role of rhizosphere processes in controlling both iAs and DMA accumulation in rice grain will be discussed.