Organic Arsenic Uptake by Rice: Interactions with Silicon

MATT LIMMER[1*], PATRICK WISE[1], GRETCHEN DYKES[1], ANGELIA SEYFFERTH[1]

[1]University of Delaware, Department of Plant & Soil Sciences, Newark, DE, USA. limmer@udel.edu

Rice, a staple food for much of the planet, readily accumulates arsenic (As), which poses a health risk to consumers. Additionally, As can reduce yields through its toxicity to rice plants. However, the toxicity of As to humans and plants is dependent on the form of As present, which is affected by the subsurface biogeochemistry. The organic As species monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA), while notably toxic to rice, are considered less toxic to humans than their inorganic counterparts. These organic As species are known to be rapidly translocated through the plant, but exact mechanisms of uptake and strategies for reducing uptake remain unclear.

We performed hydroponic and field experiments with rice grown under supplemental silicon (Si), which is an emerging technique to mitigate rice uptake of inorganic As, resulting from the shared transport pathway between Si and inorganic As in rice. When grown under hydroponic conditions, increasing concentrations of Si in the solution resulted in a downregulation in expression of the root Si transporters Lsi1 and Lsi2. Increasing concentrations of Si in the solution also significantly decreased concentrations of DMA in the straw, husk, and grain, suggesting that the Si transport pathway plays a role in rice uptake of DMA. However, in field experiments rice receiving supplemental Si did not show less accumulation of DMA in grain, although Si did decrease total As in the plant. We attribute this difference to complexities in the subsurface biogeochemistry in the field system. In field conditions, inorganic As was also present, which can be microbially methylated to form MMA and DMA. Additionally, Si interacts with sorbed As species which affects their bioavailability. Collectively, while Si appears well suited to decrease rice uptake of inorganic As, the numerous biogeochemical processes that are affected by supplemental Si need to be further studied to elucidate the conditions under which Si can be used to minimize rice uptake of organic As species.