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Protecting rice from coupled impacts of increasing temperatures and soil arsenic

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More than 50% of the global population consumes rice daily, and the demand for rice is increasing [1]. Unfortunately, many rice growing regions have soil and groundwater contaminated with geogenic arsenic (As). The combination of soil As and climate change have *coupled* negative effects on rice yield and grain quality. A recent greenhouse study found that at a temperature increase of 5° C, the worst case scenario projected for the end of the century (38° C, 850 ppmv CO_2), a soil As concentration of 24.5 mg kg^{-1} increased porewater As(III), decreased grain yield by 42%, and doubled inorganic As in grains, to ~400 µg As kg^{-1} grain [2].

Alternate wetting and drying (AWD) water management has the potential to simultaneously decrease As uptake, water use, and methane emissions, without compromising yields [3, 4]. Yet, no studies have explored how rising temperatures and CO_2 will alter the effects of AWD on paddy biogeochemistry and plant response. Successful future implementation of AWD may require more frequent drainage of paddy soil to counteract increased microbial activity resulting in accelerated anaerobic As(V)/Fe(III) reduction. In a rhizotron experiment (each containing 20 kg of Californian soil), AWD with drainage to ~35% volumetric water content every 16 days increased root depth and led to the oxidative regeneration of Fe(III) (hydr)oxides which sequester As. The drainage events decreased porewater As 10 cm below the soil surface under both current and future climatic conditions. However, 25 cm below the surface, the severity of drainage did not limit dissolved As, and higher temperatures exacerbated and accelerated As mobilization at the deeper sampling point. These results reveal that drainage induced oxidative conditions are the dominant control of plant-available As near the surface, but temperature becomes a more significant driver deeper in the paddy soil. Thus, while AWD may continue to be an effective As mitigation strategy, depth- and temperature-dependencies need to be appreciated.

[1] USDA (2022), *Production, Supply and Distribution* database. [2] Muehe *et al.* (2019), *Nature Communications* 10, 1-10. [3] Carrijo *et al.* (2018), *Field Crops Research* 222, 101-110. [4] Li *et al.* (2019), *Agriculture, Ecosystems & Environment* 272, 188-198.