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Silicon cycle in rice paddy fields: insights provided by relations between silicon forms in topsoils and plant silicon uptake

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Silicon (Si) enhances the resistance of plants against abiotic and biotic stresses. The amounts of Si taken up by rice plants typically exceed those of major essential nutrients such as nitrogen and phosphorous. Silicon cycling in paddy fields is, however, still poorly studied. We examined relationships between Si forms in topsoil and plant Si uptake for 4 Vietnamese regions with low, and 3 Philippine regions with high Si availability (10 fields per region). Mean rice straw Si concentrations within regions ranged from 3.0 to 8.4%. For most of the Vietnamese fields they were lower than the critical value of 5.0%, suggesting a Si limitation of plant growth. For fields with low Si availability, straw Si concentrations were positively related to acetate-extractable Si in topsoil (i.e. dissolved and adsorbed Si), while such a relationship was not found for fields with high Si availability, where straw Si concentrations were on a similar level, suggesting a maximum Si uptake capacity was reached. Mean annual Si uptake by rice within regions ranged from 0.31 to 1.40 Mg Si ha-1 year-1, i.e. values that are much larger than published values for other ecosystems. They are determined by the continuous supply of plant-available Si during the cropping season, biomass production, and number of crops per year. Weatherable silicate minerals mainly cause spatial differences in supply of plant-available Si. Regional means of concentrations of carbonate-extractable Si (i.e. amorphous Si oxides) ranged from 2.2 to 16.7 g Si kg-1. Input of phytoliths (amorphous Si bodies in straw) is presumed to be an important factor for storage of carbonate-extractable Si in topsoil. Laboratory incubation experiments showed positive relationships between concentrations of carbonate-extractable Si and the release of dissolved Si from soil, suggesting amorphous Si oxides are among the most soluble Si-containing solids in soil. Estimates suggest that up to ∼20% of Si taken up by plants might derive from dissolution of phytoliths. Recycling of straw may thus advance the stress resistance of plants in regions of low Si availability.