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Redox Cycling of Plant-Derived Coumarins by Soil Bacteria

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Iron is an essential micronutrient for plant growth; however, despite its abundance in soils, it is predominantly present as insoluble iron oxides with low bioavailability at circumneutral pH. Numerous dicot plants, including the model plant *Arabidopsis thaliana* and many major crops (e.g., soybean, tomato, and sunflower) produce coumarins, redox-active secondary metabolites that aid in iron acquisition and regulate microbial community structure at the plant root. The fate of coumarins in soils and the extent to which they are transformed by natural microbial communities is poorly understood. We tested the hypothesis that bacteria might be able to redox-cycle coumarins, thereby regenerating and maintaining an active pool of reduced coumarins capable of reacting with iron oxides. To evaluate this, we electrochemically characterized and oxidized the model coumarin fraxetin and conducted short-term incubations with the soil-dwelling bacteria *Pseudomonas aeruginosa* and *Pseudomonas synxantha.* Experiments were conducted with both wild-type and their Δphz-null mutant strains that are unable to produce extracellular redox-active metabolites such as phenazines to decouple metabolite-mediated vs cellular reduction. Because oxidized fraxetin is unstable at circumneutral pH, coumarin reduction and reversibility were monitored using real-time absorbance measurements and cyclic voltammetry under anaerobic conditions. Results show that all strains tested, regardless of their ability to produce extracellular redox-active molecules, reduced oxidized fraxetin, providing proof-of-concept evidence for a potential cross-kingdom redox interaction between plants and microbes that may play an important role in plant iron acquisition.