Plant manipulation, control and oxidative digestion of seed-vectored bacteria in the rhizophagy cycle symbiosis

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Plant manipulation, control and oxidative digestion of seed-vectored bacteria in the rhizophagy cycle symbiosis

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Plant seeds carry a community of symbiotic bacteria on surfaces of and within seeds. When a seed germinates bacteria are triggered to colonize root and shoot meristems and become distributed throughout the plant; simultaneously bacteria colonize the rhizosphere where they reduce growth of soil pathogens and suppress colonization of seedlings by pathogenic fungi. Bacteria internally colonize cells of the plant—in roots colonizing root cells to establish the 'rhizophagy symbiosis'. In the rhizophagy symbiosis plants obtain nutrients from bacteria that alternate between a root intracellular endophytic phase and a free-living soil phase. Bacteria acquire soil nutrients in the free-living soil phase; nutrients are extracted from bacteria oxidatively in the intracellular endophytic phase. Plants manipulate and control these bacteria by: 1) stimulating bacterial growth around root tip meristems of seedlings, 2) triggering bacteria to become intracellular in root cells at the root-tip meristem, and 3) subjecting bacteria to root-produced superoxide to extract nutrients from them. We conducted experiments on seed-vectored bacteria using seedlings of several plant species. We found that bacteria grow on the rhizoplane in the exudate zone behind the root meristem. Bacteria enter root tip meristem cells—locating within the periplasmic space between cell wall and plasma membrane. In the periplasmic spaces of cells bacteria convert to wall-less L-forms. As root cells mature, bacteria are exposed to reactive oxygen produced by NADPH oxidases on root cell plasma membranes. Reactive oxygen degrades some of the intracellular bacteria. Surviving bacteria in root epidermal cells trigger root hair elongation; as hairs elongate bacteria exit at the hair tips, reforming cell walls as they emerge into the rhizosphere where they may obtain additional nutrients. Later, attraction of bacteria to the root tip meristem again places bacteria in position to enter root meristem cells. Experiments involving grass seedlings with and without endophytic bacteria grown on 15N-labeled proteins suggest that rhizophagy symbiosis could account for 30% of the nutrients absorbed by grass roots.