How plants use microbes to help them extract nutrients from soil

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How plants use microbes to help them extract nutrients from soil

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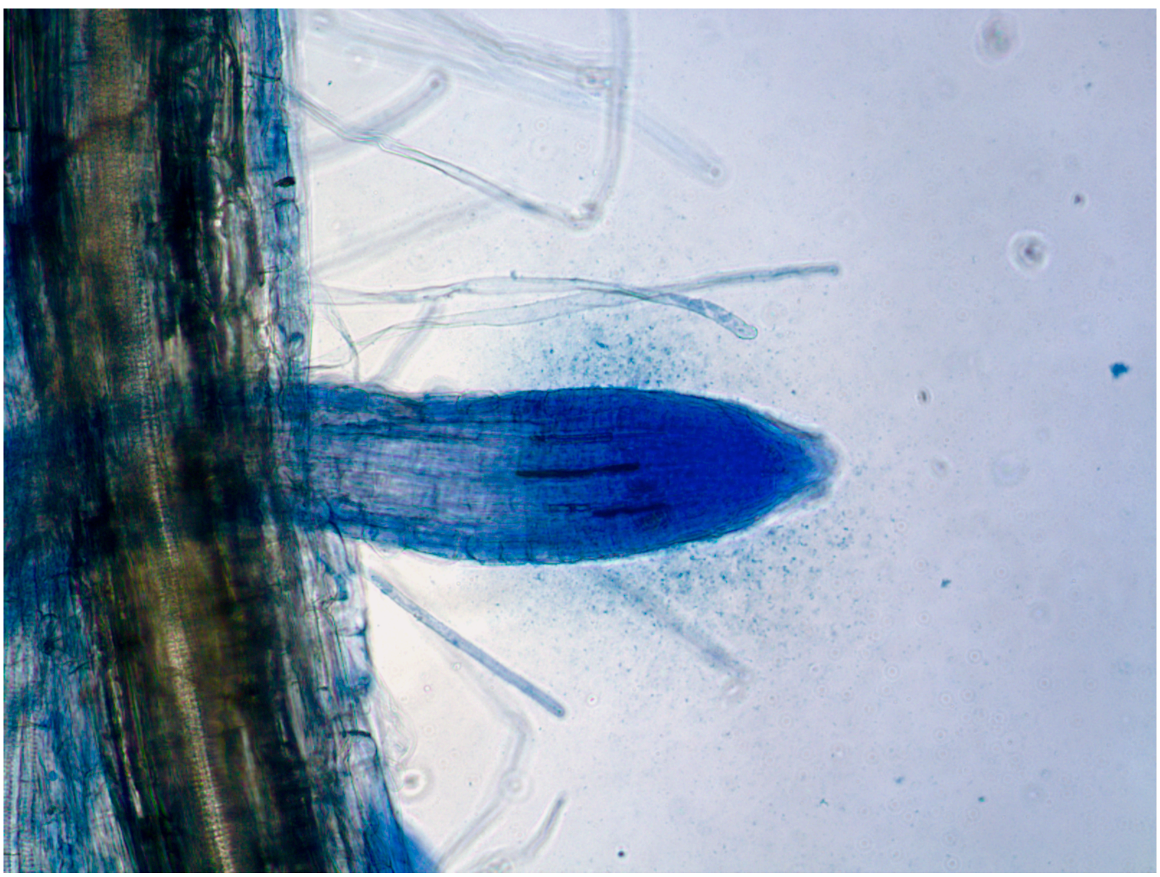

[Photo: The root of *Phragmites australis* - "common reed grass" - with a cloud of bacteria around the root tip where bacteria enter root cells.]

Our research at Rutgers University has shown that plants are able to extract nutrients directly from soil microorganisms in their roots. This nutrient extraction process is outlined in a peer-reviewed article published online in the journal *Microorganisms* (https://doi.org/10.3390/microorganisms6030095). The process is called the 'rhizophagy cycle' (pronounced 'rye-zo-FAY-gee'). In the rhizophagy cycle, microbes cycle between two phases, one phase in soil and the other phase inside root cells. Microbes acquire nutrients in the soil. Those nutrients are extracted from microbes after they enter the plant's root cells through exposure to plant-produced reactive oxygen. Through the rhizophagy cycle, nutrients like nitrogen and minerals are provided to plants directly from soil microbes.

Plants 'farm' soil microbes in the rhizophagy cycle

In the rhizophagy cycle, plants 'farm' bacteria and fungi to get nutrients from them. Initially, microbes grow on plant roots in a zone outside the growing root tips. To cultivate microbes, roots secrete carbohydrates and other nutrients. Microbes then enter the root tip cells and locate themselves in the space between the cell wall and plasma membrane of the root cells. Here microbes lose their cell walls, becoming naked protoplasts. As root cells mature, the microbes are doused with reactive oxygen (superoxide) produced on the root cell plasma membranes. Reactive oxygen degrades some of the microbes, which effectively extracts nutrients from them. Surviving microbes in the root's epidermal cells trigger root hair elongation, and as the hairs elongate, the microbes are ejected from root hair tips, re-forming cell walls as they emerge into the soil. There they may obtain additional nutrients and the cycle begins again. This sustainable cycle occurs in all root tips of plants. Plants with more root tips obtain more nutrients from the rhizophagy cycle.

What does this mean for gardeners?

The rhizophagy cycle shows that plants develop an intimate connection with microbes--to the extent that microbes enter into the plant root cells themselves. Through the rhizophagy cycle plants obtain nutrients--but also the rhizophagy cycle microbes suppress plant pathogens in soils--and increase oxidative stress tolerance in plants. Basically, the rhizophagy cycle results in healthy plants, and without it plants may be poorly developed and more susceptible to disease and stress. The rhizophagy cycle functions automatically in plants most of the time.

Is there something we should do differently now?

Gardeners could encourage functioning of the rhizophagy cycle by increasing microbial activity in the soil with organic amendments. It is possible to suppress the rhizophagy cycle by use of sterilized or chemically treated seeds that remove or inhibit the symbiotic microbes on seeds. This is what happens in cotton where seeds are treated with acids that kill symbiotic microbes leaving seedlings that grow poorly and are vulnerable to diseases. Potting mixes with antimicrobials should probably be avoided because that might inhibit the rhizophagy cycle.

Why are organic gardeners interested in the rhizophagy cycle?

The prevailing view of plant nutrition (dogma) has been that plants only absorb into their roots inorganic nutrients (like nitrates or phosphates) that are soluble in soil water. However, organic gardeners have long believed that increasing organic material in soils results in better plant growth--and that plants somehow get nutrients from the soil organics. The rhizophagy cycle shows how plants get nutrients from organic materials added to soils in providing a linkage between soil organic material, soil microbes, and plants. In the rhizophagy cycle, symbiotic microbes go from plants into the soil, acquire nutrients of various kinds, and carry nutrients back to plants, enter plant root cells where plants oxidatively extract nutrients from microbes, then plants deposit microbes back into the soil from tips of root hairs to continue the cycle.

Is it just more evidence of the benefits of a healthy, living soil or is there something more to it?

The rhizophagy cycle is definitely more evidence that healthy soils with diverse microbes and organic materials are better for plants--but also microbes that vector on seeds are important. Many of the seed microbes function in the rhizophagy cycle, so we want to conserve the microbes on seeds. In addition--we may be able to learn how to manage the rhizophagy cycle so that we can increase plant growth significantly without use of inorganic fertilizers--or with minimal use of inorganic fertilizers. Some of the rhizophagy microbes increase growth of their particular host plant--but inhibit growth of other plant species. Here, we may be able to develop these microbes into 'bioherbicides' to favor growth of some plants, but inhibit weedy plants. In the future it may be possible to cultivate plants using only microbes to increase plant growth, and suppress diseases and weeds.

Reference

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