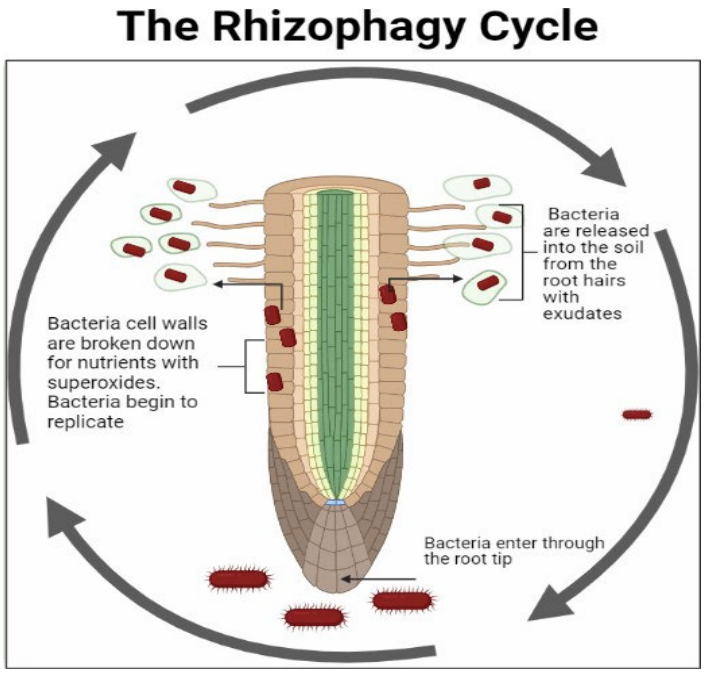
Rhizophagy: Root Interactions with Soil Microbes

Previous knowledge about plant microbe interactions hypothesized that microbes and the roots form a beneficial relationship to provide each other with nutrients. Current research by Dr. James White at Rutgers University has shown that roots absorb microbes in the rhizophagy cycle. The name rhizophagy comes from a Latin word that means “root eating”.



Microbes enter the root

Microbes are attracted to the root tip and produce ethylene, a plant hormone, and the roots give off exudates to the microbes. The microbes then enter the root cells at the tip where cells are dividing, and microbes are trapped between the cell walls of the roots. The root cells then produce super oxides to break down the cell wall of the microbes and this process extracts nutrients that the microbes carry.

Microbes respond by secreting an antioxidant in the forms of nitrogen, nitic oxide, which combines with the superoxide to form nitrate (NO_3^-) that can be absorbed by the root cells. The microbes cannot stop secreting nitrogenous antioxidants or else they will be degraded by the superoxide. Microbes that do not produce antioxidants will be dissolved or “eaten” by the roots during the production of superoxide.

The rhizophagy process causes the microbes to replicate quickly and creates more bacteria within the root that are fixing nitrogen to rebuild their proteins. The microbes that repopulate the soil are ones that function well in the rhizophagy cycle by giving off nutrients during the superoxide process.

Exiting the root hairs

Dr. White’s research shows that roots do not form root hairs without the presence of microbes. Without microbes, the root does not grow properly in the soil because their gravitropic response is skewed so roots stay near the surface. Microbes produce ethylene, a plant hormone, which causes the root hair to elongate and mature. The production of ethylene by microbes drives the formation of root hairs.

The process of cyclosis moves nutrients from microbes to plant cells and moves microbes to the tip of the root hair. This circulation may encourage bacteria to replicate within the root cells. The buildup of more microbes producing ethylene causes a growth spurt in the root hair tip resulting in microbes being expelled through the pores of the root tips. Microbes then reform cell walls and reacquire nutrients back in the soil. The process is repeated as the nutrient rich microbes are drawn back to the root tip.

Nutrient Uptake

One important aspect of this research is having an explanation for the benefits associated with microbes, such as better uptake of plant nutrients and more robust plants. This phenomenon can be related to the roots having another source of nitrogen from the microbes. Dr. White's lab found around a 30% increase in the uptake of nitrogen, phosphorus, potassium, and other micronutrients when bacteria were present.

Microbes can also carry other nutrients on their cell walls that are also feeding the plant. Different microbes can impact nutrients that the plant can access. Dr. White has hypothesized that the plant can alter root exudates to attract different microbes that can provide the nutrients that the plant needs. This altering of extracts would show that the plant can determine what it needs to thrive in each environment.

New work by Dr. White suggests that plant hairs and other stem structures use microbes to fix nitrogen in the plant as well. Microbes are transported by xylem and phloem into plant hairs where bacteria can produce nitrogen. Having microbes is not only important to the root system but the stems and leaves.

Plant Health

Another aspect of the rhizophagy cycle is the increased production of plant antioxidants. Plants produce antioxidants to offset the production of superoxides from the roots. Increased levels of antioxidants make the plant more tolerant to stress because all stress is oxidative stress. If plants are stressed, they will shut down the N-fixing process. Dr. White's lab has shown plants to have more tolerance to salt and hot soils when they are making antioxidants during the rhizophagy process.

Plants making antioxidants in response to superoxide can also increase production of phenolic compounds. These benefits have been observed by the increase of terpenes and other phenolic compounds when microbes in Worm Power Liquid Extract were added to cannabis plants.

While plants are creating antioxidants to be more tolerant to stress, microbes are also helping combat the stress of diseases. Microbes can colonize pathogens like fungi to alter their behavior to make them not as pathogenic, which in combination with antioxidants can help the plant be more tolerant to diseases. Dr. White's lab measured less disease with microbes present. When microbes were removed from seeds, the seedlings were found to be more susceptible to diseases. Worm Power Liquid Extract has shown similar results when applied to seedlings susceptible to Pythium species. These studies prove that microbes are essential for plant health.

Worm Power Liquid Extract

Plants need microbes in the soil. Plants have developed a way to farm the soil for microbes so that they can receive nutrients and thrive in different environments. Worm Power branded products have identified over 1400 microbes in suspension. Worm Power Liquid Extract provides a natural and diverse set of microbes that help increase yield and stress tolerance.

For more information, please visit http://www.wormpower.net