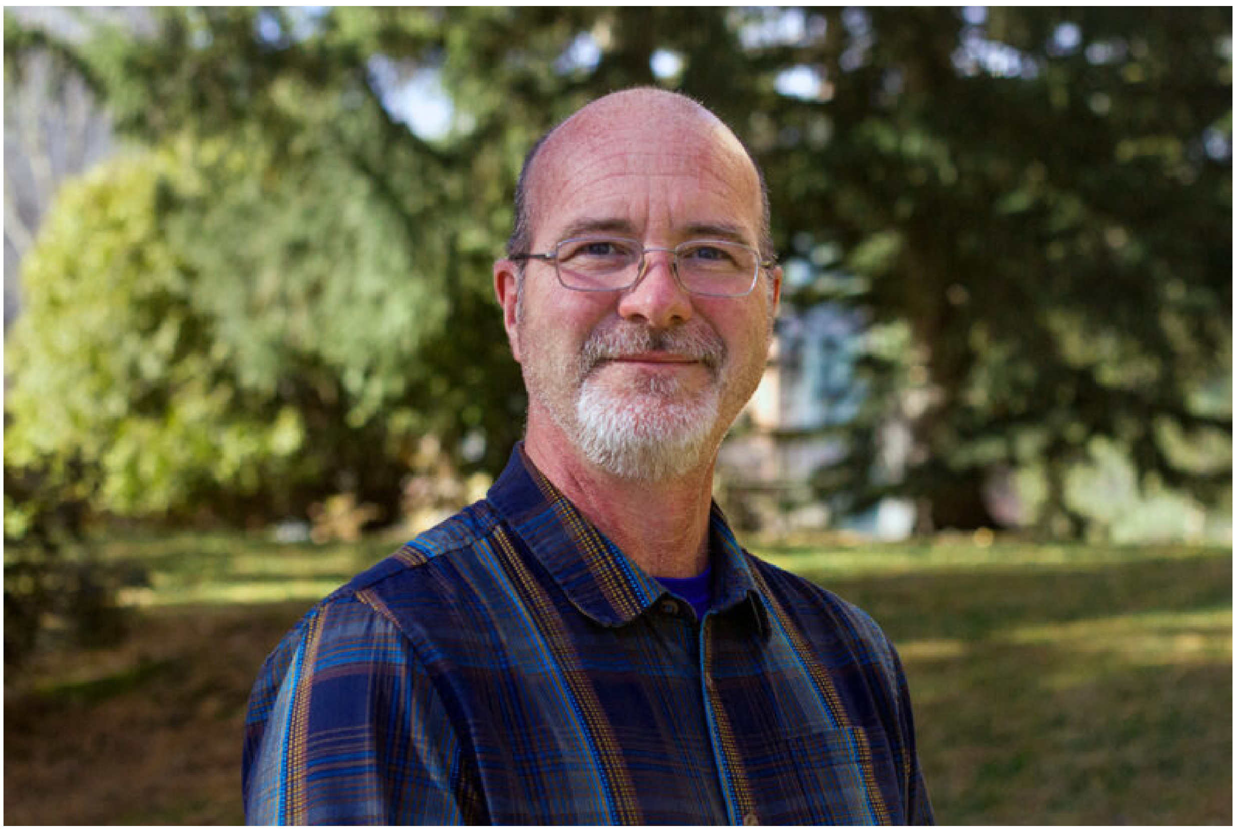
Nitrogen-fixing genes could help grow more food using fewer resources

January 15 2020, by Scott Weybright



John Peters. Credit: Washington State University

Scientists have transferred a collection of genes into plant-colonizing bacteria that let them draw nitrogen from the air and turn it into ammonia, a natural fertilizer.

The work could help farmers around the world use less man-made fertilizers to grow important food crops like wheat, corn, and soybeans.

The group of scientists, including two from Washington State University, published the study "Control of nitrogen fixation in bacteria that associate with cereals" late last month in *Nature Microbiology*.

"There's a growing interest in reducing the amount of fertilizer used in agriculture because it's expensive, has negative environmental impacts, and takes a lot of energy to make," said John Peters, Director of WSU's Institute of Biological Chemistry and a co-author on the paper. "There's a huge benefit to developing ways to increase the contributions of biological nitrogen fixation for crop production around the world."

How legumes get nitrogen

The team's research helps share a symbiotic benefit found in legume crops, which farmers have relied on for centuries to naturally enrich the soil.

Legume crops, such as chickpeas and lentils, require significantly less fertilizer than other crops, because they've developed a symbiotic relationship with bacteria that grow within their root tissues. These bacteria convert nitrogen gas to ammonia through a process called biological nitrogen fixation.

Bacteria take nitrogen from the air and convert it into ammonia for the plants, which use it for energy to grow. The plants in turn provide carbon and other nutrients to the microbes.

To work symbiotically, legumes and microbes have evolved to release signals that each can understand. The plants give off chemicals that signal to the bacteria when they need fixed nitrogen. The bacteria produce similar signals to let the plants know when they need carbon.

Fertilizer reduction

To develop a synthetic method for this symbiosis between other bacteria and crops, scientists worked to determine the groups of genes in bacteria that enable nitrogen fixing, then add those gene groups into other bacteria.

"This is just one step, although a large step, on the road to figuring out how to promote increasing contribution of biological nitrogen fixation for crop production," Peters said.

Peters and WSU are co-leads on the overall project with his colleague Philip Poole at the University of Oxford in the UK.

Reducing fertilizer requirements could have massive impacts on food availability, energy use and agriculture costs all over the world.

Fertilizers are too expensive for many farmers around the world. Without them, many nutritionally valuable foods won't grow in many areas due to nitrogen-poor soil.

"This project is aimed at increasing food production and helping feed the world," Peters said. "Transforming food production to work without nitrogen-based fertilizers could be a huge development in underdeveloped countries. Adding these microbes would be like pouring kombucha on roots."

Complex challenge

Peters' lab specializes in studying metabolic processes in bacteria, or how they create and use energy. His lab provided a blueprint for how nitrogen fixation works in different organisms. Then his co-authors, synthetic biologists at the Massachusetts Institute of Technology, can create the mechanisms that microbes and plants will need.

"This is such a complex and wide-spread challenge it really takes a large team with varied areas of expertise to solve," Peters said. "But if we succeed, the reward could be huge for the entire planet."

More information: Min-Hyung Ryu et al, Control of nitrogen fixation in bacteria that associate with cereals, *Nature Microbiology* (2019). DOI: 10.1038/s41564-019-0631-2

Provided by Washington State University