Review article discusses potential role, benefits of non-rhizobia bacteria in root nodules of legume

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Phytobiomes is a multidisciplinary journal that publishes original research about organisms and communities and their interaction with plants in any ecosystem.

Its objective is to offer a new vision for agriculture in which sustainable crop productivity is achieved through a systems-level understanding of the diverse interacting components of the phytobiome. Credit: The American Phytopathological Society

For many years, it was believed that the only nitrogen-fixing organisms of legume nodules were rhizobia. However, there is a strikingly diverse population of non-rhizobia bacteria often detected within nodules obtained from soil, revealing a complex phytomicrobiome, whose interactions likely affect the behavior and fitness of the host plant.

To date, relatively few studies on the function of these other nodule-associated bacteria in nodules have been done. But are they in any way responsible for any benefits to the Rhizobium-legume nitrogen-fixing symbiosis, or are they parasites/saprophytes, contaminants, or commensals? It is this and similar questions that led Drs. Pilar Martínez-Hidalgo and Ann M. Hirsch of the University of California, Los Angeles (UCLA) to conduct a research review.

The end result is a comprehensive review article titled "The Nodule Microbiome: N2-Fixing Rhizobia Do Not Live Alone."

This fully open-access research review published in *Phytobiomes*, a new journal of The American Phytopathological Society, highlights various studies from throughout the world on these lesser-known bacteria living in nitrogen-fixing nodules. It also includes a comprehensive discussion of their possible role in the bacterial community and the likely benefits for the host plant or to the rhizobial inhabitants of the nodule.

In short, this review is a one-stop shop of research and discussion on non-rhizobia bacteria and its interactions on the root nodule, often

highlighting literature from various countries often not seen or cited in the United States.

Hirsch expects that the knowledge from this review may one day lead to crop management strategies involving the deployment of these non-rhizobia bacteria not only as elite bioinoculants by themselves but also more importantly combined with optimal rhizobia. This approach can enhance rhizobial performance or persistence, lead to new cultural practices that promote organic crop production and decrease the usage of chemical fertilizers and pesticides, and keep the planet's soil from deteriorating even more.

"It is a paradigm shift in that most people don't think of the nitrogen-fixing symbiosis (the nodule) as a multi-organism phenomenon," said Hirsch. "Although many of these nodule inhabitants are not capable of nitrogen fixation, they have the potential to enhance legume survival especially under conditions of environmental stress."

In addition, Hirsch hopes this article will encourage researchers to bely their biases when looking at the interactions of organisms within the plant's microbiome. "The interactions among organisms are usually the province of ecologists," said Hirsch. "With the advent of the knowledge from the human genome, molecular biologists, geneticists, microbiologists, and other scientists in medicine and agriculture are learning that everything is interconnected."

On discussing this concept of interconnection, Hirsch quoted D.H. Janssen, a well-known plant ecologist who in 1985 wrote that "Plants wear their guts on the outside."

"He was referring to the root," said Hirsch. "So if a root is the plant's gut, we think that the root nodule is similar to an appendix. Like the appendix, the nodule replenishes the bacterial community, such that

during the next growing season when rhizobia re-initiate root nodule formation, the nodules will be repopulated by the same bacteria. This strategy is similar to a human gut where the bacteria have been wiped out after severe diarrhea or a course of antibiotics; the bacteria in the appendix repopulate the gut. However, keep in mind we are not yet sure how these other non-rhizobia bacteria get inside the root nodule nor how long this community persists in soil."

More information: Pilar Martínez-Hidalgo et al, The Nodule Microbiome: N2-Fixing Rhizobia Do Not Live Alone, *Phytobiomes* (2017). DOI: 10.1094/PBIOMES-12-16-0019-RVW

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