

RESCUE RANGERS: HOW BACTERIA CAN SUPPORT PLANTS

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YOUNG REVIEWER:



KONSTANTIN
AGE: 14

Plants, in addition to being very beautiful, provide us with oxygen and food, among other things. In their ecosystems, plants coexist with various types of bacteria, some of which are friendly and others that are the plant's enemies. Friendly bacteria can help plants grow by helping the plants to obtain nutrients such as phosphorous and nitrogen, or by defending the plants from other microbes that can make them sick. Our goal in the lab is to find the bacteria that can help plants grow and defend them from enemy attacks, understand how those bacteria work, and join forces with the bacteria to make agricultural plants produce enough food for everyone's table. In this article, we discuss four bacteria we have identified that can help and defend some plants.

RELATIONSHIPS BETWEEN PLANTS AND BACTERIA

Plants are a very important part of our lives. They provide us with oxygen, wood, medicines, and foods, but they do not do it alone. Plants share the soil habitat with many microorganisms, such as

Figure 1

(A) Relationships between bacteria and plants can be helpful to the plant, harmful to the plant, or neutral. **(B)** Through the production of enzymes and acids, friendly bacteria can help plants obtain necessary nutrients from the soil, including nitrogen (N) and phosphorus (P). Other important nutrients for plants are potassium (K), copper (Cu), zinc (Zn), boron (B), molybdenum (Mo), manganese (Mn), iron (Fe), and chlorine (Cl). **(C)** Bacteria can defend plants from harmful pathogens through a process called induced systemic resistance (ISR), which is like a vaccination for the plant, or by producing antibiotics or volatile organic compounds (VOCs).

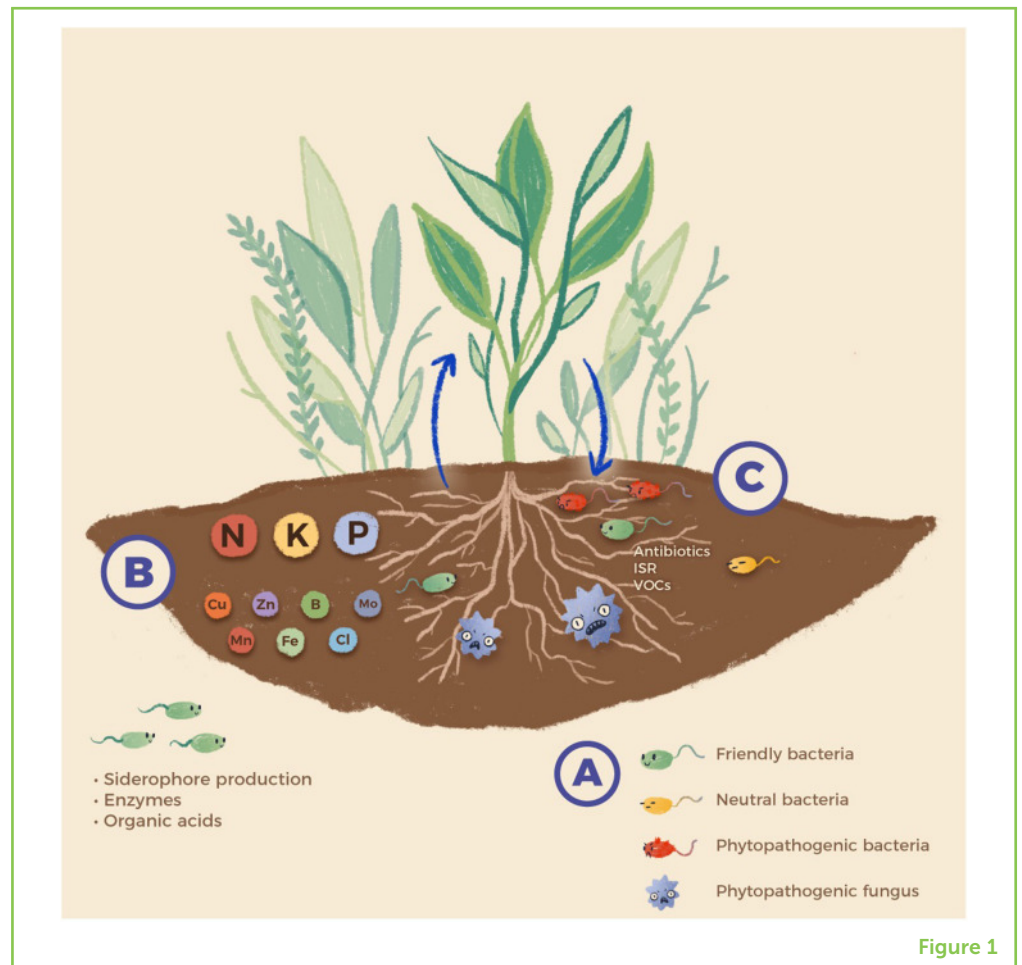


Figure 1

fungi, small worms called nematodes, and bacteria. Bacteria are tiny living things that we cannot see with the naked eye. Various types of bacteria look different from each other and play different roles in the ecosystem. What kind of relationships exists between soil bacteria and plants?

Three main types of relationships exist between plants and bacteria (Figure 1A). Some bacteria can be harmful to plants and attack them, causing them to rot, or they might make the plants sick or cause them to dry up. The relationship between these harmful bacteria and plants is a negative relationship, and these bacteria are called **phytopathogens**. However, there are also bacteria that can be plant-friendly, helping plants or defending them from phytopathogenic bacteria, fungi, and viruses. These relationships are positive. In return for this friendship, plants feed bacteria with carbohydrates, vitamins, and organic acids, among other things. Plants also provide a home for the helpful bacteria, allowing the bacteria to live near the plants or even within them. If the bacteria do not attack the plant but do not help it either, the relationship is neutral.

PHYTOPATHOGEN

An organism that makes plants sick.

SESSILE

The inability to move from place to place.

NUTRIENTS

Chemicals from which energy is obtained to perform a function.

MOLECULES

Two or more atoms united. Is the smallest unit of a substance.

ENZYMES

Molecules that regulate chemical reactions.

NODULE

Round or oval structure made of plant cells.

INDUCED SYSTEMIC RESISTENCE

It is one of the mechanisms that plants have developed to defend themselves against phytopathogens.

ANTIBIOTICS

Substances that destroy microorganisms.

VOLATILE ORGANIC COMPOUNDS

Molecules released as gases.

SIDEROPHORES

Small molecules that bind to iron and make it easier for the plants to use it.

SOME HELPFUL BACTERIA HELP PLANTS GET NUTRIENTS

Plants grow in the soil and cannot move around, meaning they are **sessile**. Sessile organisms cannot go looking for the **nutrients** they need to grow. However, bacteria can help plants to obtain the proper nutrients (Figure 1B). For example, plants need phosphorus to grow, but much of the phosphorus in the soil is trapped in **molecules** that plants cannot break down. In this case, the plant's bacterial friends show up to help, releasing molecules like special acids, or proteins called **enzymes** that help break down these phosphorus-containing molecules and release the phosphorus so plants can use it [1].

Nitrogen is another important nutrient for plants. Bacteria can help plants to obtain nitrogen by releasing other enzymes. But there's a problem, because the nitrogen-freeing enzymes are destroyed by oxygen. To get around this problem, bacteria help plants to form a protected fort called a **nodule** on the plant's roots. This nodule protects the bacteria and their enzymes, and, inside the nodule, nitrogen is made available for the plant.

BACTERIA TO THE RESCUE!

Beneficial bacteria can defend plants from the attacks of phytopathogens (Figure 1C). One of the ways that they do this is called **induced systemic resistance**, which is something like a vaccine that protects plants against fungi, bacteria, and viruses. The bacteria provide resistance by being in contact with the roots of the plant, which activates the plant's defense system and prepares it for a battle. Induced systemic resistance involves signals that are carried through the plant from the roots, or signals that travel through the air, alerting the parts of the plant that have not yet been attacked [2]. Thanks to those signals, when plant pathogens arrive, the plants are ready for the invasion and can better defend themselves.

Another thing that bacteria can do to defend plants is to release substances that chase away the plant's strongest enemies. These substances are called **antibiotics**, and they are similar to the medicines we might take when we have certain infections. These bacteria-produced antibiotics have funny names like phenazine, pyrrolnitrin, or zwittermycin. Some of these antibiotics are launched against enemy bacteria and others against dangerous fungi. The antibiotics can be released as **volatile organic compounds**, which are compounds that at room temperature are in the gaseous state or can easily become a gas. Release of volatile organic compounds is a highly effective mechanism that bacteria can use to quickly help a plant, because gases can spread easily and quickly reach all parts of the plant. **Siderophores** are also molecules that bacteria produce and release when elements such as iron is not enough in the soil,

Figure 2

The control flask (left) contains a *Medicago truncatula* plant growing without any added bacteria. The remaining flasks contain the plant and the indicated friendly bacteria. The arrows show that the plants grew better in the presence of the bacteria UM240 and UM270. The color of the arrows has no meaning.

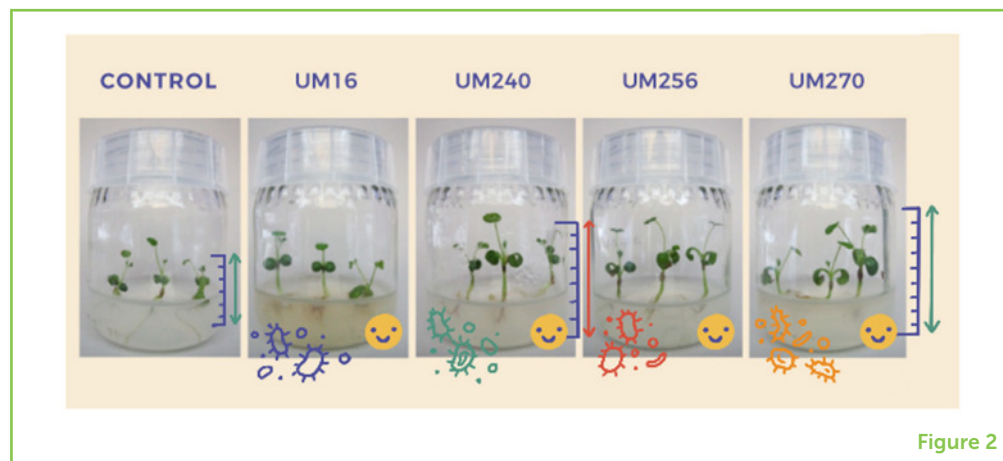


Figure 2

these molecules can give a hug to the little iron that is there, forming a siderophore-iron complex in which iron can be transported more easily and used by plants.

CREATION OF A BACTERIAL RESCUE FORCE

In the laboratory, we looked for the best “rescue rangers,” to form an army of bacteria that can help make the plants that feed us stronger. To do this, we first recruited many bacteria from the soil under different plants. Then we had the bacteria fight against many fungi that cause damage to those plants, and we selected those bacteria that did not allow fungi to grow. We will tell you about four bacteria that are part of our team of rescuers. These bacteria are called UM16, UM240, UM256, and UM270 [3].

These four helpful bacteria belong to the genus *Pseudomonas*. We put each bacteria together with a plant called barrelclover inside a flask. After 15 days, we could see that the plants were bigger when they were accompanied by the bacteria than when they grew alone (Figure 2). We also grew the bacteria in a glass bottle located inside the flask, so they couldn’t touch the plants. We saw that the plants were still bigger when the bacteria were present, even if they were not touching the plant. This means that the bacteria released volatile organic compounds that helped the plants to grow.

Another test that these rescuers passed was the ability to fight against a phytopathogenic fungus that scientist call *Botrytis cinerea*. This fungus sickens crops like tomatoes, strawberries, and grapes, causing decreased food production. To perform this test, the bacteria and the fungus were both added to a petri dish (Figure 3A). When the bacteria and the fungus were together in the dish, the bacteria prevented the growth of the fungus. We also put the fungus and bacteria into petri dishes that were divided up so that the bacteria and fungi could not touch; they could only communicate through a

Figure 3

(A) When the bacteria were grown in the same chamber of a petri dish with the fungus, the bacteria reduced the growth of the fungus compared to the control (far left). (B) When the bacteria and fungus were grown in separate chambers, the growth of the fungus was still less than the control, indicating that the substance that reduces fungal growth is a volatile organic compound. The arrows and brackets show the differences in the growth of the fungus. (C) Barrelclover infected with fungus had fewer signs of disease when grown in the presence of the bacteria.

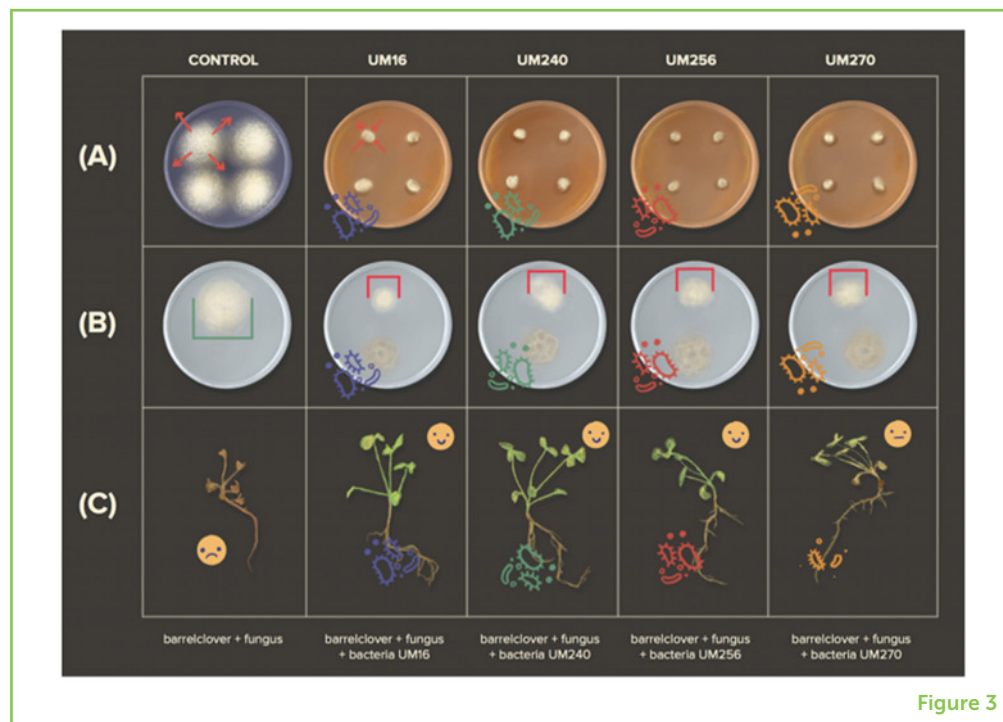


Figure 3

small window. Even when they could not touch, the fungus did not grow as large as when it was grown alone, which tells that volatile organic compounds produced by the bacteria inhibited the growth of the fungus (Figure 3B).

Once the bacteria won the battle against fungus, we had to know if they could protect an actual plant. We put the fungus in contact with barrelclover and saw that the fungus turned the plant brown and killed it (Figure 3C). When the plant was accompanied by UM16, UM240, UM256, or UM270, the fungus did not make the plant as sick as it got in the presence of the fungus alone. This means that our bacterial rescuers managed to defend the plant from the evil phytopathogenic fungus and keep the plant alive.

NEXT STEP: FORMING A BACTERIA SUPERSQUAD!

Now our bacterial rescue rangers are ready to go out into the field to protect plants and help farmers produce enough food for the world's growing population. We are still studying these bacteria, because each of them has a unique mechanism for helping plants. As we have already seen, these four bacteria are good rescuers on their own, but imagine if they all combined their superpower to form a squad—they would be invincible! Remember, all kinds of bacteria, both friendly and harmful, live together in the soil. The more microbial diversity there is in the soil, the greater the ability to fight against phytopathogens. To have healthy food, we need healthy soil—and the help of our friendly bacterial rescuers!

ORIGINAL SOURCE ARTICLE

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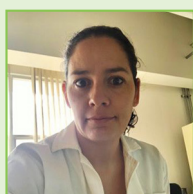
YOUNG REVIEWER



KONSTANTIN, AGE: 14

Hi I am Konstantin, your nearby Young Mind! I am from Rousse, Bulgaria and since I was little I had questions like: what's the point in recycling etc. Now, as an adolescent, I really got into ecology and decided to help bring awareness of some of the problems in our world has like the air pollution, species extinction and deforestation. If I, an ordinary student, can make a difference you can too-so what are you waiting for my young reader!

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Rocío Hernández-León is deeply in love with plants. That is why she has dedicated herself to investigating the abilities that bacteria have to help them grow. With a master's degree and Ph.D. in experimental biology, she seeks to find in the laboratory the most powerful bacteria for this important task, with as and goal to produce food in a safe, nutritious, and sufficient way. *r.hl83@hotmail.com



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