



From Yogurt to Tomato: The Hidden Life of Lactic Acid Bacteria as Plant Biostimulants

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When we hear the words lactic acid bacteria, we usually think of yogurt, curd, cheese, pickles and other fermented foods. Their connection with plants is much less familiar. Yet members of this bacterial group are increasingly being investigated for their potential roles in plant growth, nutrient availability, disease suppression and stress tolerance. Lactic acid bacteria, commonly abbreviated as LAB, have been detected in plant-associated environments and explored as biofertilizers, biocontrol agents, biostimulants and bioelicitors. Tomato provides an especially interesting system for exploring this relationship. Recent research has reported that foliar application of LAB can influence antioxidant responses and postharvest resilience in tomato exposed to drought stress. The story therefore goes far beyond the familiar role of LAB in food fermentation. These tiny bacteria may represent an underexplored microbial resource for supporting plants in a changing agricultural environment.

Keywords: lactic acid bacteria, tomato, plant biostimulants, plant growth promotion, stress tolerance, microbial biostimulants, plant-microbe interactions

Introduction

A spoonful of yogurt contains billions of microorganisms. Most of us know these bacteria because of their importance in fermentation and food production. Lactic acid bacteria are responsible for many of the transformations that give fermented foods their characteristic taste, texture and preservation properties. But what if some of these familiar bacteria could also interact with plants? This question has attracted increasing scientific attention. Researchers have found that LAB can occur in plant-associated environments and may possess several characteristics associated with plant growth promotion and biological protection. However, compared with better-known plant-associated bacterial groups such as *Bacillus*, *Pseudomonas* and rhizobia, the relationship between LAB and plants remains comparatively less understood. This makes LAB particularly interesting. The bacteria we normally associate with a glass of buttermilk or a bowl of yogurt may have another story to tell in the field.

What Are Lactic Acid Bacteria?

Lactic acid bacteria are a broad group of Gram-positive bacteria that are well known for fermenting carbohydrates and producing lactic acid as a major metabolic product. Genera and species within this group include *Lactiplantibacillus*, *Lactococcus*, *Leuconostoc*, *Pediococcus* and others.

Their ability to convert carbohydrates into organic acids has made them extremely important in food fermentation. The same metabolic characteristics, however, can also influence their interactions with plants and other microorganisms.

This is where the agricultural story begins.

Instead of viewing LAB only as “food bacteria,” scientists are beginning to ask another question:

Can their biochemical abilities be useful for plants?

From the Fermentation Tank to the Field

For decades, LAB have been extensively studied in food science.

Their ability to acidify foods and produce antimicrobial compounds has helped preserve fermented products and restrict undesirable microorganisms.

Interestingly, these same characteristics may have agricultural applications.

Some LAB can produce organic acids, antimicrobial substances and other metabolites that can influence the surrounding microbial community. Researchers have also reported potential roles in nutrient mobilization, plant growth promotion and induction of plant defence responses. So the transition from food microbiology to agricultural microbiology is not as strange as it first appears.

The same microbe can have different ecological roles depending on where it lives.

Why Call Them Biostimulants?

A plant biostimulant is not simply a fertilizer in another form.

Biostimulants are generally intended to stimulate natural plant processes that can improve nutrient use, growth, quality or tolerance to environmental stresses.

Microbial biostimulants can influence plants through several pathways, including nutrient mobilization, hormonal signalling, antioxidant responses and interactions with other microorganisms.

LAB are being investigated as one such microbial group. However, their effects are strain-specific, and not every LAB strain will produce the same response in every crop.

That distinction is important.

The real question is not:

“Are LAB good for plants?”

It is:

“Which LAB, applied to which plant, under which conditions, can produce a useful response?”

The Tomato Connection

Tomato is one of the world's most important vegetable crops and is also a fascinating plant for studying microbial interactions.

Its growth and productivity can be affected by drought, salinity, temperature extremes, nutrient limitations and numerous pathogens.

This makes tomato an interesting target for biological approaches that could complement conventional crop management.

Research has already investigated microbial biostimulants in tomato, while specific studies on LAB are beginning to reveal their potential effects on plant physiology and stress responses. The story becomes even more interesting when water becomes scarce.

Can LAB Help a Tomato Facing Drought?

Imagine a tomato plant growing under limited water.

The plant begins experiencing physiological stress. Water availability decreases, cellular processes are disturbed and oxidative stress can increase.

Now introduce LAB as a biological treatment.

Rather than simply supplying a nutrient, the bacteria may influence the plant's own biochemical responses.

A 2026 study investigated foliar-applied LAB in tomato under drought conditions and reported changes associated with antioxidant defence and postharvest quality. LAB treatment was

associated with increased total phenolics, flavonoids and carotenoids and reduced deterioration during storage.

This finding offers a fascinating possibility:

The bacteria may not simply “feed” the plant.

They may help the plant respond to stress.

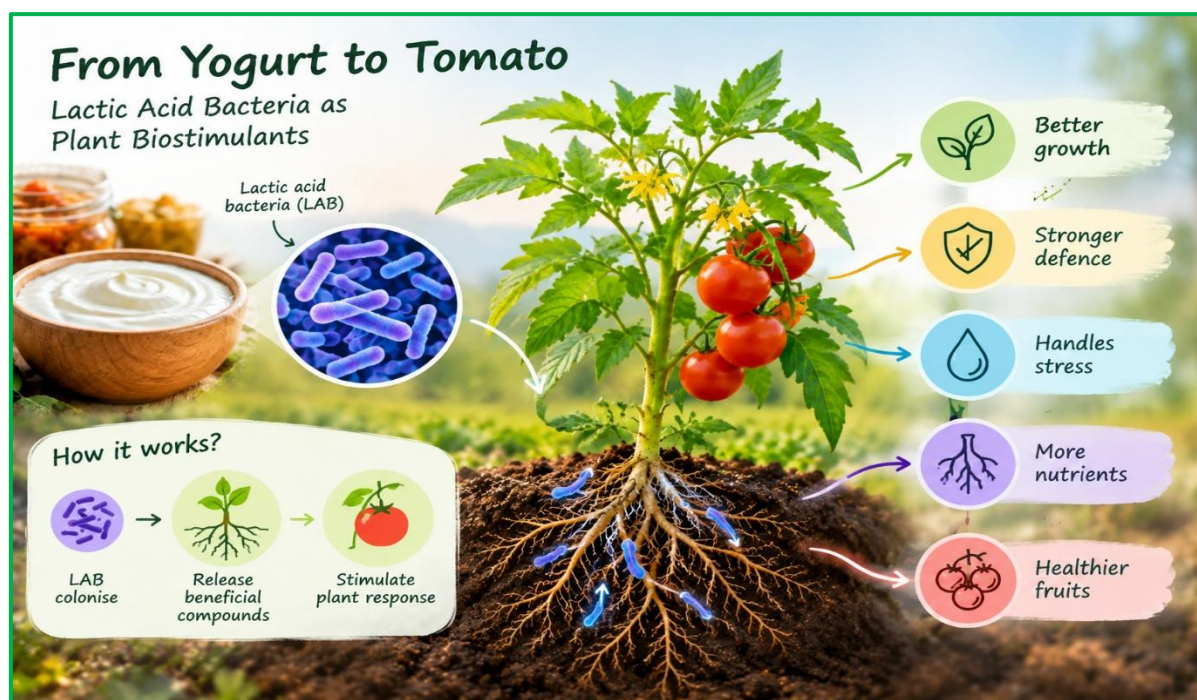


Figure 1. From Lactic Acid Bacteria to a Healthier Tomato: The Hidden Biostimulant Pathway

The Plant's Own Defence System

Plants cannot run away from drought, pathogens or environmental stress.

Instead, they rely on remarkably sophisticated biochemical defence systems.

When plants experience stress, antioxidant enzymes and protective compounds help manage reactive oxygen species and limit cellular damage.

LAB have been investigated for their ability to influence such defence-related responses. Studies in tomato seedlings have reported changes in enzymes and compounds associated with plant defence following LAB treatment.

This leads to an interesting idea.

A microorganism does not necessarily need to directly remove every threat from the plant. Sometimes, it may help the plant strengthen its own response.

The Hormone Connection

Plants communicate internally using hormones.

Auxins influence root development.

Gibberellins influence growth and development.

Other hormones participate in flowering, defence and stress responses.

Some LAB have been reported to produce or influence plant-associated phytohormones, including auxin-related compounds and gibberellins. These compounds can potentially influence root development and other aspects of plant growth.

But there is an important caution.

Finding a hormone-producing trait in a bacterium does not automatically mean that applying that bacterium will produce a predictable increase in plant growth.

The concentration, plant species, microbial strain and environmental conditions all matter.

Plant–microbe communication is much more complicated than simply adding one hormone to a plant.

Tiny Acids with a Big Effect

One of the most characteristic abilities of LAB is organic acid production.

Lactic acid is their best-known product, but some LAB can also produce other organic acids and antimicrobial compounds.

These compounds can change the local chemical environment and may influence competing microorganisms. Organic acids can also contribute to the solubilization of certain nutrient forms, including phosphorus-containing compounds under appropriate conditions.

This creates an interesting connection between microbiology and plant nutrition.

The bacteria may not be directly “feeding” the plant.

Instead, they may alter the environment around the plant in a way that changes what nutrients are accessible.

The Phosphorus Puzzle

Phosphorus is essential for plants, but much of the phosphorus present in soil is not immediately available for plant uptake.

Certain microorganisms can contribute to phosphorus mobilization through biochemical processes.

Some LAB have been reported to possess traits associated with phosphate solubilization. Organic acid production can contribute to the dissolution or mobilization of certain phosphorus forms, potentially making phosphorus more accessible to plants.

For tomato, better nutrient availability can influence root development, vegetative growth and fruit production.

However, the effectiveness depends strongly on soil chemistry, microbial strain and environmental conditions.

Could LAB Help Fight Tomato Diseases?

Tomato is affected by numerous bacterial and fungal diseases.

Chemical control remains important in many production systems, but increasing attention is being given to biological alternatives and integrated disease management.

LAB have shown antimicrobial activity against several plant pathogens in laboratory and applied studies. Proposed mechanisms include organic acid production, bacteriocins and other antimicrobial substances, as well as possible stimulation of plant defence.

Some studies have even investigated LAB against pathogens associated with tomato.

For example, LAB strains have been reported to inhibit *Fusarium* species associated with tomato crown and root rot in experimental studies.

The important word here is experimental.

Laboratory inhibition does not automatically translate into reliable field disease control.

That transition remains an important research challenge.

The Plant May Be Listening

One of the most interesting ideas in modern plant microbiology is that plants are not passive hosts.

They can sense microbial signals and respond to them.

Microorganisms can influence plant signalling pathways, while plants release compounds that shape their microbial surroundings.

This creates a two-way biological conversation.

LAB may therefore influence tomato not simply by living near its roots or leaves, but by changing the chemical signals and microbial interactions around the plant.

The tomato plant is not just receiving a microbial treatment.

It is responding to a biological signal.

LAB and the Tomato Microbiome

A tomato plant is surrounded by a community of microorganisms.

Introducing one bacterial strain into this environment does not mean that it operates alone.

It encounters native bacteria, fungi, root exudates, soil particles, nutrients and changing environmental conditions.

The introduced LAB may compete with some microorganisms, cooperate with others or simply alter the surrounding environment.

This is why the response of a plant to a microbial biostimulant can vary from one field to another.

The microbial community is part of the story.

From Bacterial Cell to Better Plant

The potential pathway can be imagined simply:

LAB enter the plant environment.



They produce metabolites and interact with other microorganisms.



They may influence nutrient availability and plant signalling.



The plant may alter its growth and defence responses.



Under suitable conditions, this can contribute to improved plant performance or stress resilience.

This is not a universal sequence for every LAB strain.

Instead, it represents the multiple pathways through which LAB may influence plant biology.

An Unexpected Connection Between Food and Agriculture

There is something beautifully circular about this story.

LAB have helped humans preserve food for thousands of years.

Now scientists are asking whether these same microbial groups can help us produce food more sustainably.

Fermented food → microbial knowledge → plant microbiology → biological agriculture

But LAB Are Not a Magic Solution

It would be misleading to describe LAB as a universal solution for tomato production.

Microbial biostimulants can behave differently depending on bacterial strain, crop genotype, application method, soil conditions, climate and surrounding microbial communities.

Recent reviews also point out that much of the research on microbial biostimulants has been conducted under controlled or greenhouse conditions, while field responses can be more variable.

This is one of the major challenges facing microbial agriculture.

A bacterium that performs beautifully in a laboratory flask still has to survive the complexity of a real farm.

What We Still Do Not Know

The relationship between LAB and plants remains surprisingly underexplored compared with the enormous amount of knowledge accumulated about LAB in food microbiology.

Researchers still need to understand which LAB strains are best suited to particular crops, how they colonize plant surfaces and tissues, how long they remain active and how their metabolites interact with the existing plant microbiome.

There is also a major question of formulation.

Should LAB be applied to seeds?

Should they be delivered to the soil?

Could foliar application work better under particular conditions?

Could cell-free metabolites provide some benefits without applying living bacteria?

These questions are opening new directions for research.

The Future: From Fermentation Bacteria to Precision Biostimulants

The future may not involve simply spraying a generic LAB culture onto every tomato field. Instead, agricultural microbiology may move toward more precise microbial formulations. A particular LAB strain could potentially be selected for a particular function, such as nutrient mobilization, pathogen suppression or stress priming.

Different strains could then be combined according to the crop and environmental conditions. This would transform microbial biostimulants from a broad concept into a more targeted technology.

Conclusion

Lactic acid bacteria are usually introduced to us through food.

We meet them in yogurt, fermented vegetables, cheese and countless other products.

But their biological story does not necessarily end at the fermentation vessel.

Selected LAB can interact with plants and have been investigated for their potential as biostimulants, biofertilizers, biocontrol agents and bioelicitors. Their possible roles include nutrient mobilization, production of bioactive compounds, influence on plant signalling, suppression of certain pathogens and modulation of stress responses.

In tomato, this emerging story becomes particularly intriguing. Recent research has shown that LAB treatment can influence antioxidant responses and help maintain aspects of fruit quality under drought-associated stress.

The most exciting part is that scientists are still uncovering how these interactions work.

The next time we see a cup of yogurt, it may be worth remembering that its familiar bacteria have a much larger biological story.

Some of the smallest organisms we use in our food may one day become part of how we grow our food.

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