The Benefits Of *Bacillus*

Acting as a natural bio-fertiliser, biocontrol agent, and bio-stimulant, *Bacillus* bacteria are cornerstone beneficial microbes in agriculture. As they colonise the root zone, *Bacillus* bacteria suppress harmful root diseases, stimulate vigorous crop growth, and convert insoluble soil nutrients into plant-available forms.

Key agricultural benefits of *Bacillus* species include:

Nutrient Availability

By converting locked-up, insoluble nutrients into simple, plant-available forms, *Bacillus* bacteria improve soil fertility. They achieve this by colonising the rhizosphere and secreting a powerful biochemical cocktail that breaks down stubborn organic and mineral compounds.

Acidifcation

Bacillus species, such as *B. subtilis* and *B. megaterium*, break the bonds in insoluble mineral compounds by secreting low-molecular-weight organic acids like critic, lactic, succinic and acetic acid that lower the local soil pH and release protons (H+), which frees up bound nutrients for root absorption.

Chelation

Bacillus excretes chelating agents such as organic acids and siderophores (specialised iron-binding molecules). These compounds bind to positively charged metal ions like iron, zinc and potassium, converting them into highly mobile, stable complexes that can be easily absorbed by plant roots.

Enzymatic Catalysis

Certain *Bacillus* species synthesise and release specialised extracellular enzymes:

- Phosphatases break down organic, complex phosphorus that plants cannot use into inorganic, simple phosphate (PO_4^{3-}).
- Phytases specifically target and release locked phosphate in manure and plant material.

Nutrient-Specific Breakdown

Different *Bacillus* species target specific essential elements:

- Phosphorus and Potassium: to release bioavailable phosphorus and potassium, organic acids and enzymes dissolve rock minerals like apatite or basalt.
- Iron: insoluble iron oxides are dissolved by siderophores and transported to the root surface.
- Zinc: *Bacillus* solubilises zinc oxide and zinc carbonate through acidification, improving availability of this crucial micronutrient.

Nitrogen Fixation

Bacillus can bring nitrogen into the soil nutrient pool, as certain *Bacillus* strains possess nitrogenase enzymes that directly convert atmospheric nitrogen (N_2) into soluble ammonia (NH_3).

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Disease Suppression

By acting as a natural biocontrol agent, *Bacillus* bacteria suppress diseases by inhibiting pathogens through resource competition, producing antimicrobial compounds (like peptides and antibiotics), and inducing plant innate immunity. Widely recognised in soil health and agriculture, *Bacillus* species, such as *B. subtilis, B. amyloliquefaciens*, and *B. coagulans*, suppress disease by utilising several key mechanisms.

Resource and Space Competition

Once *Bacillus* spores germinate and multiply rapidly around the rhizosphere, they occupy space and consume microbial resources, such as with nutrient-grabbing siderophores, thus starving harmful fungi and bacteria and preventing them from establishing.

Antimicrobial Compounds

Bacillus bacteria impede or directly destroy the growth of plant pathogens by producing a wide variety of powerful antimicrobial compounds, such as lipopeptides, bacteriocins, and volatile organic compounds (VOCs).

Siderophores

Bacillus bacteria create nutrient deficiencies for harmful microbes, thus preventing their growth, by secreting siderophores, which are specialised iron-chelating molecules that bind up iron in the soil.

Induced Systemic Resistance (ISR)

Bacillus boosts plant immunity against pathogens by interacting with plant roots and triggering plant defence mechanisms. Primed plant defence then enhances resistance to attacks from pathogenic fungi, bacteria, and viruses.

Hydrolytic Enzymes

Bacillus can protect against fungal pathogens by secreting enzymes like chitinases, glucanases, and proteases that actively break down fungal cell walls.

Plant Growth Promotion

By regulating plant hormones, enhancing nutrient availability, suppressing pathogens, improving overall stress resilience, and boosting root development, *Bacillus* promotes plant growth when used as an agricultural bio-fertiliser.

Nutrient Solubilisation

Bacillus bacteria convert insoluble soil nutrients, like phosphorus and zinc, into forms readily available for plant uptake.

Phytohormone Production

Bacillus bacteria secrete plant hormones, including cytokinins, gibberellins, and auxins (IAA), which stimulate plant root development, thus enhancing access to nutrients and water.

Pathogen Suppression

Bacillus restricts the growth of harmful fungi and bacteria by producing antimicrobial compounds and siderophores, while also triggering plant systemic defence mechanisms.

Induced Systemic Resistance (ISR)

Bacillus species, such as *B. subtilis* and *B. amyloliquefaciens*, trigger Induced Systemic Resistance (ISR) by colonising plant roots. This results in plant defence priming, in which *Bacillus* trains the plant's defence systems to respond faster and more vigorously during subsequent pathogen attacks. With crops, *Bacillus* use can establish broad-spectrum, cost-effective defence mechanisms that fight viruses, insect pests and pathogenic bacteria and fungi. ISR primes the plant so that a defence response occurs only upon actual pathogen attack, which is more energy-efficient than defence responses that are always activated.

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Root Colonisation and Elicitor Production

Bacillus bacteria secrete specific biochemical "elicitors" or signalling compounds as they colonise the rhizosphere, which include volatile organic compounds (VOCs) like butanediol and acetoin.

Defence Regulatory Genes

Bacillus primarily stimulates Ethylene (ET) and Jasmonic Acid (JA) signalling pathways associated with ISR. Molecular signalling within the plant triggered by *Bacillus* root colonisation involves key regulatory proteins. Acting as a central master switch, the regulatory protein NPR1 modifies plant transcriptional responses and coordinates the expression of multiple defence genes.

Chemical Defences & Physical Fortification

Defence-primed plants deploy an aggressive, localised response when attacked by a pathogen or insect. *Bacillus* root colonisation results in reinforced cell walls due to rapidly deposited callose and lignin, which physically blocks pathogens from entering plant cells. Defence-primed plants also accumulate reactive oxygen species (ROS) to kill invading pathogens; a mechanism known as the oxidative burst. Altered metabolite production and upregulated synthesis of pathogenesis-related (PR) antioxidants, phytoalexins, and proteins also contributes to neutralising external threats.

Bacillus in Ecogrowth® fertilisers

Ecogrowth® incorporates *Bacillus* in our range of granular fertilisers by including select Bacillus strains in EcoAdvance® premium biology. EcoAdvance® premium biology is our proprietary granular fertiliser inoculum, containing select strains of beneficial soil microbes and complementary bio-stimulants. This powerful microbial primer/catalyst works by kick-starting soil microbial activity. Ecogrowth® rock-mineral fertiliser granules directly support microbial growth, acting as 'seeds' of beneficial soil microbes. The low-soluble nature of rock-mineral nutrients also encourages plant–microbe symbiosis, which then renders rock-mineral nutrients as plant bioavailable. Once inoculated rock-mineral fertiliser granules are introduced to soil and EcoAdvance® premium biology microbes

proliferate, microorganism-based processes are supported that have many soil and plant benefits, including natural mineral cycling, enhanced nutrient release and delivery, improved soil structure and moisture retention, and increased overall plant health and resilience.

Soils are diverse and complex living ecosystems. Biologically driven soil processes provide plant nutrition, and their presence are a key indicator of overall soil health and functioning. Without biology, soils are simply geology.

Biologically active soils are the cornerstone of healthy, resilient and sustainable agricultural production systems. When functioning effectively, soil microbe–plant root interactions positively influence plant health and productivity. Microbial activity in the rhizosphere surrounding plant roots stimulates soil building processes and enhances mineral availability.

Summary

Bacillus bacteria are cornerstone beneficial soil microbes widely used in agricultural production as a natural biopesticide, bio-stimulant, and bio-fertiliser. *Bacillus* improves soil fertility by converting locked-up, insoluble nutrients into plant bioavailable forms. *Bacillus* as a bio-fertiliser promotes growth by boosting root development, regulating plant hormones, enhancing nutrient availability, suppressing pathogens, fixing nitrogen, and improving abiotic stress resilience.

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