



Bacillus

A Tool for Sustainable Agriculture

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Introduction

A range of plant diseases is caused by a variety of pathogenic microorganisms, which decrease agricultural production and

cause notable yield losses. Various techniques have been applied to stop plant diseases but due to resistance to pesticides,

their effectiveness is generally lower. Moreover, the overuse of synthetic fertilizers not only has detrimental effects on the biosphere but also impairs ecosystem functioning and reduces agricultural sustainability. One of the best-studied biocontrol agents as biopesticides is *Bacillus* species, which inhibit plant pathogens through competitive and antagonistic mechanisms. The capacity of

Bacillus species to produce antibiotics and hardy, resistant Endospores to control a variety of phytopathogens has made them an essential biological control agent. Volatile organic chemicals produced by *Bacillus* are required to stimulate plant development and activate plant defence mechanisms by enhancing plant Induced Systemic Resistance (ISR) (Compant *et al.*, 2005).

Types of Toxins

1. Crystal Toxins

- These are produced during the stationary phase of growth, also referred to as delta endotoxins, as parasporal crystalline inclusions. These include the poisons such as Cry and Cyt.

2. Cry Toxins

- At the moment, the cry proteins make up the majority of the insecticidal proteins generated by *Bacillus* species.
- To date, the Bt toxin Nomenclature

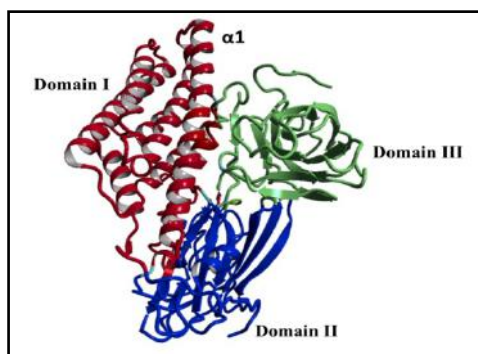


Fig. 1(a) Cry Toxins

Committee has classified 73 different types of Cry Proteins.

- It shows toxicity against Lepidopterans, Coleopterans, Hemipterans, Dipterans, and Nematodes.

3. Cyt Toxins

- Cyt (Cytotoxin) proteins, coded by Cyt genes.
- In contrast to Cry proteins, Cyt proteins exhibit a general cytolytic activity in vitro and predominantly dipteran specificity in vivo.

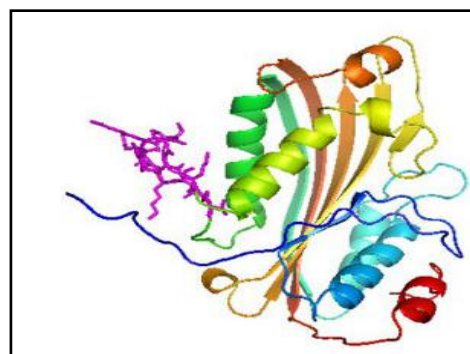


Fig. 1(b) Cyt Toxins

The major concern in the use of conventional pesticides

Pesticides are intentionally released into the environment to kill living organisms, such as weeds, insects, fungi and other microorganisms, and rodents. It is a hazardous substance. Excessive or careless use of pesticides without following

recommended practices and safety standards has serious consequences for living organisms (including human beings as well) and the atmosphere. According to Rajmohan *et al.* (2020), "the nature of pesticides is characterized by their

interaction with the environment and their particular structure". The end users, such as farmers and consumers, who are aware of

Bacillus spp. as PGPR (Plant Growth Promoting Rhizobacteria)

Bacteria that establish colonies in the rhizosphere (root zone of plants) and promote plant growth are known as plant growth-promoting rhizobacteria - PGPR. *Bacillus* boosts plant growth either by increasing the absorption of nutrients from the soil or by the activation of the host's defensive mechanism against various plant

the negative impacts of pesticides, may yet be forced to use synthetic pesticides in their daily practices.

pathogens. And other species can repress the population of plant pathogenic organisms. Two *Bacillus* strains, CJCL2 and RJGP41, were highlighted in a study by Zubair for their potential contribution to reducing cold stress and promoting plant growth in wheat plants (Zubair *et al.*, 2019).

Known Mechanisms of PGPR

1. Nitrogen Fixation

- Biological nitrogen fixation (BNF) is a phenomenon in which microorganisms absorb nitrogen from the environment and convert it into a compound that is used by plants as nutrients.

2. Phosphate Solubilization




- Phosphorus (P) is a primary macronutrient crucial for the development and growth of plants. A

variety of soil microbes are capable of solubilizing P into Pi, which can then be used by plants.

3. Phytohormones Production

- Chemical messengers that are mediated in biochemical and physiological processes of higher plants that are active at very low concentrations refer to as phytohormones.

Genetically Engineered Crops to produced Bt Proteins

<p>1. <i>Bt</i> Potato</p>		<p>Colorado Potato Beetle Resistant Bt Potato (U.S – 1995) Potato Tuber Moth Resistant Bt Potato (South Africa)</p>
<p>2. <i>Bt</i> Maize</p>		<p>European corn borer Resistant Bt Corn (U.S – 1995) Corn rootworm Resistant Bt Corn (U.S – 2022)</p>
<p>3. <i>Bt</i> Cotton</p>		<p>Lepidopteran Resistant Bt Cotton (U.S – 1995)</p>

Varieties of species of the genus *Bacillus* existing in the soil

In soils, a wide variety of microorganisms, including bacterial species, archaea, and fungi, are interwoven in an unstable manner and are involved in ecosystem function. It is estimated that 1 g of soil consists of 10^{10} - 10^{11} bacteria, 6,000-50,000 species of bacteria, and up to 200 m of microfungus hyphae, most of which are suitable for plants and soil (Mishra *et al.*, 2016). Recently, an intensive agriculture system is the main source of nutrition for a growing population. These industrially synthesized

chemicals cause environmental pollution and reduce the number of beneficial microorganisms in the soil. Microorganisms grown in synthetic culture are known as microbial inoculum or biofertilizer. *Bacillus* species including *B. subtilis*, *B. cereus*, *B. thuringiensis*, and *B. pumilus*, boost plant development and reduce plant diseases by secreting different exudate compounds like chitinase and beta-1,3-glucanase.

Table 1. Different *Bacillus* species are used as biocontrol agents against various pathogens.

<u><i>Bacillus</i> Species</u>	<u>Plant Species</u>	<u>Pathogens</u>
<i>Bacillus subtilis</i>	Wheat	<i>Rhizoctonia cerealis</i>
<i>Bacillus cereus</i>	Potato	<i>Fusarium oxysporum</i>
<i>Bacillus subtilis</i>	Tomato	<i>Pythium ultimum</i>
<i>Bacillus amyloliquefaciens</i>	Tomato	<i>Fusarium oxysporum</i>

Conclusion

Pesticides have shown promise as a means of meeting the food needs of a growing population. However, these harmful pesticides cause human health problems, development of pest resistance, narrow biodiversity, and many environmental problems, raising concerns about pesticide safety and their use. Therefore, the need to reduce our dependence on these synthetic pesticides is important. The application of PGPR is the most promising solution for green agriculture. *Bacillus* has been elucidated through direct and indirect

mechanisms as a growth promoter for sustainable agriculture. It was described as a promising biocontrol agent. Biopesticides have long been attractive globally because they are a safer option than conventional pesticides. Given the importance of sustainable agriculture, *Bacillus* spp. organic-based products could be a promising addition to sustainable agriculture due to the limited range of products available. There is an urgent need to exploit the potential of *Bacillus* spp.

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