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# ENTOMOPATHOGENIC BACTERIA: A POTENT BIOPESTICIDE FOR SUSTAINABLE AGRICULTURE

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The increasing use of chemicals in agriculture has given rise to concerns regarding public health, soil degradation, and environmental safety. To address these issues and ensure the consistent productivity of agricultural land, a sustainable approach is imperative. Pesticides, the primary chemical inputs in agriculture, pose significant risks. In response, microbial pesticides, derived from entomopathogenic microorganisms, offer promising alternatives. There are different entomopathogenic microbes such as fungi, nematodes, bacteria, protozoa and viruses. Bacteria are prokaryotic (without nucleus) single-celled organism and exist in communities of millions. Bacterial populations pathogenic to insect pests can cause major damage to the target insect population and are known as entomopathogenic bacteria (EPBs) (Lacey *et al.*, 2001). EPBs are mainly divided in two groups *i.e.*, endospore forming (e.g. genus *Bacillus*) and non-endospore forming (e.g. *Serratia* sp. and *Pseudomonas* sp.). The endospore forming bacteria are further divided into obligate and facultative pathogens. Families of bacteria having the properties of pathogenesis comprise bacillaceae, clostridiaceae, proteobacteria and actinobacteria. Their cosmopolitan nature and inherent versatility positions EPBs as promising alternatives for pest control in agriculture, aligning with the goals of sustainable and eco-friendly farming practices.

## Bacterial Insect Pathogenesis

There are various modes and means for pathogenesis in insect by bacteria. There are three modes of entry: through the consumption of infected food, through a lesion and through vector. Mainly there are three types of infection *viz.*, bacteremia: multiplication in insect haemocoel; septicemia: bacteria invades the haemocoel, multiplies and produces toxins; toxaemia: bacteria that produces the toxin and usually confined to the gut lumen.

**Bt *(Bacillus thuringiensis)*:** *Bacillus thuringiensis*, aerobic, rod-shaped, motile, gram positive, endospore-forming bacterium, is one of the most successful microbial biopesticides. It produces crystal protein and delta-endotoxin, affecting very wide range of insect-pests (Gangwar *et al.*, 2021).

Gonza´lez-Cabrera *et al.* (2010) tested three commercial products of Bt against *Tuta absoluta* in tomato. In laboratory assay, Costar® (Bt var. *kurstaki*) showed least leaflet area damage. Costar® at concentration 45.2, 90.4 and 180.8 $MIUl^{-1}$ showed low infested leaflets per plant in greenhouse and open field condition and low infested fruits in open field. In the open-field 90.4 and 180.8 MIU $l^{-1}$ treatment gave similar highest non-injured yield.

Patel *et al.* (2020) from Anand reported that Bt strain of AAU was more effective than Bt strain of NBAIR for the management of *Spodoptera frugiperda* larvae of 2nd and 3rd instar under laboratory conditions.

Aarthi *et al.* (2022) evaluated different bioagents against 2nd instar larvae of *S. frugiperda* under laboratory conditions and found that Bt @ (3.5% ES) 2ml/l recorded higher mortality percentage than other treatments.

Wakde *et al.* (2022) concluded that per cent mortality increased with the increase in concentration after 96 hrs. of inoculation of Bt broth formulation in 3rd and 4th instar larvae of *Corcyra cephalonica* and *Galleria mellonella.*

**EPBs other than Bt:** This includes *Lysinibacillus sphaericus*, *Bacillus popillae*, *Serratia marcescens*, *Pseudomonas aeruginosa*, *Photorhabadus sp.* and *Xenorhabadus sp.* having different modes of infection. Among these bacterial entomopathogens some are discussed below.

***B. popillae*:** Spores of *B. popilliae* infect larvae (grubs) of Japanese beetles, eventually killing the larvae and preventing their development into adult beetles. They cause milky spores disease in grubs.

Shinde and Sharma (1971) conducted an experiment to assess the development of milky disease in inoculated grubs by injection method and soil inoculation method at two different doses against 1st, 2nd and 3rd instar white grubs of Japanese beetle (*Lachnosterna consanguinea*). In injection method, the higher dose $10^6$ spores/ grub shows high mortality, while soil inoculation at 4 × $10^9$ spores/kg soil showed high mortality after 6 and 12 days but similar results after 18 days.

***S. marcescens***: The pathogenicity of *S. marcescens* is increased by the action of serralysin metalloproteinase. It allows bacteria to suppress cellular immunity by reducing the adhesion properties of immune surveillance cells in the insect hosts (Gangwar *et al.,* 2021).

***P. aeruginosa*****:** This ubiquitous bacterium infects insect larvae orally and determines extensive intestinal cell damage. Toxic compounds produced such as extracellular proteinases and metalloproteases are exported throughout the insect's body as a result of intestinal infection (Vacheron *et al.,* 2018).

Chin *et al.* (2021) observed the behavioral activities and mortality rate of *Coptotermis curvignathus* termite on wood block and in soil treated with different bacterial concentrations of *S. marcescens* and *P. aeruginosa.* They concluded that as the concentration increased the mortality rate increased and the percentage of weight loss of wood and soil decreased.

***Photorhabadus* sp**. and ***Xenorhabadus* sp:** Bacteria produce and spread various antimicrobial compounds to combat the growth of other microorganisms. They also release various enzymes that contribute to the degradation of haemocoel and make an ideal environment for the development of the nematode population (Gangwar *et al.,* 2021).

Adithya *et al.* (2020) compared 4 strains of *Photorhabdus luminescens*, 1 strain of *Xenorhabdus nematophila* and Bt in two different forms *viz.,* intact cell and cell supernatants against *Earias vitella* larvae. In both forms *X. nematophila* showed highest mortality followed by 4 strains of *P. luminescens* and least mortality was found in Bt.

Gümüssoy *et al.* (2022) observed that *Xenorhabdus bovienii* A54 cell-free supernatant exhibited high mortality rate against 5th instar larvae of *Cydia pomonella* in contact efficacy.

Unal *et al.* (2022) found that in cell suspension treatment of different *Xenorhabadus* and *Photorhabadus* against cutworm larvae, oral application showed better result than contact and highest mortality was recorded in *X. bovienii* KCS-45 in $1^{st}$ and $2^{nd}$ instar and *X. budapestensis* MGZ-4-5 in $3^{rd}$ and $4^{th}$ instar. They also conducted cell-free supernatants treatment of same species and strains against cutworm larvae where contact application performed better than oral application and *P. luminescens* subsp. k*ayaii* AV815 caused high mortality in $3^{rd}$ and $4^{th}$ instar.

Muhammad *et al.* (2022) exhibited that mortality of migratory locust was higher in cell-free filtrate than the bacterial suspension of *P. luminescens* (EGAP3). Both bacterial suspension and cell-free filtrate caused increasing mortality as concentration increased. During 7 days after treatment with cell-free filtrate showed higher results.

Yuksel *et al.* (2023) generated results against different larval instars of *Ephestia cautella* that contact application efficacy produced high mortality than oral. Cell-free supernatant caused higher mortality than cell suspension. In contact application, *X. nematophila* E76 strain showed higher mortality for all larval instar. In oral application, except for 3rd instar of cell suspension treatment, all instar in both treatments, *X. bovienii* MÇB-8 strain caused high mortality.

**Genetically modified entomopathogenic bacteria (GM-EPBs):** Genetic engineering has great potential for the development of new genetically modified entomopathogens. These GM-EPBs are developed to achieve more resistance to adverse environmental factors, higher pathogenicity, lower spraying requirements and long-term persistence of entomopathogenic bacteria (Azizoglu *et al.*, 2020).

## Conclusion

In conclusion, the transition to sustainable agricultural practices is paramount for safeguarding public health, preserving soil integrity, and ensuring environmental safety. Embracing microbial pesticides, with a focus on entomopathogenic microorganisms, presents a viable solution to mitigate the adverse effects associated with conventional chemical inputs in agriculture.

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