Bacillus thuringiensis Proteins: Structure, Mechanism And Biological Control Of Insect Pests

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Manuscript No: KN-V2-01/031

Introduction

Bacillus thuringiensis (Bt), the most widely utilized biopesticide, is a gram-positive, spore-forming bacterium with entomopathogenic properties commonly inhabiting soil, leaf surfaces, and deceased insects. Its distinctive feature lies in the ability to generate insecticidal proteins, primarily composed of Cry and Cyt toxins, during the sporulation phase. These toxins exhibit remarkable specificity and diversity, making them environmentally friendly agents effective against Lepidopteran, Dipteran, Coleopteran, and other targeted insects. The application of these toxins has led to the development of biopesticides, applied either as foliar sprays or through the incorporation of toxin-encoding genes into transgenic plants, thereby contributing to sustainable pest management (Mendoza-Almanza et al., 2020).

By analyzing the amino-acid sequence homology, researchers have identified 80 crystal proteins (Cry1–Cry80), 4 vegetative insecticidal proteins (Vip1–Vip4), and 7 cytolytic proteins (Cyt1–Cyt7) within Bacillus thuringiensis(Bt) (Chakrabarty et al., 2022). During the stationary growth phase, Bt strains produce Crystal (Cry) and Cytolytic (Cyt) toxins (δ-endotoxins), while in the vegetative growth phase, vegetative insecticidal proteins (VIP) are synthesized. The mechanism of action for these insecticidal toxins involves the activated Cry toxins selectively binding to various mid-intestinal epithelial cell membrane receptors in a sequential manner. As these toxins mature, they form oligomers that are subsequently inserted into the cell membrane, causing perforations and disrupting osmotic balance, ultimately leading to cell lysis and the demise of the targeted insect (Liu et al., 2016).

Bioassay studies on Bacillus thuringiensis isolates: from diamondback moth larvae to white grubs :
Navya et al. (2021) demonstrated the diversity of Bacillus thuringiensis (Bt) isolates and emphasized the ongoing need for exploring new isolates to identify novel genes with potential toxicity against the Diamondback Moth (DBM) under controlled conditions. Out of 60 isolates examined, 51 featured white-colored colonies with a characteristic fried egg appearance and distinct crystal shapes. The analysis of spore crystal mixtures using SDS-PAGE revealed the presence of proteins with varying molecular weights ranging from 26 to 124 kDa. Among the isolates, those containing cry1 genes were predominant (30 isolates), followed by cry2 (9 isolates) and vip3A1 (9 isolates). Notably, twelve isolates exhibited high toxicity, causing 100% mortality in DBM larvae.

A bioassay study was conducted targeting the white grub (Holotrichiaserrata), a polyphagous pest affecting sugarcane and other crops. The study revealed significant toxicity against first instar grubs, with the highest mean mortality reaching 91.11% for various tested doses compared to untreated larvae. In vitro proteolytic assays and histopathological examinations of the midgut in infected white grubs unveiled proteolytic processing of protoxin and extensive degeneration of larval midgut epithelial cells. These findings suggest the potential use of this novel isolate as a biopesticide or the expression of its crystal toxin genes in sugarcane and other crops to confer resistance against white grub infestations (Naveenaraniet al.,2022).

Conclusion

At present, Bt preparations stand as the most prolific and extensively employed microbial insecticides in

agriculture. These biopesticides, derived from Bacillus thuringiensis(Bt), offer an environmentally friendly solution for effectively managing diverse insect pests. The insecticidal proteins derived from Bt are widely employed as biopesticides, applied through either spraying or integration into transgenic crops. However, it's worth noting that Btbiopesticides exhibit a limited range of host specificity. Therefore, there is a need for advanced studies to enhance the efficacy of these biopesticides, emphasizing the development of new strains with heightened insecticidal properties

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