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Original article

Integrated Bio-control Strategies Using Nuclear Polyhedrosis Virus (NPV) Parasitoids in Vegetable crops

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INTRODUCTION

Cultivation of vegetables in open fields faces significant challenges due to insect-pest and disease infestations. In the current global context, there is a growing emphasis on producing organic vegetables and reducing the harmful effects of chemical residues in the food chain. To achieve this, the use of biopesticides—or biological pesticides—is gaining attention. These involve the management of pests through living organisms such as viruses, bacteria, fungi, and protozoa. (Payne *et al.,* 1988). Among the biological control agents, parasitoids and predators play a crucial role; however, their usage in vegetable crops remains minimal, accounting for only 1–2% compared to chemical pesticides. One such effective biocontrol agent is the Nuclear Polyhedrosis Virus (NPV), an obligate pathogenic virus with a rod-shaped structure (Mondal *et al*., 2021 and Fuxa *et al*., 2004). NPV contains double-stranded circular DNA and is enclosed within a lipoprotein layer, which forms the outer envelope of the nucleocapsid. This envelope can be either singly or multiply embedded.

NPV particles are arranged in a paracrystalline protein matrix, which is visible under a compound microscope, typically ranging in size from 1 to 15 µm. The NPV species used for insect pest management belong to the *Baculoviridae* family, specifically within the *Baculovirus* group, and have proven effective in controlling a range of insect infestations in an eco-friendly manner (Harrison and Hoovery, 2012).

Virus Infection or Transmission in insect, eggs and larva

NPV infection occurs when insect larvae ingest virus-infected material, such as polyhedral inclusion bodies (PIBs) or granules. The occlusion bodies enter the host's body either through horizontal or vertical transmission and quickly dissolve in the alkaline environment of the larval midgut lumen. The midgut lumen of the larvae maintains an alkaline pH, supported by potassium ions, which not only aids in digestion but also acts as a protective barrier against harmful substances. In this alkaline environment, the crystalline protein matrix of the NPV occlusion bodies dissolves within 3–4 minutes, releasing virions into the midgut fluid. These virions bind to the epithelial cells of the midgut microvilli and enter through fusion with the cytoplasmic membrane. Within 3–4 days post-infection, the nuclei of host cells become infected, leading to systemic infection. Eventually, the larvae succumb to the viral infection. This cycle of infection continues until all susceptible insect larvae are infected and die (Hamx *et al*., 1974)

Application of NPV on field crop

NPV is highly sensitive to adverse environmental conditions, particularly high sunlight and ultraviolet (UV) radiation in the range of 280 to 320 nm. These factors can significantly reduce its effectiveness when applied during the day. To enhance the efficacy of NPV, it is recommended to avoid direct exposure to sunlight during application. When applied as a foliar spray, NPV remains active for only 4–5 days. However, when applied to the soil, it can remain effective for 8–10 years under favourable conditions. Therefore, for optimal results and improved persistence, NPV should be sprayed in the evening or during periods of low sunlight, ensuring maximum activity and protection against degradation by UV rays. (Mondal *et al.,* 2021)

Types of genomes NPV (Nuclear Polyhedrosis Virus) Parasitoids on Vegetables pest

(1) *Helicoverpa armigera* Single-nucleocapsid nucleopolyhedrovirus (HaSNPV)

*Helicoverpa armigera***,** commonly known as the tomato fruit borer, is a highly destructive pest of tomato. It damages the fruits directly, leading to significant reductions in both yield and quality. Nuclear Polyhedrosis Virus (NPV) has proven effective in controlling this pest (Moore *et al.,* 2004). A lower concentration of NPV at 1.15×10^6 OB/ml has been shown to achieve 100% mortality of *H. armigera* within 15–16 days after application. Another effective lower concentration of 7.26×10^5 OB/ml also resulted in 100% control of *H. armigera*. These findings highlight the potential of NPV as a highly effective biological control agent against tomato fruit borer (Chen *et al.,* 2001).

(2) Spodoptera exigua multicapsid nucleopolyhedrovirus (SeMNPV)

Spodoptera exigua, commonly known as the beet armyworm, has a wide host range and causes significant damage to various vegetable crops such as asparagus, cabbage, pepper, tomato, lettuce, celery, and brinjal. The most damaging stage of *S. exigua* is the larval stage, during which the larvae feed extensively on the soft leaves of the host plants (Jkel *et al.,* 1999).

(3) Spodoptera litura multicapsid nucleopolyhedrovirus (SpltMNPV)

Spodoptera litura is a widely destructive pest affecting both horticultural and agronomic crops, as well as various wild plants. It infests a broad range of vegetable crops such as potato, beet, spinach, brinjal, cabbage, and cauliflower, along with fruit crops like grape, citrus, and also soybean (Pang *et al.,* 2001).

(4) Nucleopolyhedrovirus has other variant Anticarsia gemmatalis (AgMNPV)

AgMNPV (Anticarsia gemmatalis Nuclear Polyhedrosis Virus) is a biological pesticide primarily used to control the velvet bean caterpillar in soybean fields. It is effective in managing insect populations and reducing the development of resistance. In addition to its action against *Anticarsia gemmatalis*, AgMNPV has also shown the ability to infect *Spodoptera frugiperda*, commonly known as the fall armyworm. This pest attacks a wide range of agricultural crops, including cotton, sorghum, sugarcane, rice, and various vegetables (Maruniak, 1999).

(5) *Rachiplusia ou* nuclear polyhedrosis virus (RoMNPV)

The genome of *Rachiplusia ou* Nuclear Polyhedrosis Virus (RoMNPV) is closely related to that of *Autographa californica* Nuclear Polyhedrosis Virus (AcNPV) and has been found to be highly effective against *Galleria mellonella* larvae. *Galleria mellonella*, commonly known as the honeycomb moth or wax moth, is a pest of beehives and stored honeycombs (Croizier *et al.,* 1988).

(5) Granulosis virus (GvNPV)

The virus is used in a freeze-dried powdered form to effectively control the potato tuber moth, *Phthorimaea operculella*. It has shown high efficiency in managing infestations in potato crops (Wormleaton *et al.,* 2003).

CONCLUSION

There are various types of Nuclear Polyhedrosis Viruses (NPVs) found worldwide, all belonging to the family *Baculoviridae*. These viruses are rod-shaped and contain double-stranded DNA. NPVs primarily act as parasitoids of lepidopteran insects and serve as effective biological control agents. The use of NPVs offers an environmentally friendly and cost-effective alternative to chemical insecticides for managing agricultural pests. Their application is particularly effective against lepidopteran pests, providing a sustainable and reproducible approach to pest control in modern agriculture.

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