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# Biological Control for Management of Plant Parasitic Nematodes

(*Pratikshya Sahoo)
M.Sc. (Ag.) Department of Nematology, OUAT, Bhubaneswar, India
*Corresponding Author's email: pratikshya.sahoo2212@gmail.com

Worldwide, plant-parasitic nematodes pose a serious danger to the production of several crops. Nematodes, including *Heterodera* (cyst nematodes) and *Meloidogyne* (root-knot nematodes), can result in large agricultural losses; estimates place their yearly output decreases at over $157 billion worldwide. By feeding on the roots of plants, these nematodes weaken them, causing wilting, stunted growth, and in extreme situations, plant death. Since biological control encourages beneficial soil organisms and lessens the need for chemical control, it is a sustainable and eco-friendly method of managing nematodes. Nematode populations are managed by biological control, which makes use of natural enemies like bacteria, fungi, and other organisms.

A small number of genera are regarded as important plant-pathogens, whereas others are confined to a smaller range of crops. To far, about 4100 species of plant-parasitic nematodes have been reported. These microscopic, soil-borne pathogens, known as nematodes, can consume any part of a plant, including the roots, stems, leaves, blossoms, and seeds. However, the majority of species feed on roots. They can enter the cells of plants by using their protruding feeding stylet. Three to five pharyngeal glands that generate effector molecules—which are frequently released and aid in penetration, internal migration, and parasitism are attached to the stylet. Plant-parasitic nematodes can be roughly classified as either ectoparasitic or endoparasitic based on their feeding locations. However, sedentary endoparasites, root knots (*Meloidogyne spp*.), and cyst nematodes (*Heterodera* and *Globodera spp*.) are the most significant nematodes in terms of crop losses. Controlling plant-parasitic nematodes is becoming more and more necessary worldwide as a result of the need to provide more food to the expanding population. Since biological control encourages beneficial soil organisms and lessens the need for chemical control, it is a sustainable and eco-friendly method of managing nematodes. The use of live creatures to reduce a particular pest organism's population density or impact, making it less prevalent or harmful than it otherwise would be, is known as biological control, or biocontrol. In particular, the regulation of nematode populations and/or a decrease in nematode damage by species antagonistic to them is known as biological control of plant parasitic nematodes. The biological control agent (BCA) is the organism that suppresses the nematode. In order to suppress nematode populations, biological control of PPNs uses beneficial soil organisms, antagonistic microbes, and natural enemies. Bacteria, Fungi, Nematode-Trapping Fungi, Predatory and Parasitic Nematodes, and Plant-Derived Biocontrol Agents (Endophytes and Botanicals) are the main categories of biological control agents.

## Fungi as Biocontrol Agents

Several fungi have nematicidal properties and act as endophytes, pathogens, or competitors to suppress nematodes. One of such spp is Trichoderma spp. It is known for its mycoparasitism and ability to induce plant resistance. *Trichoderma harzianum* suppresses nematode populations by degrading their eggs and juvenile stages. *Purpureocillium lilacinum* (formerly *Paecilomyces lilacinus*) a nematophagous fungus that infects nematode eggs and juveniles, reducing population densities. It is Effective against root-knot and cyst nematodes. The fungus *Verticillium chlamydosporium* specializes in infecting the eggs of cyst nematodes (*Heterodera* and *Globodera spp.*). It promotes plant growth while reducing nematode damage.

## Nematode-Trapping Fungi

These fungi form specialized structures such as adhesive networks, constricting rings, and sticky spores to capture and kill nematodes. Example of such fungi are *Arthrobotrys spp.* as it produces adhesive networks that trap and digest nematodes. Another such example is *Dactylella spp*. It Uses constricting rings that close around nematodes, immobilizing and digesting them.

## Bacteria as Biocontrol Agents

Beneficial bacteria can control nematodes through parasitism, antibiosis, or induced systemic resistance in plants. Some important bacterial genera used against PPNs include:
*Pasteuria penetrans* It is a gram-positive, spore-forming bacterium that attaches to the cuticle of nematodes and penetrates their body, leading to sterility and death. This bacterium is effective against root-knot nematodes (*Meloidogyne spp.*). Bacillus spp. Such as *Bacillus subtilis* and *Bacillus thuringiensis* produce toxic metabolites that inhibit nematode growth and reproduction. They enhance plant defense responses, making plants more resistant to nematode attacks. *Pseudomonas fluorescens* produces hydrogen cyanide (HCN) and other secondary metabolites that inhibit nematode egg hatching and juvenile development.

## Advantage of biological control

Combining biological control with other management techniques, such crop rotation and resistant crop varieties, is one of its benefits. This may contribute to the development of a more comprehensive and successful nematode management strategy. However, a number of variables, such as the choice and application of suitable biological control agents, the surrounding environment, and the general condition of the soil, affect how well biological control works. Furthermore, nematode populations' inherent diversity and capacity for environmental adaptation may restrict the efficacy of biological control.

## Conclusion

An efficient and long-term method of managing nematodes is biological control, which can encourage healthy soil organisms and lessen the need for chemical control. Farmers can minimise their need on chemical nematodes while reducing nematode numbers by employing natural enemies including bacteria, fungi, antagonistic microorganisms, and predatory nematodes. The efficiency of biological control is increased when it is combined with organic amendments, resistant crop cultivars, and cultural activities. To guarantee long-term success, its efficacy is contingent upon a number of variables and needs to be combined with other management techniques. The usefulness and effectiveness of biological control in nematode management will increase with further developments in microbial formulations and integrated pest management (IPM) techniques.