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IMPACT OF NEMATOPHAGOUS FUNGI AS BIO CONTROL AGENT – A REVIEW

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Research Paper

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ABSTRACT

Many century scientists were studying different facts of biology of Nematophagous fungi including their potential ability being bioagents to control nematodes. Study of nematophagous fungi has advanced suddenly in past few years, specially with advancement of molecular biology knowledge and omics sciences. This article focuses on the basic information of nematophagous fungi as on aspects like predatory behavior, toxin production, biological control of parasitic nematodes. This study also highlighted the past and present knowledge but future more work has to be remain yet on this topic has special attack devices and real medieval weapons to control pest and pathogens. Much study remains to be done to better understand some fungi and to discover new fungi with nematophagous and biological control potential.

Keywords: Landuse, landcover, change analysis, satellite data, Baltana, Panchkula.

INTRODUCTION

Fungi which feed on nematodes either by trapping or parasitizing them are termed Nematophagus fungi. They are predator or natural enemies of nematodes and have developed highly good understandable strategies of infection (Braga and Araujo, 2014; Degenkolb and Vilcinskas, 2016). About 700 nematophagous fungal species, from several phyla, as *Chytridiomycota, Basidiomycota, Ascomycota and Zygomycota*. Especially even organisms under phylum Oomycota had their nematophagous activity mentioned by (Li et al., 2015).These Fungi classified as per their characteristics of attacking or predation on nematodes: (1)Nematode-trapping/predatorial, (2) Endoparasitic. 3) Opportunistic or ovicidal. Deep study of this topic highlights the characteristics of each group. These fungi mainly are obligate parasites of nematodes, and use spores (conidia, zoospores) assource of causing infection in structures, which may cause harm to the nematode cuticle orbe ingested (Braga and Araujo, 2014).Currently the two new groups of nematophagous fungi havebeen mentioned as toxin-producing fungi and producers of special attack devices (structures which mechanically damage the cuticle ofnematodes) (Liu et al., 2009).

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Toxin-producing fungi

The study of nematophagous fungi was first described by Fresenius (1852) and Zopf (1888a, b). Drechsler (1937)described in good manner as a predatory activity of different species of thesefungi. Past years, several studies shows that predatory behavior of nematophagous fungi have been recorded (Cooke, 1963; Cooke andPramer, 1968; Monoson, 1968; Belder and Jansen, 1994; Araujoet al., 1995; Gives et al., 1999; Braga et al., 2009). Those fungi who produces of special nematode-attacking devices are consider to be similar as sharp sword, causingdamage to the nematode cuticle, resulting in leakage of intravenously blood, lymph or other fluid of the nematodes and allowing complete damage and spread throughout nematode body by fungal hyphae. In short, themechanism of action of these special devices can be explained as:1) hyphae grow towards the cuticle of the nematode, and press onit; 2) a penetration peg is formed and enter the nematodecuticle; 3) hyphae colonize the inner part of the nematode; and 4)hyphae project themselves from the infected nematode (Luo et al.,2004, 2006, 2007). Same secreting appendages or parts were found inConocybe lacteal. However, nematodes does not use them as food when this fungus after paralyzed and killing. (Hutchison et al,1996). *Coprinus comatus* is under group of basidiomycetous fungus which producesanstructureof uncommon as a designated “spiny ball” that resembles acaltrop. This structure is used in form of special device by thefungus to damage the nematode cuticle and then, to feed on them (Luo et al., 2004).

Biological control of parastic nematode using nematophagus fungi:-

In different studies on the use of nematode-trapping fungi found that the fungus *Duddingtonia flagrans* which is not an obligate parasite but produces traps in the presence of nematodes. Nematophagous fungi such as *D. flagrans* don't affect the already established colony or populations of worms within the host and are cannot be curative. This fungi *D.flagrans* targets the free-living larval stages from outside the host. The most correct path to apply the fungus tothe faecal environment is via gap or passage through the gastrointestinal tract of the host. *D. flagrans* is unique in that itproduces in vast numbers a survivalstructure known as a chlamydospore, when fed to livestock, can survive passage through the gastrointestinal tract to be deposited in faeces. Once entered in the faeces, *D. flagrans* grows within the faecal deposit and traps emerging larvae.

The majority of nematopathogenic organisms fall under the category of nematode catching; these organisms use choking (dynamic) or non-constricting (inert) rings, sticky hyphae, sticky handles, sticky branches, or sticky systems at various points along a widely distributed vegetative hyphal framework to trap and kill nematodes by infiltration and development of hyphal components inside the have, for example, *Arthrobotrys candida, A. oli* (Santos and Charles. 1995), *Harposporium anguillulae* (Charles et al., 1996) and *Monacrosporium spp.* (Gronvold et al., 1985). The nematode-catching organism *Duddingtonia flagrans* produces thickwalled clamydospores that enable it to survive entry through the gastrointestinal tract and is thus effective in crushing the larval stages of parasitic nematodes in animals. This organism has shown significant prevalence in the decline of gastrointestinal nematodes parasitizing animals (Mendoza de Gives et al., 1998; Vilela et al., 2012).

Habitats of Nematophagous Fungi:-

Gray (1984b) stated ten different terrestrial habitats on their investigation on nematophagous fungi in Ireland and get result that although nematophagous fungi were survived mostly in allthe habitats examined, coastal vegetation, agricultural pasture and coniferous leaf litter had the maximum number of samples with nematophagous fungi. Also established that nematophagous fungi present in soil are associated with specific soil variables, such as including soil, depth, pH moisture, phosphorus, nitrogen, and potassium in some amount, and its densities of soil fungi, nematodes and bacteria, (Gray 1985, 1988).

Table 1: Media used for isolating nematodes (Li *et al*. 2014).

Media	Recipe	Methods	Reference
PDA	200 g peeled potato, 20 g agar; 20 g glucose; 1,000 ml water	Boil potatoes for 30 min, cheesecloth filter through	----
CMA	20 g cornmeal; 20 g agar; 1,000 ml water	Boil cook cornmeal for 30 min, filter through cheesecloth	----
Water agar (WA) Oat meal medium	20 g agar; 1,000 ml water20 g oatmeal; 20 g agar; 1,000 ml water	Boil oatmeal for 30 min, filter through cheesecloth	----
Maize meal agar	20 g maize meal (or crushed maize grains), 20 g agar; 1,000 ml water	The maize and water are warmed) to about 70°C, for 1 h	Duddington (1955)
Difco CMA	8.5 g Difco cornmeal;10 g agar, 1,000 ml water	----	Rubner (1996)
Rabbit-dung agar	Rabbit pellets; 20 g agar; 1,000 ml water	Soak rabbit pellets in tap water for 2 or 3 days, and pour off the supernatant fluid, filter and dilute with tap water until a pale straw colour	Duddington (1955)
Selective media	1% water agar or 1% tryptone glucose agar; 1,000 mg/l triton, 50 mg/l streptomycin sulfate, 50 mg/l rose Bengal	------	Lopez-Llorca and Duncan (1986)

Culture Medium

There are many culture media used for incubation and isolation of nematophagous fungi. As a general rule, low media of nutrient should be used for isolation and high nutrient media should be used for incubation. Once isolated the most commonly used media for incubation of nematophagous fungi are PDA and CMA. However, it should be observed in case of nematophagous fungi, if more nutrients are present they produce less conidiophores are generally.

Baits for Nematophagous Fungi:

Addition of nematodes as baits in isolation media can successfully stimulate the growth and trap formation of nematophagous fungi, providing their accurate quantitative and qualitative assessment (Wyborn et al. 1969).

1) PDA : Recipe 200 g peeled potato, 20 g agar; 20 g glucose; 1,000 ml Water

   Method Boil potatoes for 30 min filter through cheese cloth.

2) CMA: Recipe 20 g cornmeal; 20 g agar;1,000 ml waters

Method Boil cook cornmeal for 30 min, filter through Cheese cloth.

This media encourages the multiplication of nematodes, but does not support good vegetative growth even of predacious fungi, which makes it useful for the study of internal parasites of nematodes or for material where, as sometimes happens, mould contamination is severe. A disadvantage is that the agar often becomes rather soft, that the nematodes are plentiful and the surface may be badly disturbed

Early history

Mankau 1979 investigated that fungal antagonists of nematodes can be nematode-trapping fungi, endoparasitic fungi, parasites of nematode eggs and cysts, and fungi which produce metabolites toxic to nematodes. *Verticillium chlamydosporium* which is the fungal pathogen that acts as biocontrolagent forsusceptible root-knot nematode, *Meloidogyne incognita*by parasitizing the eggs and females of parasitic nematodes. That fungus produced an alkaline serine protease in submerged culture. This enzyme, VCP-I, was characterized as a class II subtilisin, based on amino acid sequence homology (Segers 1996). Frans *et al 1991*reported that the potential three isolates of *Verticillium chlamydosporium* were believed to be biocontrol agents against *Meloidogyne arenaria*on tomato plants under protected cultivation.Meyer (1999) conducted his studies on Two strains of the fungus *Verticillium lecanii* (A. Zimmermann) Viégas as potential biocontrol agents for root-knot nematode (*Meloidogyne incognita* (Kofoid& White) Chitwood) on cantaloupe (Cucumis melo L.). For the study, pots were filled with soil that had been inoculated with M. incognita (inoculum was applied at two levels: 1000 and 5000 eggs/pot). Each fungus strain was applied individually by pouring an aqueous suspension (made from a wettable granule formulation) into the inoculated soil. Controls received water only. One cantaloupe seedling was then transplanted into each pot. Plants were grown for 55 days in the greenhouse, and then harvested and assessed for root and shoot growth and for nematode egg production. In pots inoculated with 1000 eggs/plant, neither fungus strain affected nematode egg numbers. At the 5000 eggs/ plant inoculum level, both strains of the fungus suppressed egg numbers (counts were 28% and 31% less than water controls).

Neither strain of *V. lecanii* affected the number of eggs embedded in root galls; the fungus suppressed nematode population numbers overall solely by affecting the number of eggs located outside of root tissues. Both fungus strains were also autoclaved and then applied to soil, to test for effects of nonviable fungus. In pots inoculated with 5000 eggs, application of one autoclaved strain resulted in a 35% suppression in egg numbers after 55 days, suggesting that the fungus produced a heat-stable substance deleterious to the nematode. Davies *et al*1991 reported the development of a BCA for a nematode pest is still very inadequate. Several microorganisms are capable of providing effective natural control of some nematode pests, including cyst and root-knot nematodes. Some selected BCAs would appear to have considerable potential, particularly in subsistence farming, but it remains to be seen whether any of the organisms so far identified have the potential for commercial exploitation. Grundler 1996 reported that Plant-parasitic nematodes cause severe damage and economic loss to many crops. Engineered resistance may provide protection against nematodes in cases when conventional means are not effective enough, too expensive or just not available. Hazardous effects on the environment, as observed with all nematicides, may also be avoided. As the development of engineered resistance is expensive, profits presumably can be made only with crops of high economic importance and protection of patents. Patent protection of single genes in cultivars presumably will strongly affect the international seed market.

Kerry 1982 studied about the populations of the cereal cyst nematode fail to multiply in many soils in Europe and farmers are able to grow susceptible crops intensively on infested land. Similar numbers of females develop on roots in summer in soils where numbers of the nematode increase or decline. Two fungi, *Nematophthoragyniophila* and *Verticillium chlamydosporium* parasitize females on roots, prevent cyst formation, decrease fecundity, and limit nematode numbers.

Formalin (38 % formaldehyde) soil drenches at 3000/ha reduce the activity of these fungi and populations of the nematode increase. *N. gynophila* is an Oomycete which infects by motile zoospores whose activity is decreased when summer rainfall is light whereas *V. chlamydosporium* is much less affected by soil moisture. The decline of *Heterodera avenue* populations is associated with large numbers of spores in soil. At present it is not possible to control the nematode by introducing these fungi into soils where they are few or absent.Sayre *et al* 1991studies involved in examining the efficacy of soil factors influencing the antagonist-nematode relationship, there is clear demonstration that management practices can be used effectively to manipulate the natural enemies of nematodes. Eventually, healthy root growth, little impaired by nematode pests, may be achieved by the introduction of populations or individual strains responsible for suppression. Sikora *et al*1992management has been neglected in favor of the inundative release approach tobiological controlthat gave importance for using integrated crop production methods to manage the nematode antagonists discussed hereworking in the soil ecosystem for use in manipulating or controlling the behavior of nematode antagonists. This research drastically needed to develop alternative strategies to control plant parasitic nematodes.

Current research

Pandit *et al* 2014 stated that after a research on parasitic nematodes which were harming plants and animals developed resistance for nematode populations, pesticides and environmental pollution led them towards the biocontrol of parasitic nematodes. Fernandes *et al* 2017studies aimed to evaluate the efficacy of the association of the nematophagous fungi (Duddingtonia flagrans-AC001); (Pochonia chlamydosporia-VC4) and (Arthrobotrys robusta-I31) with gastro-intestinal nematodes in a pelletised formulation of a sodium alginate matrix.The percentage reduction of infective larvae in the in vitro test was 94% (p<.01). In the in vivo test, the treated animals with fungal association had lower egg counts per gram of faeces (p<.01) compared to the control group animals – a reduction of 91.8%.Luns *et al* 2018studies compared the coadministration among the three nematode predatory fungi, *Duddingtonia flagrans*, *Monacro sporiumthaumasium* and *Arthrobotrysrobusta*,in the biologicalcontrolofcattlegastrointestinal nematodes is in comparison with the use of the fungus *D. flagrans*alone.The associations which include *A.robusta* werelessefficientin thisstudy than *D. flagrans* alone or associated with *M.thaumasium.* Mortan *et al* 2004 reported that for controlling plant parasitic nematodes as a biological control agent can be understood by their infectious process. The egg-parasitic fungi, *Pochonia chlamydosporia* and *Paecilomyces lilacinus*, and the nematode trapping fungus, *Arthrobotrysoligospora* has involved the characterisation of enzymes that aid penetration of the eggshell or the nematode body wall and the identification of nematicidal toxins. This growing understanding of the biology of infection is opening new avenues in the improvement of fungi as biological control agents. Zhang *et al* 2016 studied about many important nematophagous and entomogenous fungi including nematode-trapping fungi (*Arthrobotrysoligospora*and *Drechslerella stenobrocha*), nematode endoparasite (*Hirsutella minnesotensis*), insect pathogens (*Beauveria bassiana* and *Metarhizium spp*.) and Chinese medicinal fungi (*Ophiocordyceps sinensis* and *Cordyceps militaris*), have been genome sequenced and extensively analyzed in China.

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