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Bioefficacy of Insecticidal Nematodes against Stored Grain Pests: An Overview

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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Review Article

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ABSTRACT

For protection of stored agricultural products in ware house, grain store and food processing factory from insect damage, control measures should be taken. Stored grain insect pests are difficult to control. Though chemical insecticides are effective in controlling pests, other environment friendly methods have been advocated. Entomopathogenic nematodes are potential bio control agent for management of insect pests. In this review research work done so far for management of stored grain pests has been highlighted so that further wok can be preceded.

Keywords: Stored grain pests; biological control agent; entomopathogenic nematodes (EPNs); bioefficacy.

1. INTRODUCTION

In storage and post harvest processing large quantities of stored grains and products are destroyed by insect pests. Insects bore and feed the kernel of the grain, reduce the grain quality , spread mold contamination, and cause grain rancidity. It has been estimated that in stores, an average of 1% losses caused by pests in industrialized countries and 10-30% losses in developing countries [1]. "These insect pests conceal themselves in cracks and crevices of the storehouse, and machinery used and thus difficult to control them. Therefore, there is a need to protect stored food products from attack by insects. Chemical substances for pest control in storage should provide a residue-free technology. To minimize the use of toxic chemicals and to provide better protection of the environment, application of bio control agents

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have been advocated. Among the biocontrol agents such as bacteria, fungi, viruses and nematodes, nematodes are measured as important for control of several stored product insects" [2].

2. STORED GRAIN PESTS

In a store house different types of insects are present which show different activity and nature of damage. The female lays eggs inside the kernels and develop inside kernels, larvae feed on the inner endosperm, and producing holes in the kernel through which the adult insects exist and the female lays eggs. The kharpa beetle (*Trogoderma granarium*) and the warehouse beetle (*Trogoderma variabile*), larvae feed on dried cereal grains, dried spices and food products. The rice weevil (*Sitophilus oryzae*), granary weevil (*Sitophilus granarius*), lesser grain borer (*Rhyzopertha dominica*), maize weevil, the Angoumois moth feed and develop inside the kernels. The sawtoothed grain beetle (*Oryzaephilus surinamensis*), the red flour beetle (*Tribolium castaneum*), the confused flour beetle (*T.confusum*), the Indianmeal moth (*Plodia interpunctella)*, the Mediterranean flour moth (*Ephestia kuehniella*), the Mealworm (*Tenebrio molitor*), and the larger black flour beetle feed on damaged grain or products [1]. Due to their survival potential in dry condition, they are destructive and difficult to control. Some fumigants, have found to be effective at lower cost. However, public concern about chemical pesticide related risks increases the development of alternative, environment friendly disinfestations methods such as high temperatures. The use of biological control agents have been utilized effectively. Arbogast [3] stated that "bio control agent or any organism has been considered as an undesirable contaminant of stored product"

3. ENTOMOPATHOGENIC NEMATODES (EPN$_S$)

Laboratory experiments showed that entomopathogenic nematodes (EPNs) are considered as potential biological agents for killing of stored grain pest. Entomopathogenic nematodes (EPNs) *Steinernema* and *Heterorhabditis* from families Steinernematidae and Heterorhabditidae respectively are lethal parasites of a wide range of insect pests. *Photorhabdus* [4] and *Xenorhabdus* [5] are symbiotically associated "bacteria with *Heterorhabditis* and *Steinernema*, respectively". "The third-stage infective juvenile, which are free-living stage, seek out and invade potential hosts and release their pathogenic bnacteria into the nutrient-rich hemolymph. They can kill target insects within 48 h" [6]. "The bacteria proliferate; the nematodes feed on bacteria and insect tissues, and reproduce. When the host cadaver is depleted of resources, nematodes associated with pathogenic bacteria emerge and search for new hosts to infect. These bio control agents have received much attention in many countries, as these agents have special character such as searching for the insect pests in cryptic habitats, massive reproductive ability, easy mass-production, safety to humans, and other vertebrates as well non-target insects" [7]. Efficacy against stored grain pests depend on host biology and surrounding environmental condition. It is well-known fact that storage environment are dry and application of entomopathogenic nematodes to dry storage environment is risky. Entomopathogenic nematodes have solved this problem through proper application technology and now become a consistent alternative for commercial applications in warehouses and storage facilities.

4. ENTOMOPATHOGENIC NEMATODES AGAINST STORED GRAIN PESTS

Research work conducted in different parts of the world revealed that Entomopathogenic nematodes (EPNs) effective against different species of stored grain insects. The rate of desiccation (RD) among IJs of different EPN species, at different range of relative humidity (RH) influences nematode efficacy against those pests. Ramakrishnan et al. [8] observed that "at RH equivalent to 74%, IJs of *S. carpocapsae* are a better adaptable than *S. feltiae* and *H. bacteriophora* while an optimal RH of > 90% is required for *S. feltiae* and *H. bacteriophora.* Thus entomopathogenic nematodes (EPN) species differ in their capability to withstand Rapid Desiccation (RD). Moreover, host searching ability is important factor for entomopathogenic nematodes efficacy". "Cruiser entomopathogenic nematode, *H.bacteriophora* and *H.megidis* are more virulent against adults of Indian meal moth (*Plodia interpunctella*) than against larvae" [9]. "Intermediate foraging entomopathogenic nematode *S. feltiae* was moderately effective against the granary weevil (*Sitophilus granarius*) and caused low mortality to *T. confusum* larvae" [10] . *"S.feltiae* can cause over 90% larval mortality of Indian meal moth, Mediterranean flour moth, red flour beetles" [11]. However, they found that S. *carpocapsae* was more effective than *S. feltiae* for killing of larvae of *E. kuehniella.* Athanassiou et al*.* (2008) found that virulence of different strains of *S. feltiae* varied, against adults and larvae of *T. confusum* (79% larval mortality) and larvae of *E. kuehniella.* In that study, they observed that the most effective strain against *T. confusum* larvae was not effective against *E. kuehniella* larvae. Similarly, intermediate foraging entomopathogenic nematodes, *S.riobrave* have a potential to kill over 65% larvae of Indian meal moths, Mediterranean flour moths, sawtoothed grain beetles, mealworms, red flour beetles and warehouse beetles. "Generally entomopathogenic nematodes are considered more effective against the larval stage than adults as most of the adults are more mobile and may avoid the contact with entomopathogenic nematodes" [12] (Athanassiou et al*.* 2008). Ramos-Rodroguez et al*.* [13] found that "entomopathogenic nematodes were found to be more effective against larvae of the red flour beetle, *Tribolium castaneum* than against adults". Pathogenic level and prevailing temperature are important factors for efficacy of entomopathogenic nematodes. Mortality rates of adults of rice weevil, *S.oryzae* depend on temperature and doses of nematode, *S. feltiae* as well as on the strain of nematodes *S. feltiae* B30, B49 and 3162 [14]. In the case of adults of *S. oryzae*, the mortality was very low at all doses and temperatures and did not exceed 9%. Mortality of *T*. *confusum* adults did not exceed 17% regardless of the entomopathogenic nematode species tested. Trdan et al*.* [15] noted that higher doses of *S. carpocapsae* were required to achieve a high level of mortality of sawtoothed grain beetle (*Oryzaephilus surinamensis*)*. S. feltiae* was more effective against *S. granaries* and *O. surinamensis* at 20°C and 25°C than at 15°C. At 100 IJs per ml at 20°C or at 30°C*, S*. *feltiae* provided mortality of *E. kuehniella* larvae (36.7% to 78.3%) and at 20°C very few larvae were dead with *H*. *bacteriophora* whereas no mortality was observed with *S*. *carpocapsae* in wheat treatments. "The mortality of adults of *Rhyzopertha dominica* at 20°C, at 20,000 IJs per ml in wheat treated with *S*. *feltiae* and *S*. *carpocapsae* did not exceed 23.3 and 41.7%, respectively. Mortality of *T*. *confusum* larvae was notably higher and exceeded 56% in wheat treated with 10,000 or 20,000 IJs per ml of *S*. *feltiae* at 20°C. Unlike *S*. *feltiae* and *S*. *carpocapsae*, the application of *H*. *bacteriophora* resulted in lower mortality levels" [2]. *S.feltiae*, *S.carpocapsae* and *H.bacteriophora* cause mortality 87.8, 63.3, and 60.0% respectively of exposed large larvae (*T. granarium*) on stored wheat treated with 50000 IJs/ml after 8 days of exposure at 30°C under laboratory condition [16]. All four species of EPNs, viz., *S. pakistanense* (LM-07), *S. bifurcatum* (LM-30), *S. affinae* (GB-14) and *S. cholashanense* (GB-22) were able to cause mortal effects of adults of *T.confusum* and *R. dominica* .*S. pakistanense* (LM-07) and *S. bifurcatum* (LM-30) were the most effective at 150 IJs/beetle at 30°C and *S. affinae* (GB-14) and *S. cholashanense* (GB-22) at the same concentration at 20°C [17]. Hundred per cent mortality of *T. confusum* and *R.dominica* was observed at a concentration of 150 IJs of *S. pakistanense* per adult at 30°C. *S. riobrave*, *H. bacteriophora* showed various levels of efficacy against cowpea weevil (*Callosobruchus maculates*), khapra beetle (*Trogoderma granarium*), and rust red flour beetle (*Tribolium castaneum*).The highest mortality rate 16.67% was recorded with *S.riobrave* (2000 IJs / ml) after 72 hours post-treatment of *C. Maculates*, while the lowest rate of mortality (1.33%) of adult insects for rusty flour beetle at the dose of 500 IJs / ml after 24 hours [18].

5. CONCLUSION

Better knowledge of the nature of the grain storage system and the pest complexes that occur in them is necessary to achieve success in their implementation of bio control measures. To avoid insect infestation and facilitate control operations at an early stage, the design of factories, granaries, and warehouses should be improved. Environmental conditions in the grain storage buildings are very important along with good sanitary measures and good monitoring system in order to render the conditions unfavourable for development of the insects (Scholler et al*.* 1997). Since stored product environments are enclosed, biological control options are restricted to augmentative biological control. Augmentation or inundative release of the EPNs keeps insect damage within acceptable limits. The EPNs should be released at level of consumer's acceptance on pathogen - treated food while insect pest populations are small [19]. Before release or treatment, proper sampling should be done in order to locate insect infestation, their identification up to developmental stages. For large scale application, bioinsecticides have to be ready to use and easy to apply by means of simple equipment. A condition of an aqueous environment is required for entomopathogenic nematode so that the nematode can reach the target. Usually, only a single nematode species or strain is not equally effective against all major stored product insect pests, as the virulence of entomopathogenic nematodes against post harvest insects varies depending on the nematode species and strains. Therefore, specific species and time of application is necessary. With the discovery of new, virulent, heat-tolerant strains, with improved methods of formulation and application, could enhance the exploitation of entomopathogenic nematode in storage amenities against post-harvest insects [20-28].

COMPETING INTERESTS

Author has declared that no competing interests exist.

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