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Biological Control of Bark Eating Caterpillar *Indarbela Quadrinotata* in Indian Gooseberry

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ABSTRACT

Field trials were carried out to study the efficacy of different entomopathogens, commercial bio-pesticides and plant extract against bark eating caterpillar (*Inderbela quadrinotata* wlk.) on Indian gooseberry (*Emblica officinalis*). All the treatments show remarkable variations against the moth. Among the treatments the bio-pesticides were found superior over entomopathogens in frass reduction of the caterpillar. The result reveals that neem extracts shows maximum frass reduction of the larvae followed by *Bacillus thuringiensis* and *Beauveria bassiana* over control. Further, the efficacy test of entomopathgens reveals that *Fusarium moniliformae* was found comparably the best among the other tested fungal isolates in frass reduction. The use of biopesticides preferably the entomopathogens in pest management, is widely acceptable as it is safer and economical maintaining the ecological balance of the nature.
Keywords: Bark Eating Caterpillar, Biological Control, Plant Extract, Entomopathogens, Indian Gooseberry.

I. INTRODUCTION

The bark eating caterpillar (*Inderbela quadrinotata* wlk.) a moth of order Lepidoptera, with wood boring habits, the most prevalent in Asia Pacific region (34%) (FAO, 2009), affects nearly fifty plant species in tropical and sub-tropical India. The caterpillar damages varieties of fruit trees in central India (CROPSAP, 2013) including Indian gooseberry (*Emblica officinalis*), and thus a pest of national significance (AESA, 2014). Although bark caterpillar is apolyphagous generally considered of minor importance in forestry, however is a major pest of Indian gooseberry (Mathew, 1997; Bharpoda et al 2009). The infected plant generally shows symptoms in form of large dark-brown masses of chewed wood and faecal matter near the forks. The larva bores into the bark making tunnel of nearly 20 cm. depth take refuge during the day and eats the bark of the tree during night. Bark damaged by the larva results in inhibiting translocation of cell sap, and reduces growth of host species (Sashidharan et al 2010) along with adverse impact on fruiting of the plant.

The infestation of pest generally starts in the month of April with the emergence of moths (Pathak, 2003). The damage due to this pest prevails more or less but maximum during rainy season over rest of the season in a year (Sasidharan and Varma, 2008; Bharpoda et al 2009). The temperature plays an important role in population variations of the pest, thus the insect–tree host–natural enemy relationship can help in developing timely control management of the larvae (Sasidharan and Varma, 2008).The incidence of pest is also influenced due to elevation, varying 0 to 98% which is negligible in high elevation, followed by mid and maximum in low areas (Gupta et al 2014).The age of plant species and availability of appropriate alternative host plants are significant factors for survival of a residual pest population (Mathew, 1997).

The pest control using pesticides are found effective but create toxicity in the environment. The Agro-ecosystem analysis (AESA) focusing bio-intensive techniques based IPM shows least damage to the ecosystem, and has emerged as a better alternative of pest management programme in various countries (FAO, 2016). Among the integrated management approaches, biological control is favourable in terms of cost-benefit ratio, combating insecticide-resistant pests and minimizing the practice of chemical pesticides (Bale et al., 2008). Biological control has also gained maximum acceptance for management of major pests as they restore the natural balance through meaningful human intervention (Ballal and Verghese, 2015). A large number of *Fusarium* species are entomopathogenic known for their abundance in nature and can be easily cultured and mass produced, and causes high insect mortalities along with high host specificity without damaging to plants (Teetor-Barsch and Roberts, 1983). The microbial biocontrol agent shows different mechanisms of action (Fravel, 2005) and are natural enemies devastating the vast population of the pest with no hazardous effect on human health and the environment (Khan et al 2012). Therefore, the present work is based on evaluation of various biocides, plant extract and entomopathogens as a part of biological control system and their potentiality in effective management of bark eating pest of Indian gooseberry.

II. METHODS AND MATERIAL

The experiment was conducted in a nursery, in Jabalpur district of Madhya Pradesh, in central India ($23^0 10'$N $79^0 56'$E) during year 2014. The experimental plot contains 105 trees of *E. officinalis* distributed in 21 rows of 5 trees each. The bark eating larvae infected with entomopathogenic fungi was collected from the nursery and brought for further laboratory study.

Larval Cultures and Isolation of Entomopathogens

The infected larvae were put on moist and sterilized paper on petridishes for the germination of entomopathogen for 72 hrs. The entomopathogenic fungal isolates used in this study were obtained as natural infections in host insects. Three species of entomopathogenic fungi viz. *Fusarium oxysporum*, *F. moniliformae* and *Aspergillus niger* were identified with the help of standard mycological literature (Booth, 1971; Ellis, 1971; Grove, 1937; Sutton, 1980).

Pathogenicity Test

The isolates were grown on Potato Dextrose Agar (PDA) at various concentrations for 10-15 days. The harvesting of conidia were carried out by scraping the surface of the agar using sterile spatula, and rinsing it with distilled water containing 0.1% Triton X-100.The conidial suspension was filtered to remove debris. The conidia were determined using hemocytometer *(neubauer improved* cell counting chamber) and the suspensions were adjusted to 1×10^8 conidia mL⁻1 to prepare required volume for each isolate. The conidial suspensions of the isolates were applied by pipetting onto the larva. The *F. oxysporum* isolate was applied at concentrations of 1.6×10^{-3}, 1.6×10^{-5},1.6×10^{-6}, 1.6×10^{-7},1.6×10^{-8} cell mL⁻1, *F. moniliformae* isolates at 1.5×10^{-3}, $1.5 \times 10^{-5,}$ 1.5×10^{-6}, 1.5×10^{-7},1.5×10^{-8} cell mL⁻1 and *A. niger* isolates at 1.8×10^{-3}, 1.8×10^{-5}, 1.8×10^{-6}, 1.8×10^{-7},1.8×10^{-8} cell mL⁻1 along with one control plate in each experiment. Finally the petri-plates were tightly sealed and incubated at 25 ± 1^0C, 70% RH and larvae were examined for pathogenicity at regular interval of one week for four weeks. It was observed that *Fusarium. oxysporum* at 1.6×10^{-6}, *Fusarium moniliformae* at $1.5 \times 10^{-6}$and *Aspergillus niger* at 1.8×10^{-6} cell mL⁻1 concentrations was found to be effective against larvae and kept for further experimental studies.

Field Trials

Two field trials were laid out in triplicates in randomized block for testing the efficacy of biocontrol agents along with control, against bark eating pest of Indian gooseberry. In first trial three commercial biopesticides including Deuteromycotina fungi *Fusarium oxysporum* (fungal suspension) @ $1.7 \times 10^{-}$ cell mL⁻1 and *Beauveria bassiana (Trade name-*Boverin*) (1% w/w)* @25 g L^{-1}, and a spore forming bacteria *Bacillus thuringiensis* (var. kurstaki) (Btk) *(Trade name-Dipel BL)*@ 25 g L^{-1}, along with aqueous extract of Neem@10% were tested against the larvae. The bio-pesticides were prepared on the basis of their active spore formulation and were sprayed by Hand Sprayer (cap. 5lit).The second trial was conducted to evaluate the entomopathogenic activity of three in vitro isolated fungi with their effective dose of pathogenicity on the larvae. *Fusarium oxysporum*@1.6×10^{-6}, cell mL^{-1}, *F. moniliformae*@1.5 $\times10^{-6}$ cell mL^{-1}and *Aspergillus niger*@ 1.8 $\times10^{-6}$ cell mL^{-1}, and solvent extract of *Cleistanthus collinus* prepared in petroleum ether@10%, were applied on the infected tree. The observations on the reduction of frass made by *I. quadrinotata* were recorded 3 7 10 and 15 DAT in both the trials. The effects of various treatments on bark eating caterpillar were determined using ANOVA and treatment means were separated using the LSD test.

III. RESULT AND DISCUSSION

1. Results

Effect of commercial biopesticides and plant extract on frass reduction

The efficacy of fungal suspension, commercial bio-pesticides and plant extract was studied and all the treatment shows significant frass reduction of *I. quadrinotata* in compared to control plot ($p<0.05$) (Table 1). There was a lower production of frass where neem extract was applied and in contrast, the frass formation progressed a little more in other treatments. The pooled mean data revealed that neem extract @10% was found significantly effective, followed by *Bacillus thuringiensis* @25g L^{-1} in reduction of frass 15 DAT. The Larvae treated with fungal suspension of *Fusarium oxysporum* and *Beauveria bassiana* also shows frass reduction to a satisfactory percentage over control at 15 DAT.

Table 1. Effect of bio-pesticides and plant extract in frass reduction (%)

Treatment	Dose	Frass reduction (%)*
F. oxysporum	1.7x10^{-7} cell mL^{-1}	60.83
B. bassiana	25g L^{-1}	68.52
B. thuringiensis	25g L^{-1}	70.27
Neem Extract	10%	79.5
Control		0.00
SEm ± CD at 5%		3.0201 6.5802

*mean of three replications

Effect of entomopathogens and plant extract on frass reduction

The pathogens isolated from the infected larvae were bio assayed for entomo-pathogenic activity against *I. quadrinotata* and were found effective in frass reduction. The assessment of the efficacy of three isolates and solvent petroleum ether plant extract shows significant variations from the control treatment (Table 2).

Table 2. Entomopathogenic activity of isolated pathogen in frass reduction (%) 15 DAT

Treatment	Dose	Frass reduction (%)*
F. oxysporum	1.6 $\times10^{-6}$ cell mL^{-1}	55.55
F. moniliformae	1.5 x 10^{-6} cell mL^{-1}	60.73
A. niger	1.8 $\times$10-^{6} cell mL^{-1}	51.48
C. collinus	10%	55.1
Control		0.00
SEm ± CD at 5%		7.6727 17.693

*mean of three replications

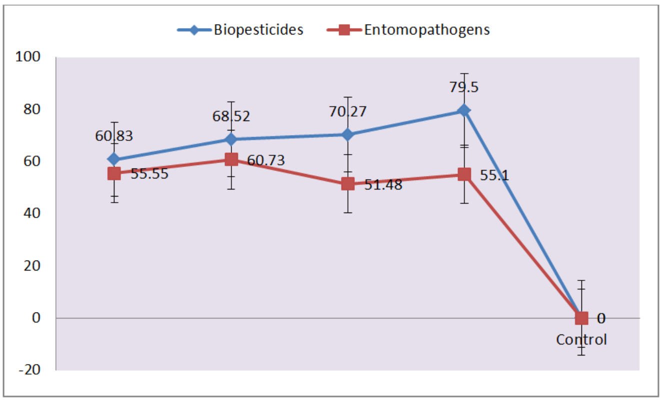

Figure1: Comparison of various treatments in frass reduction (%) of larvae, 15 DAT. Values expressed as mean SEm± over control

Among all the treatments *Fusarium moniliformae* @ 1.5 $\times$ 10^{-6} cell mL^{-1} shows maximum frass reduction. The suspension of the fungal isolates and petroleum ether extract of *Cleistanthus collinus* shows remarkable differences due to effects of mycoses in the frass of the larvae. The fungal suspension *F. oxysporum* @ 1.6 $\times10^{-6}$

cell mL⁻1 and *Cleistanthus collinus* extract were found at par with each other in minimizing frass formation by the larvae 15 DAT. The comparative study of all the treatments reveals that neem extract was found to be significantly superior among all the treatments in frass reduction of *I. quadrinotata* larvae (Figure 1).

2. Discussion

The use of bio-control agents and plant extracts in pest management in fruit trees was found significant. The present study reveals that neem extract was found significantly superior among all the treatments in frass reduction of the larvae. Sundararaj (2014) advocated the use of maximum quantity of neem based products as an integral component for pest management due to its feasibility. Kurosawa et al (2012) reported that emulsion form of nano organic pesticide prepared from Azadiractin A, B and Limonoids in combination with Earthen Pot Irrigation System (EPIS) resulted 50-90% reduction in apical twig, gall maker, leaf roller, bark and shoot borer and termites in Indian gooseberry in arid areas. Satti et al (2013) observed that botanical treatment of Neem and Argel at ten days interval has potentiality in controlling green leaf caterpillar (*Noorda blitealis* Walker), in drumstick tree (*Moringa oleifera* Lam.). The application of biocontrol agents in combination with biofertilizers for Fusarium wilt of *Delbergia sissoo* (Singh et al., 2002) and with organic manure against Fusarium wilt of *Gmelina arborea* (Singh et al 2003) was reported to be effective, which support the present work. Tounsi et al (2005) reported that the wild strain of *B. thuringiensis*, kurstaki individually as compared to toxin mixtures, have more effective biopesticidal action against the Mediterranean flour moth, *Ephestia kuehniella*. Mohan et al (2014) determined toxicity of *Bacillus thuringiensis (Bt) kurstaki* against important lepidopterous insect pests of agricultural importance. Similarly, the effectiveness of the entomopathogenic fungi *Beauveria bassiana* has been reported against the larvae of *Polyphylla fullo* (Erler and Ozgur Ates, 2015), cotton bollworm (*Helicoverpa zea*) (Lopez and Sword, 2015) Colorado potato beetle *Leptinotarsa decemlineata* (Wraight and Ramos, 2015) and tobacco caterpillar (*Spodoptera litura*) (Kaur et al 2011).

The efficacy of entomopathogenic fungi against bark eating caterpillar was found to be encouraging. In the present study the efficacy of *Fusarium sps*. and *Aspergillus sps.* was less significant in frass reduction as compared to plant extract and biocides which may be due to their weak pathogenesis on diseased lepidopteran forest pests as reported by Draganova et al (2013). The entomopathogenic activity of the pathogens on various other pests gave promising results. Abd El- Ghany et al (2012) observed that crude extract of *F. oxysporum* was found effective in controlling Greater wax moth *Galleria mellonella* (49.48%). Similarly, the entomopathogenic activity of *F. oxysporum* observed on southern green stink bug (*Nezara viridula*) of rice shows 51.96% mortality (Dutta et al 2013). Under laboratory conditions *Aspergillus niger* causes mortality of Red spider mite, *Oligonychus coffeae Nietner* of tea up to 91.11% (Mazid et al 2015).

IV. CONCLUSION

The present research concludes that biological management of bark eating caterpillar in Indian gooseberry trees, the bio-pesticides appeared to be a promising candidate however the fungal isolate were also effective and thus needs a wide investigation. The Integrated pest management using plant extract, bio-pesticides, entomo pathogenic fungi is environmental friendly, feasible and widely accepted. Future investigation in search of new biological control methods with the integration of modern scientific techniques can lead to develop ecofriendly pest control model.

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