Field assessment of delivery methods for fungal pathogens and insecticides against cashew stem and root borer, *Plocaederus ferrugineus* L. (Cerambycidae: Coleoptera)

V. Ambethgar

**ABSTRACT**

Field trials were conducted to assess the performance of *Beauveria bassiana* and *Metarhizium anisopliae* against cashew stem and root borer, *Plocaederus ferrugineus* Linn (Coleoptera: Cerambycidae) and to compare them with conventional prophylactic treatment with insecticides. Cashew trees with early phase of borer infestation were marked and the treatments were applied sequentially adopting different delivery methods viz., swabbing of saturated conidial-mud slurry over tree trunk, pouring saturated aqueous suspension of conidia through larval entry holes and soil incorporation of fungal spawn, after removing the grubs and cleaning the frass materials. The effectiveness of treatments was assessed based on the extent of recovery of infested trees. All the treatments were superior to untreated control in reducing the borer infestation. Variations among the treatments could be observed with higher co-efficient of variation with 58.16 per cent. The efficacy of *B. bassiana* and *M. anisopliae* were on a par, but the delivery methods varied significantly. Pouring conidial suspension effected 33.3-36.4% recovery of infested trees followed by swabbing conidial slurry with 23.0-25.0% and soil application with 15.4-16.6% recovered trees. Conventional insecticidal treatments remained superior with 46.2-50.0% recovery of infested trees. However, implementation of fungal application in integrated control of *P. ferrugineus* should be considered, because fungi would not only safer to non-target organisms, but also be more effective in the long term pest control programme.

**Key Words:** Cashew, *Plocaederus ferrugineus*, fungal entomopathogens, delivery methods

**INTRODUCTION**

Cashewnut is a major foreign exchange earning plantation crop of India. The productivity of the crop is threatened by insect-pests. Of them, the cashew stem and root borer (CSRb), *Plocaederus ferrugineus* Linn (Coleoptera: Cerambycidae) is the most harmful one in India. The adults are dark brown longicorn beetles, and the gravid female lays eggs in the crevices of loose bark of the trunk and exposed roots. The emerging larvae bore into the living bark and causes significant damage to the vascular system by feeding and tunneling the inner layer of bark, resulting in reduced nutrient uptake, premature leaf senescence, gradual shedding of leaves and death of the tree. The intensity of infestation and extent of damage varies widely across the regions. On an average, this borer kills about 2-5% productive trees every year (Rai, 1984). As much as 6-35% trees of neglected plantations were infested in Kerala, Tamil Nadu and Orissa (Mistra and Basu Choudhury, 1985; Senguttuvan, 1999; Mohapatra and Satapathy, 1998). In Guntur and Prakasam Districts of Andhra Pradesh, CSRb infestation went up to 40% in different periods (Arjuna Rao, 1978; Ayyanna and Rama Devi, 1986). Severely attacked trees die within a period of two years causing capital loss to the growers needing to uproot and replace the infested trees. Existing pest management strategies utilizing cultural, mechanical and chemical control methods have met with limited success mainly due to the cryptic life-cycle of the borer inside the trunk and roots (Samiyyan et al., 1991; Punnaiah and Deva Prasad, 1995; Senguttuvan and Mahadevan, 1997; Mohapatra and Satapathy, 1998; Ambethgar, 2002). Cultural and mechanical control tend to be labour intensive, while the use of pesticides is often met with control failure which makes it necessary for repeated application. The variable response of existing control measures has prompted investigation for alternative targeting strategies. Use of fungal entomopathogens as an alternative strategy seemed to be a potential measure particularly for the concealed pests like stem borers owing to the prevalence of congenial environment within the larval tunnels for development of mycoses. The biostages of *P. ferrugineus* in dead cashew trees were found often
naturally infected by *Metarhizium anisopliae* (Metsch.) Sorok., and *Beauveria bassiana* (Bals.) Vuill., at enzootic levels (Bhat and Raviprasad, 1996; Ambethgar et al., 1999).

Diverse isolates of *M. anisopliae* and *B. bassiana* were reported to be highly pathogenic to *P. ferrugineus* under laboratory bioassay studies (Ambethgar, 2002), but their potential following artificial introductions in fields was seldom explored due to inadequate application technology. In the present study, the efficacy of *B. bassiana* against *P. ferrugineus* was assessed under field conditions using different delivery methods and were compared with the recommended chemical insecticides.

**MATERIALS AND METHODS**

**Source of Fungal pathogens**

The fungal pathogens, *M. anisopliae* and *B. bassiana* were initially isolated from naturally infected cadavers of *P. ferrugineus* grubs and selected based on laboratory bioassay adopting two-way screening *viz.*, using an initial single-dose assay with a standard concentration of 1x10^5 conidia/ml in 0.02% Tween 80, followed by a multiple-dose mortality assay with six different conidial concentrations *viz.*, 1x10^6, 10^7, 10^8, 10^9 and 10^10 conidia/ml in 0.02% Tween 80 as surfactant (Ambethgar, 2002).

**Production and Preparation of inoculum**

The fungal isolates were initially passed through the larvae of *P. ferrugineus* and the type-isolates were re-isolated on Sabouraud Dextrose Agar medium with 0.25% w/v yeast extract (SDAY). After re-isolation, the fungi were inoculated separately in autoclavable polythene bags each containing 250g of 24h presoaked sorghum grains, and autoclaved at 15 lbs/cm² pressure for 30 minutes. The fungus inoculated grains were incubated at 28°C ± 2°C until fluffy sporulation. The conidia were harvested from 2-3 week old sporulated spawn by crushing and mixing in sterile distilled water containing 0.02 per cent Tween 80 as surfactant to preserve the efficacy of fungi. Viability of the conidia was determined by direct examination at 200x with a phase contrast microscope, prior to use.

**Field Trial**

Field trials were conducted during 2004-2008 on the efficacy of *M. anisopliae* and *B. bassiana* using three different delivery methods in controlling *P. ferrugineus* infestation and compared with the standard check monocrotophos 0.02% and neem oil 5% swab as an environment friendly component on a ten years old clonal planting of VRI 2 cashew at the Regional Research Station, Vridhachalam (11.3°N of latitude, 79.26°E of longitude and 42.67m MSL), Tamil Nadu. The trial was conducted in Completely Randomized Block Design using nine treatments *viz.*, T_1_ Swabbing the trunk with saturated conidia of *M. anisopliae* in mud slurry; T_2_ Swabbing the trunk with saturated conidia of *B. bassiana* in mud slurry; T_4_ Pouring saturated conidial suspension of *M. anisopliae* through borer’s entry holes; T_5_ Pouring saturated conidial suspension of *B. bassiana* through borer’s entry holes; T_6_ Soil application of *M. anisopliae* spawn 250g + FYM 50Kg/tree under the canopy; T_7_ Soil application of *B. bassiana* spawn 250g + FYM 50Kg/tree under the canopy; T_8_ Spraying the trunk with Monocrotophos 0.2%; T_9_ Spraying the trunk with Crude Neem oil 5% and T_1_ Control (only extraction of grubs).

Early phase borer infested cashew trees with symptoms of gummosis and extrusion of frass were marked. Before imposition of the treatments, the grubs residing in the trees were removed mechanically. The expelled remains of frass and resin in the damaged portions of bark were cleaned. The treatments were applied to the dewormed trees adopting the following delivery methods described: (1) Swabbing: Two litres of mud slurry containing saturated conidial suspension of respective fungus were swabbed thoroughly on the exposed roots and trunk from collar to one meter height after brushing the scaly bark to dislodge the eggs; (2) Pouring conidial suspension: Two litres of saturated aqueous spore suspension of respective fungus containing 0.02% Tween 80 was poured through borer’s entry holes all-around the collar region of trunk until the point of saturation and (3) Soil application: Crushed spawn (250g) containing conidia and mycelia was mixed with 50kg of well ripened / decomposed farm yard manure and incorporated in to soil up to 20cm deep and 1.0m radius from the tree base under the canopy area.

The treatments were imposed one-by-one sequentially as and when infested trees are available (AICRP, 2004). The sequential treatments refer to T_1_ on the first infested tree; T_2_ on the second infested tree; T_3_ on the third infested tree, like wise up to T_9_ on the ninth infested tree. Again T_1_ on the tenth infested tree, T_2_ on the eleventh infested tree and so on. In this way, 11-13 trees were used per treatment with a total of 110 infested trees received different treatments throughout the period of study as shown in Table 1.

**Observation recorded**

Observations on active holes of stem borer were recorded one day prior to treatment and post observations were made three months after imposing the treatments. Stoppage of frass extrusion/gum extrudation from borer’s entry hole after treatment was treated as dead holes, and holes with fresh frass and continuous gum extrudations was
# RESULTS AND DISCUSSION

The data on the efficacy of *M. anisopliae* and *B. bassiana* against *P. ferrugineus* are presented in Table 1 and Fig. 1. All the treatments were superior to the untreated control in reducing the borer infestation at varying levels. Variations among the treatments were evident as indicated by a higher coefficient of variation (58.16%), exhibiting superiority to the untreated control.

Even though the efficacy of *M. anisopliae* and *B. bassiana* was on a par with each other, the performance of delivery methods varied. Among three delivery methods, direct pouring of saturated suspension of conidia through cashew stem and root Borer Management

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. of trees</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>Total no. of trees treated</th>
<th>Total no. of trees recovered</th>
<th>Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1 Swabbing with <em>Metarhizium anisopliae</em> in mud slurry</td>
<td>Treated Recovered</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>3</td>
<td>25.0</td>
</tr>
<tr>
<td>T-2 Swabbing with <em>Beauveria bassiana</em> in mud slurry</td>
<td>Treated Recovered</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>13</td>
<td>3</td>
<td>23.0</td>
</tr>
<tr>
<td>T-3 Pouring <em>M. anisopliae</em> saturated conidial suspension through borer’s entry holes</td>
<td>Treated Recovered</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>11</td>
<td>4</td>
<td>36.4</td>
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<tr>
<td>T-4 Pouring <em>B. bassiana</em> saturated conidial suspension through borer’s entry holes</td>
<td>Treated Recovered</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>4</td>
<td>33.3</td>
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<tr>
<td>T-5 Soil application of <em>M. anisopliae</em> spawn 250g + FYM 50 Kg/tree</td>
<td>Treated Recovered</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>16.6</td>
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<tr>
<td>T-6 Soil application of <em>B. bassiana</em> spawn 250g + FYM 50 Kg/tree</td>
<td>Treated Recovered</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>13</td>
<td>2</td>
<td>15.3</td>
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<tr>
<td>T-7 Spraying with Monocrotophos 0.2%</td>
<td>Treated Recovered</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>6</td>
<td>50.0</td>
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<tr>
<td>T-8 Spraying with Crude Neem oil 5%</td>
<td>Treated Recovered</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>13</td>
<td>6</td>
<td>46.2</td>
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<tr>
<td>T-9 Control (only removal of grubs)</td>
<td>Treated Recovered</td>
<td>3</td>
<td>3</td>
<td>2</td>
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<td>2</td>
<td>12</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>58.16</td>
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</table>

**Note:** Treatments 1-8 were also imposed after mechanical removal of grubs and cleaning the decayed bark portions
bore’s entry holes registered maximum of 36.4 and 33.3% recovery of infested trees for *M. anisopliae* and *B. bassiana* respectively, which were on a par with each other; but significantly superior to rest of the two delivery methods viz., swabbing the tree trunk with mud slurry containing saturated concentration of conidia, (with 25.0 and 23.0 per cent recovery) and soil application of crushed fungal spawn under tree canopy, with 16.6 and 15.4 per cent recovery of trees for *M. anisopliae* and *B. bassiana* respectively. None of the untreated trees recovered (Fig. 1). The result of the present study agrees with the findings of the recent field studies. Pouring spore suspension of *M. anisopliae* and *B. bassiana* through bored holes was effective compared to swabbing and soil application of spores (Saminathan et al., 2004). Soil application of *M. anisopliae* and *B. bassiana* spawn @250g in combination with 500 g neem cake during October-November minimized the CSRB infestation to 7.40 and 11.10% respectively as against 20.35% infestation in the untreated control (Sahu and Sharma, 2008). However, swabbing conidial suspension of *M. anisopliae* as prophylactic measure was not satisfactory and resulted less effect against the borer (Mohapatra and Jena, 2008). In the present study, phytosanitation by mechanical removal of grubs followed by pouring infested portions with fungal inoculum have improved the efficiency of *M. anisopliae* and *B. bassiana* by realizing 33.3-46.4% recovery of infested trees. The overall recovery per cent in each of the treatment confirmed the performance of the delivery methods in the following descending order: pouring through infestation holes > swabbing the trunk and exposed roots > soil application under the tree canopy.

![Image](image-url)
would not only safer to non-target organisms, but also be more effective in the long term by displaying self-replicative mechanisms in the cropped ecosystems.

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V. Ambethgar
All India Coordinated Research Project on Cashew, Tamil Nadu Agricultural University, Regional Research Station, Vridhachalam-606 001, Tamil Nadu, India, *E-mail: drvga1965@yahoo.co.in*