Effect of Some Ecological Factors on The Growth of Beauveria bassiana and Paecilomyces fumosoroseus Against Corn Borers.

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Abstract: Two entomopathogenic fungi against were evaluated against some corn borers insect pests under laboratory and field conditions. Results showed that, the Sesamia cretica; Ostrinia nubilalis; Chilo agamemnon were susceptible to the fungi; Beauvaria bassiana (B.b). Paecilomyces fumosoroseus(P.f). LC50 obtained were: 164X10^4, 189 X10^4 spores/ml for S. cretica when treated with different concertinos of (B.b) and (P.f), respectively. Respective LC50 for O. nubilalis 144 x10^4 and 156 x10^4 spores/ml ; respectively. general, PDA was the best medium for the growth of B. bassiana and 30°C was the optimum temperature, followed by 25°C, with a significant difference at < p.05. Concerning RH, the growth of B. bassiana was much enhanced by high RH, as it increased. Linear growth increased also to reach its maximum (88.25mm) at 100% RH. Results revealed that the isolate of B. bassiana was able to grow and to utilize any carbohydrate added to the growth medium. Sucrose was the best substrate for supporting growth (87.25 mm) and followed by glucose (56.25mm) with a significant difference. Calcium nitrate was generally the best suitable nitrogen source, followed by glycine, sodium nitrate and then ammonium nitrate. Meanwhile, ammonium phosphate was found to be the lowest one. Benlate was the most toxic fungicide to B. bassiana, even at lower concentrations. Growth of the fungus was completely inhibited (100%) at 6.25 ppm. Thymol was the most destructive insecticide, followed by Pyrethrum with a significant difference at p<0.05 while Cylone was the least one against B. bassiana. Under field conditions, the tested fungi showed significant infestations decrease in the plots treated with B. bassiana, followed by P. fumosoroseus.

Key words: Sesamia cretica Ostrinia nubilalis; Chilo agamemnon, Beauvaria bassiana; Paecilomyces fumosoroseus ;Environmental factors, nutritional factors,

INTRODUCTION

The entomopathogenic fungus, Beauveria bassiana is one of several fungi that are of particular research interest because of its potential as commercial bioinsecticides. Some studies had focused on identifying nutrient substrates that B. bassiana can utilize with application to industrial production, while others focused on the pathogenic processes of B. bassiana and interactions with insect cuticle (Bidochia et al., 1990).

Entomopathogenic fungi are found worldwide associated to insects and phytophagous mite populations, contributing to biological control of these arthropods on several economically important crops (Sabbour and Sahab, 2007). Commercial products have been developed with entomopathogenic fungi (Alves and Pereira, 1998). Quintela and McCoy (1998) reported that fungal concentrations of 10^4 and 10^5 conidia/ml of B. bassiana affected the larval development, movement and mobility of corn borers larvae during the seedlings and vegetative stages of corn plant under laboratory; greenhouse and field conditions.

Success of a pest control program using B. bassiana however depends on conidia survival in the field environment (Benz, 1987). Conidia survival may be affected either by environmental factors (Furlong and Pell, 1997) or chemical products used to protect plants (Anderson and Roberts, 1983). Abdel-Rahman, et al. (2006) controlled the cereal aphids with the fungus B. bassiana and found that the infestation was reduced after fungal applications under laboratory and field conditions.

As reported by Walstad et al. (1970), B. bassiana required relative humidifies above 92.5% and temperatures between 15 and 35°C for mycelial growth. Optimun growth occurred at 100% RH and 25-30°C. Also, Hallsworth and Magan (1999) reported that the temperature ranges for growth of B. bassiana was 5-30°C and the optimum temperature was 25°C. Campbell et al., (1987) reported that B. bassiana produces greater mycelial mass by glutamine and KNO3 as nitrogen source.

Many experiments have been carried out aiming to detect side effects of pesticides on B. bassiana (Olmert and Kenneth, 1974). Most of them were evaluated for their effects on vegetative growth and sporulation. They emphasized that the inhibition of this initial step affects the plain development of the fungus in the field because the fungal structure is responsible for instability of the disease on insect pest populations.

The present study aims to estimate the effect of two entomopathogenic fungi against Sesamia cretica ; Ostrinianubilalis; Chilo agamemnon. Also, to evaluate the effect of some environmental and nutritional factors and some pesticides on growth of B. bassiana.
MATERIALS AND METHODS

Tested Insects:
Sesamia cretica; Ostrinia nubilalis; Chilo agamemnon reared on corn leaves under laboratory conditions 26 ± 2°C and 60± 5 RH. Leaves changed every two days.

Entomopathogenic Fungi:
The fungi; B. bassiana strain (BR3) and stored in the form of pure conidia in Eppendorf vials at 4°C, were kindly sent by Prof. Dr. Alain Vey, Mycology Unit at Institute National de la Research Agronomique, Montpellier Univ., France. The fungus, Paecilomyces fumosoroseus obtained from Florida Univ., USA. They were reproduced on potato dextrose agar (PDA) plus 0.4% yeast extracts (PDAY) and poured onto sterilized Petri-dishes (Alves et al., 1998). Plating was performed according to the full dish method. The conidia were transferred from the Eppendorf vial to dish containing medium by platinum loop and then streaked. Plates were incubated at 25°C with 12 hours photo phase for fungus growth and sporulation. After ten days, conidia were scraped and transferred to conical flasks (250 ml) containing 200 ml sterilized distilled water with 0.02% the speeder sticker (tween, 80). Conidial concentrations in the suspensions were quantified directly under the optical microscope with a haemacytometer. Then the suspensions were standardized until the direct concentration 1x10^7 conidia/ml was obtained.

Efficacy of Entomopathogenic Fungi Against Pests Larvae:
Spores of the entomopathogenic fungi; B. bassiana, P. fumosoroseus collected from the surface of mycelium growth and spore suspensions with 2 drops of tween 80 were prepared and adjusted at 1x10^7 conidia/ml. Conidial viability was determined by counting germ tubes produced on PDAY medium after 18 hrs, using light microscope at 400 x. Conidial viability was 95-100%. The surface of cultures was gently brushed in the presence of 20ml of sterilized water in order to free the spores and the suspension was filtered through muslin. Six concentrations of spore suspensions were prepared i.e., 10^7, 10^6, 10^5, 10^4, 10^3, and 10^2 conidia/ml. Piece of castor leaves were dipped in the prepared suspensions and left for drying under laboratory conditions then placed in Petri-dishes (one/dish). For each concentration (4 replicates/ each), ten L3 larvae of each of the tested insects were transferred into each Petri-dish. Control larvae were fed on untreated castor leaves. Percentages of mortality were calculated according to Abbot, while LC 50 was calculated throughout probit analysis. The experiment was carried out under laboratory conditions at 26°C± 2 and 60-70 % RH.

Physiological and metabolic characteristics of B. bassiana.

1- Growth on Different Culture Media:
Tested culture media were PDA; corn meal agar (CMA); glucose peptone agar (GPA); Czapek’s agar (Cz); Czapek’s carboxy methyl cellulose (Cz-CMC), Lynch A and Lynch B agar media. Plates were prepared with the different tested media and inoculated with 0.5cm (2%) water agar plugs of B. bassiana strain. Plates were incubated in darkness at 25°C± 2 during 10 days. All experiments were carried out in triplicates.

2- Effect of Temperature:
B. bassiana was inoculated in PDAY medium using 0.5 cm disc and incubated at 10, 15, 20, 25, 30 and 35°C and 100% RH in incubators for 10 days to attain maximum growth. Radial growth (mm) of the fungus was determined.

Effect of Relative Humidity:
Six levels of RH were maintained by mixtures of appropriate combinations of concentrated sulphuric acid and distilled water (Table 1) as described by Ayyasamy and Baskaran (2005).

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>D. water (ml)</th>
<th>Sulphoric acid (ml)</th>
<th>RH %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100.0</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>875</td>
<td>11.5</td>
<td>95</td>
</tr>
<tr>
<td>3</td>
<td>81.1</td>
<td>20.0</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>79.2</td>
<td>23.0</td>
<td>85</td>
</tr>
<tr>
<td>5</td>
<td>72.1</td>
<td>27.0</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>71.0</td>
<td>30.0</td>
<td>75</td>
</tr>
</tbody>
</table>

Mixtures of sulphoric acid and distilled water were placed in desiccators. Plates of PDAY medium were inoculated at the center with a 5mm diameter disc of B. bassiana. Four replicates were used for every treatment and incubated at 25±2°C. Linear growth (mm) was measured.
Carbon Source Assimilation:
Capacity of assimilation of different carbon sources with *B. bassiana* was studied. Tested carbon sources were glucose, sucrose, arabinose, mannose and citric acid. Lynch B agar medium (NH₄H₂PO₄, 1g; KCl, 0.2g; MgSO₄.7H₂O, 0.2g; CuSO₄ 5H₂O, 5mg and ZnSO₄ 7H₂O, 10mg / L) containing 0.05 g/ L of bromocresol purple and 1% (w.v) of the tested carbon source was used. The medium was adjusted to pH 6.5 and autoclaved. Plates of various carbon sources were inoculated with the fungus in the center and incubated at 25±2°C and 100% R.H. Linear growth (mm) was measured.

Nitrogen Source Assimilation:
Tested nitrogen sources were: ammonium phosphate, sodium nitrate, glycine, calcium nitrate and ammonium nitrate. Lynch A agar medium (KH₂PO₄, 1g; KCl, 0.5g; MgSO₄.7H₂O, 0.2g; CaCl₂ 2H₂O, 0.1g and sucrose 10 g/L) containing 0.05 g/L bromocresol purple and 0.2% (w.v) of the tested nitrogen source was used. The medium was adjusted to pH 6.5 and autoclaved. Plates of various sources were inoculated in the center and incubated as mentioned before.

In-vitro Evaluation of Pesticides Effect:

Fungicides: Benomyl:
Methyl 1-(butrylcarbamoyl) benzimidazol, 1-2-s-carbamate. (Benlate 50% w.p.). Rhizolex: o,o-dimethyl-o-(2.6 dichloro-4 methyl phenyl phosphoro thioat). Kocide: Cupric hydroxide. Sandofan: N-(2, 6-dimethylphenyl)-2-methoxy-N(2-oxooxazolin-3-yl) acetamide.

Insecticides: Pyrithrum:
(z)-(s)z-2-methyl-4-oxo 3-(penta-2, 4-dimethyl) cyclopent-2-enyl-(2-methoxy prop-1-enyl)-2, 2-dimethyl cyclo propane carboxylate. Cylolan: 25% 2-(diethoxy phosphinyl amino 4- methyl 1,3 dithiolane). Malation: 1.2 bis (ethoxy carbonyl) ethyl 0.0-dimethyl phosphorodithioate). Thymol: 2 isopropyl-5 methyl phenol 3 hydroxyp. cymene.

The pesticides were incorporated at different concentrations into PDAY medium at the required amounts according to their active ingredients, while still warm and the Petri-dishes were rotated gently (Subhani et al., 2008). The plates were inoculated at the centre with a 5-mm diameter disc of *B. bassiana*. Four replicates were used for every treatment and incubated at 25±2°C and the linear growth was measured.

Data were analyzed by simple factorial design (Steel et al., 1996). Four replications were used to determine the difference among individual treatments, i.e., pesticides and their doses.

Field Trials:
Field trials were carried out at Nobaria region (Behera Governorate), Egypt during the two successive corn seasons 2010 and 2011 to study the effectiveness of the tested fungi on corn borers. Corn (variety Giza 2) was cultivated by end of May during the two seasons in an area of about half feddan. Fungi were applied as single treatments in randomize plots. Regular agricultural practices were performed and no chemical control was used during the study period. Weeds were removed by hand. Five plots were sprayed with water as control. Samples from each treatment were collected weekly and transferred to the laboratory for investigation. Percentages of infection were estimated.

Yield Assessment:
Yield data in treated and untreated plots in the corn harvest seasons (2010 and 2011), represented by weight in kgs were determined. Yield loss was estimated according to the following equation:

\[
\text{Yield loss} = \frac{\text{Potential yield} - \text{Actual yield}}{\text{Potential yield}}
\]

Potential yield of the *B. bassiana* treatment (the best result among the tested pathogens) was considered the standard for comparison with the other ones.

RESULTS AND DISCUSSION

In-vitro Effect of Entomopathogenic Fungi on the Target Insects:
Data in Table (2), show that under laboratory conditions the LC₅₀ obtained was 164 x10⁴, 189 x10⁴, 179 x10⁴ after *Sesamia cretica* treated with different concentrations of *B. bassiana* and *P. fumosoroseus*, respectively. When *N. nubilalis* treated with the same fungi the corresponding LC₅₀ 144 x10⁴ and 156 x10⁴ spore/ml; respectively (Table2).

Sabbour and Abdel-Rahman (2007) reported that under laboratory conditions results showed that the LC₅₀ of *Phyllostreta cruciferaem*, *Pegomyia hyoscamii* and *Cassida vittata* of the tested fungi *Verticillium lecanii* (*V.l*), *Nomuraea rileyii* (*N.r*) and *Paecilomyces fumosoroseus* (*P.f*), respectively against the three pests ranged
between $5.4 \times 10^6$ and $1.43 \times 10^7$ spores/ml. Satisfactory results with the entomopathogenic fungi were reported by Sharaf El-Din (1999) and Sabbour and Ismail (2001). Sabbour and Abd El-Aziz (2002) as they found that the fungi; *B. bassiana* and *M. anisopliae* reduced the LC$_{50}$ of *S. littoralis* under laboratory conditions.

**Effect of Some Environmental and Nutritional Factors:**

*In-vitro* effect of media, temperature, RH, pH, carbon and nitrogen sources on the linear growth of *B. bassiana* was studied.

1 -Culture Media:

*B. bassiana* was grown on five different solid media. As shown in Table (4), the growth of the tested fungi varied depending on the type of medium. In general, PDA was the best medium for the growth of *B. bassiana*. The fungus gave its maximum linear growth as 90.4 mm within 7 days, followed by GP and Cz. media reaching 85.5 and 85.65 mm, respectively, with a significant difference at (p<0.05). However, PDA is considered a general medium for growth due to its high nutritional value (Trindade, 1994). Present results do not support the statement of Bidochia *et al.* (1987) but agree with the findings of Ayala (1996) and Santa *et al.* (2005), since PDA induced the best linear growth for *B. bassiana*.

2- Temperature and RH:

*B. bassiana* isolate was able to grow at a wide range of temperature and RH. Data in table (5) indicated that 30°C was the optimum temperature for the growth, followed by 25°C with a significant difference at (p<0.05). On the other hand, there was a very sharp decline in fungal growth above 35°C and completely inhibited at 40°C.

Concerning RH, the growth of *B. bassiana* was much enhanced by high RH; as the RH increased. Linear growth also increased to reach its maximum (88.25mm) at 100% RH (Table 6). This increment was found significant as RH rose from 75 to 95%. In this respect, Walstad *et al.* (1970) found that *B. bassiana* required RH above 92.5% and a temperature between 15 and 35°C for luxuriant mycelial growth. Optimum growth occurred at 100% and 25-30°C. Hallsworth and Magan (1999) reported that the temperature ranges for growth of *B. bassiana* was 5-30°C and the optimum temperature was 25°C.

3- Effect of Some Nutritional Factors:

3-a- Effect of Different Carbon Sources:

Results in Table (7) revealed that isolate of *B. bassiana* was able to grow and to utilize any carbohydrate source added to the growth medium. Sucrose was the best substrate in supporting growth (87.25 cm), followed by glucose (56.25 cm) with a significant difference. Mannose had the lowest capability, while other substrates showed moderate effect. Results obtained by Bharati *et al.* (2007) revealed that starch was the best carbon source which recorded maximum growth of the fungus *M. anisopliae*, followed by sucrose and fructose.

3-b Effect of Different Nitrogen Sources:

Data in Table (8) revealed that all tested nitrogenous compounds were utilized by the fungus *B. bassiana*. Calcium nitrate was generally the best suitable nitrogen source, followed by glycine and sodium nitrate and then ammonium nitrate. Ammonium phosphate was found to be the lowest one. Results obtained by Bharati *et al.* (2007) showed that KNO$_3$ was the best nitrogen source which recorded maximum growth of the fungus *M. anisopliae*, followed by NH$_4$ NO$_3$.

4- Effect of Different Pesticides on Linear Growth:

The tested pesticides showed different effects on the mycelium growth of *B. bassiana* depending on chemical composition and its concentration in the medium (Tables 9 and 10).

a- Fungicides:

The fungicide Benlate was the most toxic to *B. bassiana* even at the lower concentration. The growth of the fungus was completely inhibited (100%) at 6.25 ppm. Kocide fungicide had the least effect against *B. bassiana*, while Rhizolex, Kocide and Sandofane showed high toxicity to the fungus at the highest concentration of 400 ppm. Data also showed that Benlate was very effective, followed in a descending order by Rhizolex, Sandofane and Kocide.

b- Insecticides:

The tested insecticides showed different effects on the mycelium growth of *B. bassiana* depending on type and concentration in the medium (Table 10). No insecticides of those tested caused death to *B. bassiana* except, Thymol at higher concentrations between 100 and 800 ppm. In some cases, the inhibition was moderate especially in lower concentrations of 50 ppm. The most effective proved to be the insecticide Thymol, followed by Pyrethrum with a significant difference at (p<0.05), while Cyolane was the least one against *B. bassiana*. 

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Many experiments were carried out to detect pesticides side effects on *B. bassiana* (Olmert and Kenneth, 1974). Most of them evaluated the effects of the products on vegetative growth and sporulation. The use of incompatible insecticides may inhibit the development and reproduction of entomopathogenic fungi, affecting IPM (Malo et al., 1993).

Table (11) show summarize the percentage of infestation after treatments with the tested bioinsecticides. The fungi (B.b) and (P.f) showed a high potential effect against *Sesamia cretica; Ostrinia nubalis* and *Chilo agamemnon*, the infestation percent were, 22±3.2 and 19±1.2 of *S. cretica* among the plots treated with B.b. also the percentage of O.nubilalis decreased to 19±2.3 after 90 days of treatment as compared to 98±2.1 in the control during season 2011. When the plots treated with fungi the percentage of infestation with *C. agamemnon* were significantly decreased during the two seasons 2010 and 2011 (Table 11).

Data in table (12) show that the weights of the cotton crop treated with *P.f*-treated amounted 3510 and 3559 kgs/feddan as compared to 2911 and 3001 kgs/feddan in the control plots in 2010 and 2011 crop seasons, respectively. This led to a significant decrease in the yield loss ranged between 10% and 26% during both two seasons 2010 and 2011 (Table 12).

Mesbah et al. (2004) reported that some microbial control agents were mainly effective as biocides and reduced the infestations of the sugar beet insect pests and increased the yield in Kafer El-Sheikh, Egypt. Seweify (1998) found that the crop yield increased after treatments with fungi. Sabbour (2006) found that the yield loss of the potatoes was significantly decreased in the plots treated with *B. bassiana* and *M. anisopliae*.

### Table 2: Effect of some entomopathogenic fungi against the target insect pests larvae under laboratory conditions.

<table>
<thead>
<tr>
<th>Pathogens</th>
<th>LC50 Slope</th>
<th>Variance</th>
<th>95% confidence limits</th>
<th>LC50 Slope</th>
<th>Variance</th>
<th>95% confidence limits</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Sesamia cretica</em></td>
<td>164x10^4</td>
<td>0.01</td>
<td>0.002</td>
<td>131-175</td>
<td>189x10^4</td>
<td>0.01</td>
</tr>
<tr>
<td><em>Ostrinia nubilalis</em></td>
<td>144x10^4</td>
<td>0.10</td>
<td>0.004</td>
<td>133-210</td>
<td>156x10^4</td>
<td>0.01</td>
</tr>
<tr>
<td><em>Chilo agamemnon</em></td>
<td>188x10^4</td>
<td>0.01</td>
<td>0.003</td>
<td>176-233</td>
<td>198x10^4</td>
<td>0.02</td>
</tr>
</tbody>
</table>

### Table 4: Effect of different media on the linear growth (mm) of *B. bassiana*.

<table>
<thead>
<tr>
<th>Media</th>
<th>Growth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato dextrose agar (PDA)</td>
<td>90.4</td>
</tr>
<tr>
<td>Glucose peptone (GP)</td>
<td>85.5</td>
</tr>
<tr>
<td>Czapek’s</td>
<td>85.65</td>
</tr>
<tr>
<td>Corn meal (CM)</td>
<td>29.75</td>
</tr>
<tr>
<td>Carboxy methyl cellulose</td>
<td>7.85</td>
</tr>
</tbody>
</table>

- Each figure represents an average of 4 replicates at 25°C ±2 or 6 days.

### Table 5: Effect of different temperature on the mycelium growth of *B. bassiana*.

<table>
<thead>
<tr>
<th>Temperature ± 1°C</th>
<th>Growth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>12.25</td>
</tr>
<tr>
<td>20</td>
<td>33.75</td>
</tr>
<tr>
<td>25</td>
<td>80.00</td>
</tr>
<tr>
<td>30</td>
<td>88.25</td>
</tr>
<tr>
<td>35</td>
<td>12.25</td>
</tr>
<tr>
<td>40</td>
<td>0.00</td>
</tr>
</tbody>
</table>

- Each figure represents an average of 4 replicates at 25°C ±2 or 6 days.

### Table 6: Effect of relative humidity (RH) on the mycelium growth of *B. bassiana*.

<table>
<thead>
<tr>
<th>RH %</th>
<th>Growth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>43.25</td>
</tr>
<tr>
<td>80</td>
<td>51.50</td>
</tr>
<tr>
<td>85</td>
<td>62.50</td>
</tr>
<tr>
<td>90</td>
<td>79.50</td>
</tr>
<tr>
<td>95</td>
<td>82.50</td>
</tr>
<tr>
<td>100</td>
<td>88.25</td>
</tr>
</tbody>
</table>

- Each figure represents an average of 4 replicates at 25°C ±2 or 6 days.

### Table 7: Effect of different carbon sources on the mycelium growth of *B. bassiana*.

<table>
<thead>
<tr>
<th>Carbon source</th>
<th>Growth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>56.25</td>
</tr>
<tr>
<td>Sucrose</td>
<td>87.25</td>
</tr>
<tr>
<td>Arabinose</td>
<td>33.25</td>
</tr>
<tr>
<td>Mannose</td>
<td>22.00</td>
</tr>
<tr>
<td>Citric acid</td>
<td>27.50</td>
</tr>
</tbody>
</table>

- Each figure represents an average of 4 replicates at 25°C ±2 or 6 days.
Table 9: Effect of fungicides incorporated into PDA medium on the linear growth (mm) of B. bassiana.

<table>
<thead>
<tr>
<th>Concentration (ppm)</th>
<th>Benlate</th>
<th>Rhizolex</th>
<th>Kocide</th>
<th>Sandofane</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 (Untreated)</td>
<td>84.75*</td>
<td>84.75</td>
<td>84.75</td>
<td>84.75</td>
</tr>
<tr>
<td>6.25</td>
<td>0.0</td>
<td>53.25</td>
<td>67.25</td>
<td>63.50</td>
</tr>
<tr>
<td>12.5</td>
<td>0.0</td>
<td>51.25</td>
<td>47.25</td>
<td>51.75</td>
</tr>
<tr>
<td>25.0</td>
<td>0.0</td>
<td>51.00</td>
<td>42.75</td>
<td>47.25</td>
</tr>
<tr>
<td>50.0</td>
<td>0.0</td>
<td>33.00</td>
<td>38.50</td>
<td>43.50</td>
</tr>
<tr>
<td>100.0</td>
<td>0.0</td>
<td>23.25</td>
<td>24.50</td>
<td>16.25</td>
</tr>
<tr>
<td>200.0</td>
<td>0.0</td>
<td>16.25</td>
<td>16.50</td>
<td>11.75</td>
</tr>
<tr>
<td>400.0</td>
<td>0.0</td>
<td>10.50</td>
<td>10.50</td>
<td>10.25</td>
</tr>
<tr>
<td>Mean</td>
<td>10.59</td>
<td>40.41</td>
<td>41.44</td>
<td>40.84</td>
</tr>
</tbody>
</table>

*Colony diameter/mm  L.S.D. (5%) for Fungicides = 16.99, Concentrations = 12.02 and Interactions = 33.99. bassiana.

Table 10: Effect of insecticides incorporated into PDA medium on the linear growth (mm) of B. bassiana.

<table>
<thead>
<tr>
<th>Concentration (ppm)</th>
<th>Pyrithrum</th>
<th>Cyolane</th>
<th>Malation</th>
<th>Thymol</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Untreated)</td>
<td>89.0</td>
<td>89.8</td>
<td>86.3</td>
<td>83.8</td>
</tr>
<tr>
<td>50.0</td>
<td>38.3</td>
<td>34.8</td>
<td>37.8</td>
<td>43.5</td>
</tr>
<tr>
<td>100.0</td>
<td>22.3</td>
<td>29.8</td>
<td>27.5</td>
<td>0.0</td>
</tr>
<tr>
<td>200.0</td>
<td>9.3</td>
<td>26.8</td>
<td>21.8</td>
<td>0.0</td>
</tr>
<tr>
<td>400.0</td>
<td>9.8</td>
<td>16.5</td>
<td>16.3</td>
<td>0.0</td>
</tr>
<tr>
<td>800.0</td>
<td>8.0</td>
<td>7.3</td>
<td>14.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Mean</td>
<td>29.42</td>
<td>34.13</td>
<td>34.0</td>
<td>21.22</td>
</tr>
</tbody>
</table>

*Colony diameter/mm  L.S.D. (5%) for: insecticides = 8.19, Concentrations = 10.03 and Interactions = 20.05.

Table 11: Effect of different treatments on the target insect pests under field conditions.

<table>
<thead>
<tr>
<th>Post application date</th>
<th>Treatments</th>
<th>% of infestation (means)±s.e</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sesamia cretica</td>
<td>Ostrinia nubilalis</td>
</tr>
<tr>
<td>Control</td>
<td>46±3.2</td>
<td>83±3.4</td>
</tr>
<tr>
<td>B.b</td>
<td>30±3.1</td>
<td>27±2.1</td>
</tr>
<tr>
<td>(B.b)</td>
<td>30±3.1</td>
<td>27±2.1</td>
</tr>
<tr>
<td>(P.f)</td>
<td>45±3.3</td>
<td>39±2.1</td>
</tr>
<tr>
<td>20</td>
<td>Control</td>
<td>46±3.2</td>
</tr>
<tr>
<td>50</td>
<td>Control</td>
<td>46±3.2</td>
</tr>
<tr>
<td>90</td>
<td>Control</td>
<td>46±3.2</td>
</tr>
</tbody>
</table>

F value  Lsd5% =
35.7  17.3

Table 12: Assessments of damage caused in cotton field after the fungi treatment.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Season 2010 Wt of cotton crop (kg/ feddan)</th>
<th>yield loss%</th>
<th>Season 2011 Wt of cotton crop (kg/ feddan)</th>
<th>yield loss %</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.b</td>
<td>3510 ± 66.71</td>
<td>10</td>
<td>3559 ± 80.12</td>
<td>10</td>
</tr>
<tr>
<td>p.f</td>
<td>3510 ± 66.71</td>
<td>10</td>
<td>3559 ± 80.12</td>
<td>10</td>
</tr>
<tr>
<td>control</td>
<td>2911 ± 48.92</td>
<td>25</td>
<td>2900 ± 71.23</td>
<td>26</td>
</tr>
</tbody>
</table>

F value  Lsd5% =
34.6  122.7

ACKNOWLEDGMENT

Our thanks is extended to Prof.Dr. A.F.Sahab for his greatful efforts to produce the fungi culture.

REFERENCES


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