EFFECT OF *ISARIA FUMOSOROSEA* (HYPOCREALES: CORDYCIPITACEAE) AND *LYSIPHLEBUS TESTACEIPES* (HYMENOPTERA: BRACONIDAE) ON THE BROWN CITRUS APHID: PRELIMINARY ASSESSMENT OF A COMPATIBILITY STUDY

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Recently, a strain of *Isaria fumosorosea* Wize (*Ifr*) (= *Paecilomyces fumosoroseus* [Luangsa-ard et al. 2005]), (Hypocreales: Cordycipitaceae) was discovered in a Florida citrus grove infecting the Asian citrus psyllid, *Diaphorina citri* Kuwayama (Meyer et al. 2008). Also, laboratory studies have demonstrated that *Ifr* may be effective against several commercially important pests of citrus (Poprawski et al. 1999; Avery et al. 2009; Hoy et al. 2010; Hunter et al. 2011). Therefore, the use of *Ifr* (*PFR 97™ 20% WDG*, Certis USA, Columbia, Maryland), approved in 2011 by EPA for use in commercial citrus, may offer a potential tool for balancing citrus pest management with consumer demands for organic citrus produce.

The brown citrus aphid (BCA), *Toxoptera citricidus* Kirkaldy (= *T. citricida* [Nieto Nafria et al. 2005]), (Hemiptera: Aphididae) was discovered in Florida in 1995 and is recognized as a serious pest of citrus capable of vectoring *citrus tristeza* virus (Halbert & Brown 1996; Michaud 1998; Roy & Brlansky 2009). Under optimal conditions, native natural enemies provide good management of BCA, although these are easily disrupted by insecticide applications (Michaud 1998; 2002). Presently, the aphid’s population is managed in citrus groves by insecticide applications (Michaud 1998; 2002; Roy & Brlansky 2009). The number of live aphids on plants, and mummies, were recorded weekly over 6 weeks. Overall, compared with treatments with no *Ifr* treatments in the final 2 weeks of the study (Table 1). There was no apparent difference in aphid mortality between treatments with or without *Ifr*. The number of mummies (both unemerged and emerged) was similar between treatments with and without *Ifr*. The augmentation of entomopathogenic fungi with current IPM management strategies for *T. citricidus* and other citrus pests, may offer conventional and organic citrus growers an alternative to chemical insecticides alone. Although *Ifr* caused
some aphid mortality (based on symptoms of mycosis observed in aphids that dropped from the plant), its impact was low based on similar numbers of live aphids remaining on the plant compared with controls and lack of mycosis symptoms observed in aphids that remained on the plants. However, during the first 2 weeks post-application, it appears that as infected aphids fell off the plant, the \textit{Ifr} inoculum may have been removed with them, potentially slowing down possible epizootics. Data also suggests that \textit{L. testaceipes}, and \textit{Ifr} are compatible, since \textit{Ifr} treatments did not negatively impact parasitism or emergence. Compatibility of \textit{Ifr} with \textit{L. testaceipes} may be useful for managing aphid pests in citrus and other crops, especially under conditions that may promote higher rates of pest infection. Results of other studies involving pest-parasitoid-fungus interactions conducted with \textit{Ifr} or other species of entomopathogenic fungi concur with our findings; that in an IPM program, a parasitoid and a fungus can be compatible when utilized together (Fransen & van Lenteren 1993, 1994; Sterk et al. 1995a, b; Mesquita et al. 1997; Askary & Brodeur 1999; de la Rosa et al. 2000; Mesquita & Lacey 2001; Jaronski et al. 2003; Kim et al. 2005; Avery et al. 2008).

**Table 1. Recovery of live \textit{Toxoptera citricidus} (BCA) on individual Carrizo citrus treated with and without a parasitoid (\textit{Lysiphlebus testaceipes}) and an entomopathogenic fungus (\textit{Isaria fumosorosea}) weeks post-application**.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>22.3 a</td>
<td>21.2 a</td>
<td>40.3 a</td>
<td>55.4 a</td>
<td>60.8 a</td>
<td>179.8 a</td>
</tr>
<tr>
<td>\textit{L. testaceipes}</td>
<td>21.4 a</td>
<td>20.5 a</td>
<td>28.4 a</td>
<td>31.0 a</td>
<td>6.3 b</td>
<td>2.8 b</td>
</tr>
<tr>
<td>\textit{Ifr}</td>
<td>9.9 a</td>
<td>8.7 a</td>
<td>22.2 a</td>
<td>35.4 a</td>
<td>58.0 a</td>
<td>167.5 a</td>
</tr>
<tr>
<td>\textit{L. testaceipes} + \textit{Ifr}</td>
<td>15.2 a</td>
<td>13.3 a</td>
<td>18.5 a</td>
<td>16.9 a</td>
<td>1.8 b</td>
<td>0.3 b</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Data are the average per plant from 2 tests (5 plants per replicate).
\textsuperscript{b}Treatments: C = control (water only); \textit{L. testaceipes} = parasitoid exposed to BCA populations; \textit{Ifr} = \textit{I. fumosorosea} blastospores exposed to BCA populations; \textit{L. testaceipes} + \textit{Ifr} = parasitoid exposed to BCA populations and sprayed 4 days post-release with \textit{I. fumosorosea} blastospores.
\textsuperscript{c}Values with the different letters in a column represent significant differences between treatments (\(P < 0.05\), Fishers LSD).

**Table 2. Number of \textit{Toxoptera citricidus} aphid mummies (emerged and unemerged) recovered from individual Carrizo citrus treated with and without the entomopathogenic fungus \textit{Isaria fumosorosea} (\textit{Ifr}) weeks post-application**.

<table>
<thead>
<tr>
<th>Aphid mummies/treatment</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemerged</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>\textit{L. testaceipes}</td>
<td>0 a</td>
<td>0 a</td>
<td>8.3 a</td>
<td>13.3 a</td>
<td>32.0 a</td>
<td>18.7 a</td>
</tr>
<tr>
<td>\textit{L. testaceipes} + \textit{Ifr}</td>
<td>0 a</td>
<td>0 a</td>
<td>14.0 a</td>
<td>18.0 a</td>
<td>26.2 a</td>
<td>17.5 a</td>
</tr>
<tr>
<td>Emerged</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>\textit{L. testaceipes}</td>
<td>0 a</td>
<td>0 a</td>
<td>0.1 a</td>
<td>3.5 a</td>
<td>11.0 a</td>
<td>15.5 a</td>
</tr>
<tr>
<td>\textit{L. testaceipes} + \textit{Ifr}</td>
<td>0 a</td>
<td>0 a</td>
<td>0.4 a</td>
<td>4.6 a</td>
<td>9.6 a</td>
<td>13.4 a</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Data are the average per plant from 2 tests (5 plants per replicate).
\textsuperscript{b}Treatments: \textit{L. testaceipes} = \textit{Lysiphlebus testaceipes} parasitoid exposed to BCA populations; \textit{Lysiphlebus testaceipes} + \textit{Ifr} = \textit{Lysiphlebus testaceipes} parasitoid exposed to BCA populations and sprayed 4 days post-release with \textit{I. fumosorosea} blastospores.
\textsuperscript{c}Values with the same letters in a column for each category of aphid mummies (unemerged and emerged) represent no significant differences between treatments (\(P > 0.05\), Student's t-test).

**Summary**

Treatments with \textit{Ifr} alone were not effective for managing BCA populations in these cage trials. However, \textit{Ifr} did not inhibit parasitism or emergence, and \textit{L. testaceipes} was highly effective at parasitizing the aphids even in the presence of \textit{Ifr}. The compatibility of \textit{Ifr} with \textit{L. testaceipes} demonstrated potential for managing brown citrus aphid pests in citrus.

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