CRITERIA FOR RANKING EVALUATIONS OF IR-4
ADVANCED STAGE BIOPESTICIDE PROPOSALS-2014

Proposal number/Title/PI:  14A, Biopesticide management of armored scales in ornamental palms, Arthurs

The following criteria were established to assist the reviewers in selecting biopesticide projects for funding that: (1) are either in a more advanced stage of development (as opposed to exploratory or early stage of development) or involve expansion of the label; (2) have a high probability of being registered/marketed in a reasonable period of time; and (3) will be useful in meeting pest control needs involving minor crops (uses), including minor uses on major crops.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Score (0 to 10 or 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adequacy of investigators and facilities.</td>
<td>of 10</td>
</tr>
<tr>
<td>2. Experimental design, work plan and preliminary research.</td>
<td>of 10</td>
</tr>
<tr>
<td>3. Does experimental design allow to determine performance relative to conventional control practices and how the biopesticide might fit into IPM programs.</td>
<td>of 10</td>
</tr>
<tr>
<td>4. Evaluation of Budget</td>
<td>of 10</td>
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<tr>
<td>5. Relevance of the proposal toward the development of data for registration or label expansion of the biopesticide.</td>
<td>of 10</td>
</tr>
<tr>
<td>6. Evidence of Efficacy. Positive supporting data provided.</td>
<td>of 20</td>
</tr>
<tr>
<td>7. Probability of biopesticide being used by growers (factors such as effectiveness and economics of use rates should be considered).</td>
<td>of 10</td>
</tr>
<tr>
<td>8. Other control measures currently available to control target pest.</td>
<td>of 10</td>
</tr>
<tr>
<td>9. Probability of biopesticide being registered, time to registration, and if label expansion, time to market.</td>
<td>of 10</td>
</tr>
</tbody>
</table>

TOTAL* of 100

Funding Recommendation
  YES
  NO
  MAYBE

Note: Attach a comment page, should you have specific comments related to the proposal not covered in the above criteria.

* There is a possibility of 10 points per criteria (except efficacy=20) for a total of 100 points. A rating of 0 means that the proposal does not meet the criteria at all, while a rating of 10 means it is ideal.
**IR-4 BIOPESTICIDE GRANTS COVER PAGE**

**2014**

<table>
<thead>
<tr>
<th>Proposal Number (For IR-4 Use):</th>
<th>Principal Investigator: Steven Arthurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposal Title: Biopesticide management of armored scales in ornamental palms</td>
<td></td>
</tr>
<tr>
<td>Institution: University of Florida</td>
<td></td>
</tr>
<tr>
<td>Total dollars Requested $17,372 (Year 1 only)</td>
<td></td>
</tr>
</tbody>
</table>

Enter each biopesticide /crop/ pest combination

<table>
<thead>
<tr>
<th>No.</th>
<th>Biopesticide and/or Conventional Product</th>
<th>Active Ingredient</th>
<th>Crop</th>
<th>Pest (Weeds, Diseases, Insects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Fly</td>
<td><em>Isaria</em> strain FE9901</td>
<td><em>Cycas revoluta</em></td>
<td><em>Aulacaspis yasumatsui</em></td>
</tr>
<tr>
<td>2</td>
<td>Botani*gard® ES</td>
<td><em>Beauveria bassiana</em> GHA</td>
<td><em>Cycas revoluta</em></td>
<td><em>Aulacaspis yasumatsui</em></td>
</tr>
<tr>
<td>3</td>
<td>Molt-X</td>
<td>Azadirachtin</td>
<td><em>Cycas revoluta</em></td>
<td><em>Aulacaspis yasumatsui</em></td>
</tr>
<tr>
<td>4</td>
<td>SuffOil-X</td>
<td>Refined petroleum oil</td>
<td><em>Cycas revoluta</em></td>
<td><em>Aulacaspis yasumatsui</em></td>
</tr>
<tr>
<td>5</td>
<td>Safari</td>
<td>Dinotefuran</td>
<td><em>Cycas revoluta</em></td>
<td><em>Aulacaspis yasumatsui</em></td>
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### Biopesticide Grants Contact Information Form

<table>
<thead>
<tr>
<th>Proposal Title:</th>
<th>Address</th>
<th>Phone Number &amp; Fax Number</th>
<th>E-mail Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biopesticide management of armored scales in ornamental palms</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Street</th>
<th>City/State</th>
<th>Zip+4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Director (Principal Investigator):</strong></td>
<td>2725 Binion rd</td>
<td>Apopka</td>
<td>32703-8504</td>
</tr>
<tr>
<td>Dr Steven Arthurs</td>
<td></td>
<td></td>
<td>Fax: 407-814-6186</td>
</tr>
<tr>
<td><strong>Administrative Contact:</strong></td>
<td>219 Grinter Hall</td>
<td>Gainesville, FL</td>
<td>32611-5500</td>
</tr>
<tr>
<td>Brian Prindle</td>
<td>PO Box 115500</td>
<td></td>
<td>Fax: 352-392-4522</td>
</tr>
<tr>
<td><strong>Financial Grant Officer:</strong></td>
<td>0101 Bryant Hall</td>
<td>Gainesville, FL</td>
<td>32611</td>
</tr>
<tr>
<td>Meridith David</td>
<td>PO Box 110116</td>
<td></td>
<td>Fax: 352-392-8479</td>
</tr>
<tr>
<td><strong>Authorized Grant Official:</strong></td>
<td>219 Grinter Hall</td>
<td>Gainesville, FL</td>
<td>32611-5500</td>
</tr>
<tr>
<td>Brian Prindle</td>
<td>PO Box 115500</td>
<td></td>
<td>Fax: 352-392-4522</td>
</tr>
<tr>
<td><strong>Individual Responsible for Invoicing:</strong></td>
<td>0101 Bryant Hall</td>
<td>Gainesville, FL</td>
<td>32611</td>
</tr>
<tr>
<td>Meridith David</td>
<td>PO Box 110116</td>
<td></td>
<td>Fax: 352-392-8479</td>
</tr>
</tbody>
</table>

**Note:** This is for informational purposes only. This is not meant to be signed. Do not delay submitting your proposal by attempting to get this signed. This is not meant as a replacement for any institutional approval pages.
I. **Grant Stage** What is the grant Stage to which you are applying? Early or Advanced (Check appropriate line)

X Advanced – the biopesticide is registered or at least has completed the Tier I toxicology data requirements.

II. **Introduction** *(Limit 1 page)* Include the objective, description of the pest problem and justification.

There are 20 families and 1,058 scale insect species in the US (ScaleNet 2010). Amongst them, armored scales (Hemiptera: Diaspididae) include the most damaging and least understood pests of ornamental plants and are among the most invasive insects worldwide (Miller and Davidson 2005). In the southeastern US, armored scales infest virtually all woody and herbaceous ornamental plants grown in nurseries and landscapes. Although the removal of plant nutrients from the vascular system by scale insects do not generally cause immediate mortality, long-term feeding significantly weakens plants, causing branch dieback, and eventually death. Armored scales cause regulatory difficulties in interstate shipment of plants. An obstacle to chemical control is a layer of waxy deposits or a shell (scale) composed of wax and exuviae that protect scale insects from conventional insecticides. Therefore, management recommendations require application of dormant season oils or insecticides during the emergence period of crawlers (i.e. first-instar nymphs), which have thin or no wax layer. In southern states, the lack of a dormant period (when heavy oils can be used) and uncertain scale phenology make control problematic.

The use of entomopathogenic fungi is an overlooked aspect of integrated scale control. Recent studies confirm that some entomopathogenic fungi can successfully penetrate and germinate through armored scale covers under natural conditions (Marcelino et al. 2009). Thus further evaluation is warranted; especially since *Beauveria bassiana* was one of the strains reported. We propose to work with the cycad aulacaspis scale (CAS), *Aulacaspis yasumatsui* Takgi (Hemiptera: Diaspididae), an invasive pest of cycads accidentally introduced into Florida in 1996 from Southeast Asia. Since its arrival CAS has quickly spread through the landscape infesting cycads in the genera *Cycas, Dioon, Encephalartos, Microcycas* and *Stangeria* and has resulted in the removal of millions of cycads from Florida landscapes (Manrique et al. 2012). CAS has spread through plant shipments, and is currently found in Alabama, Florida, California, Georgia, Hawaii, Louisiana, South Carolina, Texas and the Caribbean (Germain and Hodges 2007). CAS is notoriously difficult to control. In Florida CAS are often treated with neonicotinoids (with dinotefuran favored), however reports from landscapers in 2012 suggest that even this is currently not providing adequate control in many cases [http://www.youtube.com/watch?v=GbWxh-UKYrw](http://www.youtube.com/watch?v=GbWxh-UKYrw). Such is the seriousness of CAS; the IUCN/SSC Cycad Specialist Group has elevated conservation status to *Endangered* (John Donaldson, Chair IUCN/SSC).

We propose to evaluate several entomopathogenic fungi alone and in combination with a reduced risk horticultural oil and insecticidal standard against CAS in both laboratory and landscape tests. Since CAS infests both leaves and roots, it is hard to control since it reinfests plants after treatment. However, we anticipate that this characteristic may be advantageous to entomopathogenic fungi, which can sporulate on hosts infected with the initial spray application. A recent study confirmed that CAS is susceptible to *Isaria fumosorosea* Wize, with up to 84% infection in laboratory assays Castillo et al (2011). We have identified several sprayable (emulsifiable) oils that are compatible with *Isaria* (Arthurs unpublished data) which we anticipate may enable improved control with entomopathogenic fungi.
III. Experimental Plan (Please limit this section to 10 pages)

1. Provide a numerical list of all treatments including the products (Trade names and active ingredients, rate (units), application timing, etc. A majority of the treatments must be biopesticides (see http://ir4.rutgers.edu/Biopesticides/LabelDatabase/index.cfm). If you are not sure, ask.

<table>
<thead>
<tr>
<th>Laboratory trial: To generate dosage response data (Objective 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade name</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>1. Control</td>
</tr>
<tr>
<td>2. No Fly™WP</td>
</tr>
<tr>
<td>3. Botanigard®ES</td>
</tr>
<tr>
<td>4. SuffOil-X</td>
</tr>
<tr>
<td>5. Molt-X</td>
</tr>
</tbody>
</table>

*Single application tests

<table>
<thead>
<tr>
<th>Greenhouse trial (Cycas revoluta) (Objective 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade name</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>1. Control</td>
</tr>
<tr>
<td>2. No Fly</td>
</tr>
<tr>
<td>3. No Fly + SuffOil-X</td>
</tr>
<tr>
<td>4. Botanigard®ES</td>
</tr>
<tr>
<td>5. Botanigard®ES + SuffOil-X</td>
</tr>
<tr>
<td>6. SuffOil-X + Molt-X</td>
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</tbody>
</table>

*duel application tests; **estimated – actual rates based on results of objective#1.

<table>
<thead>
<tr>
<th>Landscape tests (Cycas revoluta) (season long study) (Objective 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade name</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>1. Control</td>
</tr>
<tr>
<td>2. BP [No Fly ± BotanigardES + Horticultural Oil(s)]</td>
</tr>
<tr>
<td>3. CS (Safari 20 SG)</td>
</tr>
<tr>
<td>4. BP rotated with CS</td>
</tr>
</tbody>
</table>

2. What crops or sites will this study be conducted on?

Laboratory trial: Bioassays conducted using excised leaflets of Japanese sago
Greenhouse trial: Japanese sago in 5 gallon pots cultivated at MREC

Landscape tests: Outdoor tests will be conducted using containerized Japanese sago located on nursery ground covers at MREC

3. What experimental design will be utilized?

Laboratory trial (Objective 1)
Treatments #1-5 will be screened using a Precision Potter Spray tower (Burkard Scientific Co.) and a modification of the method of Castillo et al. (2011). One hundred leaflets (2-3 month old detached from infested sago palm fronds) will apply mycoinsecticides between 0.1 and 5 mg/ml while applying between $10^6$ and $10^9$ conidia (GHA) or blastospores (FE 9901) per ml and 0.1 – 2% v/v for oil treatments. The volume application rate (VAR) will be equivalent to 200 L/ha. These concentrations cover the range of anticipated activity, thus allowing LC$_{50}$ to be calculated for each strain. Treated leaflets will be incubated in 1 oz Potion cups (Solo Co.) at 25 and 30°C (the higher temperature will allow temperature. Mortality of different life stages is assessed at 7, 14 and 21 days post treatment. Information obtained at this stage will be valuable in finalizing treatments and rates used in later objectives.

Greenhouse Assay (Objective 2)
Thirty six Japanese sago palms grown at MREC (5 gallon containers) will be controlled-infested with CAS by placing infested fronds with a known number of crawler stages onto clean plants in spring 2013. Plants will be treated 1-2 month post-infestation when F1 crawlers are starting to emerge. Applications of No Fly, Botanigard and SuffOil-X will be applied at optimal label rates (determined from Obj#1) using a DeVries spray cabinet fitted with a cone nozzle and calibrated at 50 GPA. Plants will be treated twice at 2 week intervals. There will be six replicates per treatments with plants arranged in a randomized block design in a large research greenhouse to account for environmental variability. Since CAS is generally wind dispersed, we anticipate that cross contamination should be avoided. Plants will be assessed after 21, 35 and 49 days post treatment, to allow effects of secondary infections to be accounted for. Scale will be individually flipped over and examine and the life stage (alive or dead) recorded. The effect of treatments on the number of live scales, plant damage (chlorosis and # new fronds) will be analyzed through repeated measures ANOVA and Tukey’s HSD mean separation tests.

Landscape trials (Objective 3)
Since CAS is generally a landscape pest, the final objective will compare most promising treatments (determined from Objectives 1 and 2) and the current insecticidal standard (applied as a foliar spray) under simulated landscapes. Treatments will be applied via backpack sprayer to replicated blocks of *C. revoluta* maintained outside on nursery shade cloths. Plants will be controlled-infested (as above) in early spring and treatments applied to coincide with crawler activity. Since CAS is a persistent problem that is rarely adequately controlled by natural enemies, a threshold design is not appropriate. Chemical standard (CS) program (dinitefuran as a foliar spray) will be assessed alone and in rotation with the most promising Biopesticide program (BP) assessed from objective 1 and 2. Assessments will be made at the end of each CAS generation to determine the number of alive and dead scales and monitor life stages present. The study will continue through the southern growing season (late fall). Effects of treatments and time on insect numbers, damage to plants (# infested fronds) will be analyzed using repeated measures ANOVA and Tukeys mean separation tests.
4. **How many locations (field or greenhouse)? How many replications?**

The laboratory trial will be conducted with a minimum of 5 replicate bioassay cups per treatment and the study will be repeated 3 times for each material. Greenhouse tests will be conducted on in MREC greenhouses with six replicates per treatments. Landscape tests will be conducted with replicate planting blocks with 5 replicates.

5. **Describe how this proposal is designed to provide information on how it fits into an integrated pest management program.**

Our proposal is designed to assess products, rates and specific treatments rotations (objectives 1 and 2) and compare a biopesticide program with the current insecticidal standard (objective 3). This approach will provide more useful information compared with a single test. An important aspect will be to assess predation or parasitism of CAS in the landscape test. Natural enemies, including a species of predatory ladybeetles (*Lindorus* sp.) and the parasitoid *Coccubius fulvus* imported from Thailand, can contribute to the decline of CAS under natural conditions, but are probably suppressed by toxic insecticides used in the landscape (Smith and Cave 2006). Identifying programs compatible with biocontrol agents will help establish landscape IPM programs for CAS.

6. **Data collection – (Describe what data will be collected such as crop yields, crop quality, etc. If visual efficacy evaluations will be collected, describe the rating scale used and the evaluation timings).**

   **Laboratory test:** Percentage mortality will be evaluated and where necessary dead scales will be incubated under moist conditions for 72 hrs to encourage sporulation. Microscopic examination and Koch’s postulates will be used to confirm the strain of fungus responsible for mortality.

   **Greenhouse and landscape tests:** Scale survival will be assessed at set periods post treatment from 5 replicate pinna (1st major division of leaf) per plant. For landscape tests, movement of crawlers onto new foliage at the start of each new scale generation is a key indicator of which treatments are working. The number of infested fronds and presence of chlorosis (yellowing which occurs under high infestation pressure) will be assessed. Also, since scales may infest roots and reinfest plants the following season; some plants will be maintained and assessed on new growth in the following spring (2015).

7. **Describe the pests to be controlled, the degree to which they are a problem in your state or region and the frequency that they occur (season long problem, every year, every few years).**

Since it was first detected in 1996, CAS has become widely established throughout Florida, infesting a high proportion of cycads in the landscape. It has since been detected in several other southern states. Although CAS may be spread short distances by wind dispersal of crawlers, longer distance spread of this scale insect seems to occur by transport of infested plants. Infestations usually appear at the base of the rachis, then spread on the leaf until the whole plant is infested, weakens and dies. Cycads may become almost completely coated with a white crust that includes both live and dead scales, hence its colloquial name ‘snow scale’. Up to 500 scales per cm² are seen under a dissecting microscope. When the plant is heavily infested, scales are difficult to clean up, even after scales are dead (Castillo et al 2011). Since cycads are slow growing and long lived, their
loss in the landscape is often permanent. The continued spread of CAS is inevitable as long as trade in cycads is continued. New insecticides will help address this issue.

8. Will the crop be inoculated with the target pest or otherwise be brought into the test system to ensure that it will be available for evaluation? If not, describe the frequency of occurrence.

A colony of CAS reared at MREC since 2010 will be used for laboratory bioassays. Cycad plants will be inoculated by placing fronds infested with crawler stages on top of new growth at first emergence of crawlers. Careful plant selection will ensure a standardized population of scales for further testing.

9. What is the proposed start date and completion date? Also describe this in chronological order in the context of the experimental plan.

Work will conducted in 2014. Greenhouse and landscape studies will coincide with spring flush from plants and continue until spring 2015 to evaluate overwintering survival (outdoor plants).

10. Describe the test facilities where these studies will be conducted.

Studies will be conducted at the Mid Florida Research and Education Center. The PI (Arthurs) has necessary space to conduct these studies, including a well-equipped laboratory, 16 room insectary, spray tower and research spray booth, controlled incubation chambers, 2 large greenhouses and ground cover and micro-stake irrigation for nursery studies.

11. Budget: (see next page)

Provide an itemized budget, with categories such as labor, supplies, travel, etc.

12. Describe why this product is needed and why growers are likely to use this product. (Also list alternative conventional and alternative biopesticide treatments): See appendix for additional information.

The cycad aulacaspis scale (CAS) has had a considerable impact on the ornamental plant industry in areas where it has invaded (Germain and Hodges 2007). It is an unusually difficult pest to control since it forms dense colonies which are not easily dislodged or killed by most contact insecticides. Few materials are highly effective for control in the landscape. Horticultural oils can be used to target first instars (crawlers), which seem to prevent them successfully settling on plants, but several applications are required to achieve adequate control of adult scales (Weissling et al. 1999). Moreover there are risks of phytotoxicity with some oils that are applied during warm conditions. Currently dinofuran applied as a foliar or drench are favored for CAS since it is highly water soluble and has traditionally given good control (Caldwell 2005). However there are additional risks with overreliance on this one material and some industry reports that it does not been to be working as well as it once did (Doug Caldwell personal communication; http://www.youtube.com/watch?v=GbWxh-UKYrw). Moreover, such materials are toxic to natural enemies which ultimately may need to be encouraged to provide more effective control, including importation of specific predators from China (Cave 2009).
### BIOPESTICIDE PROJECT BUDGET

**Project Period From: March 2014 to March 2015**

<table>
<thead>
<tr>
<th>A. Senior Key person</th>
<th>Funds requested</th>
<th>Matching funds¹</th>
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<tr>
<td>B. Other Personnel</td>
<td>$14,600</td>
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Total Number, Other Personnel: $672

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<th>C. Fringe Benefits</th>
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Total Salary, Wages and Fringe Benefits: $15,272

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<tr>
<td>2. Foreign</td>
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</table>

<table>
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<tr>
<th>F. Participant Support Costs</th>
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<tbody>
<tr>
<td>1. Travel</td>
<td></td>
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</tbody>
</table>

| G. All Other Direct Costs   | $17,372        | $6,000        |
|------------------------------|----------------|
| 1. Materials and Supplies   | $1,500         | $1,000        |
| 2. Publication Costs        | $300           |
| 3. Consultant Services      |                |
| 4. Computer Services        |                |
| 5. Subawards/Consortium/Contractual Costs |        |
| 6. Equipment or Facility Rental/User Fees |        |
| 7. Alterations and Renovations | NOT ALLOWED  |
| 8. Other 1                  |                |
| 9. Other 2                  |                |
| 10. Other 3                 |                |

¹Matching, FNGLA monetary donation, materials supplied by Big Tree Plantation, GV, FL and biopesticide registrants for use of materials at no cost.
Budget Justification

Project title: Biopesticide management of armored scales in ornamental palms

PI: Steven Arthurs

Statement of work:
I propose to evaluate mycoinsecticides and other biorational pesticides for management of cycad aulacaspis scale on ornamental cycads. The work will comprise laboratory bioassays, greenhouse and landscape studies to compare whole plant treatments under semi-realistic ‘operational’ conditions. This work will contribute to our understanding of the potential for managing this important landscape pest.

Matching: $6,000 [donation by the Florida Nursery, Growers and Landscape Association (FNGLA) for work on cycad scale management in FY 2014 and In-kind contributions including fifty 3 gallon Cycas plants, valued at $15 each].

Salary: $15,272 [50% support for a biological technician (OPS) needed to assist with treatments and process samples over 12 months @ $14 p/h plus a fringe rate of 4.6%].

Travel: $300 [some local travel, field collections of insects and picking up additional plants at nurseries etc.]

Materials and supplies: $1500 [consumables, i.e. pots, soil mix, fertilizer, cages, data loggers, Petri dishes, media and miscellaneous equipment etc.]

Publication: $300 [offset publication costs in refereed and non-refereed journals]
December 6, 2013

University of Florida Board of Trustees
Division of Sponsored Programs
319 Griffin Hall
PO Box 115500
Gainesville, Florida 32611-5500

Ref: Third Party Cost Share

As the Fund Administrator for the Florida Nursery Growers and Landscape Association Research Endowment, I approve the use of the $5000 FNGLA Endowed Research funding (awarded to PI Steven Archars on October 11, 2013 for work on creek salvia species) as matching funds for additional research on this insect. I understand that Dr. Archars is pursuing additional funding through the IR4 Biosticide program (managed through Rutgers University) to conduct biosticide testing against creek salvia species. These two projects align very well and both will benefit this important industry problem.

Sincerely,

[Signature]

Mary L. Duryea
Associate Dean for Research & Associate Director
Florida Agricultural Experiment Station

The Foundation for The Citrus Industry
References cited

Note: See appendix for attachment of additional information.
IR-4 Minor Use Biopesticide (*Required Fields)  
Project Clearance Request (PCR) Form

1. *Requestor: Steven Arthurs  
   Affiliation: University of Florida  
   *Address: MREC, 2725 Binion Rd  
   *City: Apopka  
   *State/Territory: FL  
   *Telephone: (407) 884-2034  
   *Fax: (407) 814-6186  
   *E-mail address: spa@ufl.edu

2. *Pest Control Product (Active Ingredient {a.i.}): Beauveria bassiana GHA
   *TradeName/Formulation: Botanigard 22WP  
   Registrant (manufacturer): Bioworks Inc.  
   Method of Production (Fermentation, in vivo, extraction from plants): In vitro solid media

3. *Commodity (one crop or crop group per form): Cycas revoluta  
   *Use Site (e.g., field, greenhouse, post-harvest): Landscape  
   Parts Consumed: None  
   Animal Feed By-Products: Yes X  
   Planting Season: year round  
   Harvest Season: NA  
   State/Territory Acreage: % National:  Average Field Size: 1A

4. Insect/Disease/Weed: Cycad aulacaspis scale  
   Damage caused by pest: aesthetic kills plant under heavy infestation

5. *Why is this use needed?: Lack of alternative effective and non-toxic materials

6. *Proposed Label Instructions
   *Rate per Application (lbs a.i. per acre or 1000 linear ft): 1-4 oz per 1000 sq ft  
   Type of sprayers that may be used (e.g., fixed wing, ground boom sprayer, chemigation, air blast, ULV, granular spreader): backpack  
   Range of Spray Volume (if applicable): 50-100 GPA  
   Maximum Acreage Treated per Day:  
   *Crop Stage during Application(s): any  
   *Maximum no. of applications: Minimum interval betw. applications: 7d  
   Maximum lbs active ingredient per acre per year/season: *PHI: 0 d

7. *Availability of Supporting Data†: *Phytotoxicity(P)  
   *Efficacy(E)  
   *Yield(Y)  
   †Supporting data may be required before a residue study will be initiated.

8. Brief Summary of proposed study and fund request: Please see full proposal

9. *Submitted By (print name): Steven Arthurs  
   *Signature:  
   *Date: 15 Nov 2013

Send this completed form to:  
IR-4 Project Headquarters, 500 College Road East; Suite 201 W; Princeton, NJ 08540-6635;  
Telephone (732)932-9575 ext 4610 (Michael Braverman) FAX (609) 514-2612  
or e-mail: braverman@aesop.rutgers.edu
IR-4 Minor Use Biopesticide (*Required Fields)
Project Clearance Request (PCR) Form

1. *Requestor: Steven Arthurs
   *Affiliation: University of Florida
   *Address: MREC, 2725 Binion Rd
   *City: Apopka
   *State/Territory: FL
   *Telephone: (407) 884-2034
   *Fax: (407) 814-6186
   *E-mail address: spa@ufl.edu

2. *Pest Control Product (Active Ingredient {a.i.})
   Active ingredient: *Isaria fumosorosea* (=*Paecilomyces fumosoroseus*) strain FE 9901
   *TradeName/Formulation: No Fly™ WP
   *Registrant (manufacturer): Natural Industries
   *Method of Production (Fermentation, in vivo, extraction from plants): In vitro solid media

3. *Commodity (one crop or crop group per form): Cycas revoluta
   *Use Site (e.g., field, greenhouse, post-harvest): Landscape
   *Parts Consumed: None
   *Animal Feed By-Products: Yes
   *Planting Season: year round
   *Harvest Season: NA
   *State/Territory Acreage:
   *% National:
   *Average Field Size:

4. Insect/Disease/Weed: Cycad aulacaspis scale
   Damage caused by pest: aesthetic kills plant under heavy infestation

5. *Why is this use needed?: Lack of alternative effective and non-toxic materials

6. *Proposed Label Instructions
   *Rate per Application (lbs a.i. per acre or 1000 linear ft): 1-4 oz per 1000 sq ft
   *Type of sprayers that may be used (e.g., fixed wing, ground boom sprayer, chemigation, air blast, ULV, granular spreader): backpack
   *Range of Spray Volume (if applicable):
   *Maximum Acreage Treated per Day:
   *Crop Stage during Application(s):
   *Maximum no. of applications: _____ Minimum interval between applications: 7d
   *Maximum lbs active ingredient per acre per year/season: _____ *PHI: 0 d

7. *Availability of Supporting Data*: *Phytotoxicity(P)___*Efficacy(E)___*Yield(Y)___
   *Supporting data may be required before a residue study will be initiated.

8. Brief Summary of proposed study and fund request: Please see full proposal

9. *Submitted By (print name): Steven Arthurs
   *Signature:__________________________*Date: 15 Nov 2013

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IR-4 Minor Use Biopesticide (*Required Fields) 
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1. *Requestor: Steven Arthurs* 
   Affiliation: University of Florida 
   *Address: MREC, 2725 Binion Rd* 
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   *State/Territory: FL* 
   *Telephone: (407) 884-2034* 
   *Fax: (407) 814-6186* 
   *E-mail address: spa@ufl.edu*

2. *Pest Control Product (Active Ingredient {a.i.}): Azadirachtin* 
   *TradeName/Formulation: Molt-X ®* 
   Registrant (manufacturer): Bioworks Inc. 
   Method of Production (Fermentation, in vivo, extraction from plants): extraction from plants

3. *Commodity (one crop or crop group per form): Cycas revoluta* 
   *Use Site (e.g., field, greenhouse, post-harvest): Landscape* 
   Parts Consumed: None__Animal Feed By-Products: Yes___No X ___ 
   Planting Season: year round__Harvest Season: NA 
   State/Territory Acreage:___% National:_____Average Field Size:_________

4. Insect/Disease/Weed: Cycad aulacaspis scale 
   Damage caused by pest: aesthetic kills plant under heavy infestation

5. *Why is this use needed?: Lack of alternative effective and non-toxic materials*

6. *Proposed Label Instructions* 
   *Rate per Application (lbs a.i. per acre or 1000 linear ft): 1-4 oz per 1000 sq ft* 
   Type of sprayers that may be used (e.g., fixed wing, ground boom sprayer, chemigation, air blast, ULV, granular spreader): backpack 
   Range of Spray Volume (if applicable): ____________________________ 
   Maximum Acreage Treated per Day: ________________________________ 
   *Crop Stage during Application(s): any* 
   *Maximum no. of applications: ______Minimum interval betw. applications: 7d ________ 
   Maximum lbs active ingredient per acre per year/season: _______*PHI: 0 d ________

7. *Availability of Supporting Data*: *Phytotoxicity(P) ___*Efficacy(E) ___*Yield(Y) ___ 
   Supporting data may be required before a residue study will be initiated.

8. Brief Summary of proposed study and fund request: Please see full proposal

9. *Submitted By (print name): Steven Arthurs* 
   *Signature:________________________________________________________* 
   *Date: 15 Nov 2013*

Send this completed form to: 
IR-4 Project Headquarters, 500 College Road East; Suite 201 W; Princeton, NJ 08540-6635; 
Telephone (732)932-9575 ext 4610 (Michael Braverman) FAX (609) 514-2612 
or e-mail: braverman@aesop.rutgers.edu
Appendix 2
   Labels – Attached

Appendix 3
   Supporting preliminary data - Attached

Appendix 4
   Attach resume for Principal Investigator and Co-PI’s – Attached

Appendix 5
   If you were funded last year, submit a progress or final report. This must be submitted regardless of whether or not the current proposal is related to the previous one.

The proposal was not funded last year.

Appendix 6
   Registrant support. Please submit your proposal to the registrant and request the registrant or potential registrant fill out the registrant questionnaire form and submit this to IR-4. Letters of support from the registrant as well as grower or commodity groups are encouraged.

   Forms should be submitted directly to Dr Braverman
ACTIVE INGREDIENT:

*Paecilomyces fumosoroseus* strain FE 9901 …………………18.0%*

Inert Ingredients…………………………………………………….82.0%

Total……………………………………………. ……………………100.0%

* Contains a minimum of 2x10^9 colony forming units of *Paecilomyces
fumosoroseus* strain FE 9901 per gram (Dry Weight Basis)

KEEP OUT OF REACH OF CHILDREN
CAUTION
See back panel for additional precautionary statements

**FIRST AID**

If inhaled:
- Move person to fresh air.
- If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible.
- Call a poison control center or doctor for treatment advice.

If on skin or clothing:
- Take off contaminated clothing.
- Rinse skin immediately with plenty of water for 15 – 20 minutes.
- Call a poison control center or doctor for treatment advice.

*Have the product container or label with you when calling a poison control center or doctor, or going for treatment.*

**PRECAUTIONARY STATEMENTS**

Hazards to Humans and Domestic Animals: Caution. Harmful if swallowed, absorbed through skin, or inhaled. Avoid contact with skin, eyes or clothing. Avoid breathing vapor. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Wear protective eyewear, either goggles, face shield, or shielded safety glasses. Wear water proof gloves. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum or using tobacco. Remove and wash contaminated clothing before reuse.

Personal Protective Equipment (PPE): Applicators and other handlers must wear long-sleeved shirt and long pants, and shoes plus socks. Wear a dust/mist-filtering respirator (MSHA/NIOSH approval number prefix TC-21C), or a NIOSH approved respirator with any N-95, R-95, P-95 or HE filter for biological products. Remove contaminated clothing and follow manufacturer=s instructions for cleaning / maintaining PPE before reuse. If no such instructions are available use clothing detergent and hot water for cleaning all washable PPE. Keep and wash PPE separately from other laundry.

EPA Reg. No.: 73314-6
EPA Est. No.: 73314-TX-001

Net Contents: 2-lbs (912 g)

Manufactured by:
Natural Industries, Inc.
12320 Cutten Rd
Spring, TX 77066

Lot Number:
Best If Used By: 3 months from manufacturing date

OMRI Listed
May be used in organic production.
### USER SAFETY REQUIREMENTS
Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet. Remove PPE immediately after handling this product. If gloves are worn, wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

### ENVIRONMENTAL HAZARDS
Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean highwater mark. Do not contaminate water when cleaning equipment or disposing of equipment washwater.

### DIRECTIONS FOR USE
It is a violation of Federal law to use this product in a manner inconsistent with its labeling. **For greenhouse use only. Not for use on food crops.** Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

### AGRICULTURAL USE REQUIREMENTS
Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), and restricted entry intervals (REI). The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

- Do not allow worker entry into treated areas during the restricted entry interval (REI) of four (4) hours or until solution has dried.
- PPE required for early entry to treated areas (that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water) is: coveralls, chemical resistant gloves and shoes plus socks.

### NON-AGRICULTURAL USE REQUIREMENTS
The requirements in this box apply to uses of the product that are not within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries or greenhouses. Keep unprotected persons out of treated areas until sprays have dried or dusts have settled.

For use in controlling Whitefly, Aphids, Thrips, Psyllids, Mealybugs, Leaf hoppers, Plant bugs, Weevils, Grasshoppers, Mormon Crickets, Locust, Beetles and Fungus Gnats on non-food crops and ornamentals in greenhouse.

NOFLY™ WP contains live spores of the naturally occurring fungus *Paecilomyces fumosoroseus* strain FE 9901 and food grade inert ingredients. The spores are alive and may be harmed by storage at high temperatures or contact with water for more than 24 hours.

NOFLY™ WP can be applied using conventional spraying equipment. Use of manual sprayers is highly recommended, with a minimum working pressure of 40 psi. NOFLY™ WP works best in a pest management program designed to keep insect populations below levels which damage crops. Typically, it takes 3-7 days for an infected insect to die and 7-10 days after the first spray to see a reduction in an insect population. Application rates, spray frequency, spray coverage and insect numbers affect the speed at which insect populations are reduced. Frequent scouting for insects in crops is recommended. NOFLY™ WP is most effective when used at the first appearance of insects in the crop, before high insect populations develop.

NOFLY™ WP may be combined with chemical insecticides for rapid knockdown of damaging insect populations or large numbers of insects moving into crops. NOFLY™ WP can also be used in combination with fertilizers and micronutrients. If tank mixes are desired, observe the most restrictive directions, precautions, and limitations on labeling of all products used. Do not exceed label dose rates. This product cannot be mixed with any product containing a label prohibition
against such mixing. The application of fungicides is not compatible with NOFLY™ WP. A week is the minimum period allowed between treatment with fungicides and application of the product. Applications of any other pesticides must be carefully studied, taking into account that the active substance of NOFLY™ WP consists of a microorganism and any substance that could affect its viability must be avoided.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Application</th>
<th>Doses</th>
</tr>
</thead>
<tbody>
<tr>
<td>For greenhouse ornamental use</td>
<td>At any stage of the crop. Applications must be done at the first sign of insect larvae</td>
<td>1 - 4 lbs /acre</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-oz –16 oz/11,000 sq ft of greenhouse applied at minimum 0.1% (28-oz per 100 gallons)</td>
</tr>
</tbody>
</table>

Preparation Instructions
* If refrigerated, remove product from refrigeration unit and store at room temperature for at least 3 days prior to application.

Application Instructions:
* First applications should be done at the first symptoms of the presence of larvae or eggs on the leaves. Repeat applications 2 – 3 times at 15 day intervals or shorter (5 – 8 days) in the case of heavy infestations.
* Apply enough quantity of solution for a good coverage on the plants, trying to reach the lower-sides of the leaves. It is recommended to apply 26 gallons /11,000 sq ft greenhouse on small crops and up to 100 gallons /11,000 sq ft on full grown crops in greenhouse.
* Dissolve the contents of bags in an appropriate volume of water and mix with a stirring device to get a homogeneous suspension. Apply immediately using conventional-spraying equipment. A minimum pressure of 40 psi is recommended for the applications.
* Applications should be conducted during low solar radiation (late afternoon or early night) when there is high relative humidity inside the greenhouse and the temperature is below 30°C (86°F).
* NOFLY™ WP supports the action of natural predators of whitefly and other pests; therefore, it is ideal for IPM programs.

Storage and Disposal
Do not contaminate water, food, or feed by storage and disposal.

Pesticide Storage: NOFLY™ WP should be stored at refrigerated temperature (4°C - 8°C or 39 °F - 46°F). Under these conditions the product is physico-chemically stable for at least 3 months, although viability may decrease with a factor 10.

Pesticide Disposal: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal Facility.

Container Handling: Non-refillable container. Do not reuse or refill this container. Completely empty bag into application equipment, then offer for recycling if available or dispose of empty bag in a sanitary landfill or by incineration or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

Limited Warranty / Disclaimer
NOFLY™ WP conforms to the description set forth on this label and is reasonably fit for the purposes described herein when used according to the label directions and specified conditions. The manufacturer disclaims any or all other express or implied warranties for merchantability and fitness for particular purpose. To the extent consistent with applicable law buyers and users shall assume all risk and responsibility for potential loss or damage if this product is used, stored, handled or applied in a manner inconsistent with this labelling. To the extent consistent with applicable law, manufacturer shall not be liable for more than the purchase price for the quantity involved including incidental, consequential or special damages.
BotaniGard® ES
EMULSIBLE SUSPENSION MYCOINSECTICIDE

For use in controlling Whitefly, Aphids, Thrips, Psyllids, Mealybugs, Leathoppers, Weevils, Plant Bugs, Borer and Leaf-feeding Insects in Field, Agronomic, Vegetable and Orchard Crops; also in Forestry; Grasshoppers, Mormon Crickets, Locusts and Beetles in Rangeland, Improved Pastures and Agronomic Crops; Whitefly, Aphids, Thrips, Psyllids and Mealybugs in Ornamentals and Vegetables, Indoor/Outdoor Nursery, Greenhouse, Shadehouse, Commercial Landscape, Interiorspace and Turf.

Active Ingredient: Beauveria bassiana Strain GHA........11.3%**
Inert Ingredients: ..........................................................88.7%
Total: .............................................................................100.0%

*Contains petroleum distillates
**Based on the weight estimate of 4.76 x 10^12 gm/sper spore.
BotaniGard ES contains 2 x 10^13 viable spores per quart.

KEEP OUT OF THE REACH OF CHILDREN

CAUTION

See additional precautionary statements and first aid statements in attached booklet.

LAVERLAM INTERNATIONAL CORPORATION
117 S Parkmont; P.O. Box 4199-Batte, MT 59702; Ph: (406)782-2386; Fax: (406)782-9912
EPA Registration Number 82074-1 EPA Establishment Number 65626-MT-02
Edition: Net Contents:
Lot No.: Expiration Date:

Si Usted no entiende la etiqueta, busque a alguien para que se la explique a Usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION: Causes moderate eye irritation. Harmful if absorbed through the skin, inhaled or swallowed. Avoid contact with skin, eyes, or clothing. Avoid breathing spray mist. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet. Remove contaminated clothing and wash clothing before reuse.

FIRST AID

If in eyes
• Hold eye open and rinse slowly and gently with water for 15 - 20 minutes.
• Remove contact lenses, if present, after the first 5 minutes, then continue rinsing.
• Call poison control center or doctor for treatment advice.

If on skin or clothing
• Take off contaminated clothing.
• Rinse skin immediately with plenty of water for 15 - 20 minutes.
• Call a poison control center or doctor for treatment advice.

If inhaled
• Move person to fresh air.
• If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible.
• Call a poison control center or doctor for further treatment advice.

If swallowed
• Immediately call a poison control center or doctor.
• Do not induce vomiting unless told to do so by the poison control center or doctor.
• Do not give any liquid to the person.
• Do not give anything by mouth to an unconscious person.

HOT LINE NUMBER

Have the product container or label with you when calling a poison control center or doctor or going for treatment. You may also contact 1-800-2221-1222 for emergency medical treatment information.

NOTE TO PHYSICIAN

Contains petroleum distillate. Vomiting may cause aspiration pneumonia.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Applicators and other handlers must wear:
• Long-sleeved shirt and long pants
• Protective eyewear (goggles, face shield, or shielded safety glasses)
• Chemical-resistant gloves such as nitrile rubber or butyl rubber
• Shoes plus socks

Mixers/loaders and applicators must wear a dust/mist filtering respirator meeting NIOSH standards of at least R-95 or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization.

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

USER SAFETY RECOMMENDATIONS

Users should:
• Remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
• Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

This product is potentially pathogenic to honey bees. Avoid applying to areas where honey bees are actively foraging or around bee hives. This product may be toxic to fish. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas.

For terrestrial uses: Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water by cleaning of equipment or disposal of equipment wash waters or rinsate. Do not discharge into lakes, streams, ponds, or public waterways.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the State or Tribal agency responsible for pesticide regulation.
AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted-entry interval. The requirements in this box apply only to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours unless wearing the appropriate personal protective equipment.

PPE required for early entry to treated areas (that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water) is:
- Coveralls
- Chemical-resistant gloves such as nitrile rubber or butyl rubber
- Shoes plus socks
- Protective eyewear (goggles, face shield, or shielded safety glasses)

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours unless wearing the appropriate personal protective equipment.

Keep unprotected persons out of treated areas until sprays have dried.

MODE OF ACTION

BotaniGard ES acts by contact. Spores attach to the insect, germinate and penetrate through the insect cuticle. The fungus then grows rapidly within the insect, causing mortality.

Beauveria bassiana occurs naturally in close association with corn plants where it infects corn borers. When BotaniGard ES is applied to corn early in the season, the fungus persists in association with corn plants providing season long reduction in corn borer damage.

PRE-HARVEST INTERVAL

Pre-harvest interval for BotaniGard ES is zero (0) days. BotaniGard ES can be applied up to the day of harvest.

INSECTS FOR WHICH BOTANIgard ES May BE USED

ORTHOPTERA Grasshoppers, Locusts, Mole Crickets, Mormon Crickets

WHITEFLY Banded-winged Whitefly, Cassava Whitefly(*Not for use in California), Citrus Blackfly, Citrus Whitefly, Giant Whitefly, Greenhouse Whitefly, Silverleaf Whitefly, Sweet Potato Whitefly (aka Tobacco Whitefly)

APHIDS Bean Aphid, Cabbage Aphid, Cowpea Aphid, Green Peach Aphid, Greenbug, Hop Aphid, Melon/Cotton Aphid, Pea Aphid, Potato Aphid, Rose Aphid, Russian Wheat Aphid, Spotted Alfalfa Aphid

THrips Greenhouse Thrips, Cuban Laurel Thrips, Pear Thrips, Potato/Onion Thrips, Thrips palmi, Western Flower Thrips

PSYLLIDS Pear Psylla, Tomato/Potato Psylla

MEALYBUGS Citrus Cocci(*Not for use in California), Citrus Mealybug, Buffalo Grass Mealybug, Grape Mealybug, Longtailed Mealybug

LEAFHOPPERS AND PLANTHOPPERS Grape Leafhopper, Leaffoppers, Planthoppers, Potato Leaffopper, Rice Delphacid(*Not for use in California), Variegated Grape Leaffopper, Virginia Creeper Leaffopper

STEM-BORING LEPIDOPTERA European Corn Borer, Lesser Cornstalk Borer, Rice Stem Borer, Southwestern Corn Borer, Sugar Cane Borer

FOILAGE-FEEDING LEPIDOPTERA Diamondback Moth, Cabbage Looper, Fall Army Worm(*Not for use in California), Imported Cabbage Worm

LEAF-FEEDING BEETLES Bean Leaf Beetle, Cereal Leaf Beetle, Colorado Potato Beetle, Corn Rootworm, Cucumber Beetles, Elm Leaf Beetles, Flea Beetles

SCARAB BEETLES Atelius, Green June Beetle, White Grubs

PLANT BUGS (HETEROPTERA) Chinch Bugs, Flea Hoppers, Lace Bugs, Lygus Bug, Seed Bugs, Stink Bugs, Tamished Plant Bug

WEEVILS Alfalfa Weevil, Apple Curculio, Billbugs, Black Vine Weevil, Citrus Root Weevil, Coffee Berry Borer(*Not for use in California), Cotton Boll Weevil, Fuller Rose Weevil, Palm Weevil(*Not for use in California), Pecan Weevil, Pepper Weevil, Plantain Weevil(*Not for use in California), Plum Curculio, Root Weevil, Rose Curculio, Strawberry Root Weevil, Sweet Potato Weevil, Vegetable Weevil

ACARI Twospotted Spider Mite(*Not for use in California)

CROPS ON WHICH BOTANIgard ES May BE USED

VEGETABLES acerola, aracaracha, arrowroot, artichoke, arugula, asparagus, aternomya, balsam pear, bamboo shoots, beans (all varieties), beet, blackeyed peas, bokchoy, broccoli, broccoli raab, Brussels sprouts, burdock, cabbage, cantaloupe, carambola, carrots, casaba melons, cassava, catjag, cauliflower, celeriac, celery, celtuce, chayote, chervil, chickpeas, chicory, Chinese broccoli, Chinese cabbage, Chinese gai lon, Chinese longbeans, Chinese mustard, Chinese spinach, Chinese waxgourd, chrysanthemum (edible), chufa, ciliatetro, citron melon, collards, corn salad, cresaw melon, crest, cucumber, dandelion, dashleen, daikon, dock, edamame, eggplant, endive, escarole, fennel, garlic, gherkin, ginger, golden persaw melon, gourds (edible), groundcherry, gua, honey balls, honeydew
melon, horseradish, kale, kohlrabi, leek, lentils, leren, lettuce, mango melon, muskmelon hybrids/varieties, mustard greens, New Zealand spinach, okra, onion, orach, parsley, parsnip, peas (all varieties), peppers, pepper (all varieties), Persian melon, pimento (all varieties), pineapple melon, potato, pumpkin, purslane, radish, radicchio, rambutan, rupe greens, rape, raphan, rhabarb, rhatibaga, salsify, shallot, snake melon, soybeans, squash (squash/winter), sweet potato, Swiss chard, tanier, tomatillo, tumeric, turnip, watermelon, yam, zucchini

FRUITS AND BERRIES apple, apricot, avocado, bananas, blackberry, blueberry, boysenberry, calamondin, carob, cherimoya, cherry (sweet/sour), chironja, citrus citron, citrus hybrids, coffee, crabapple, cranberry, currant, dates, dewberry, durian, elderberry, feijoa, figs, gooseberry, grape (table, raisin, wine), grapefruit, guava, huckleberry, kiwi, kumquat, lemon, limes, loganberry, loquat, lychee, mandarin, mango, marionberry, nectarine, olive (all varieties), orange, oriental pear, papaya, passion fruit, peach, pear, persimmon, pineapple, plum, pomegranate, prune, pummelo, quinua, quince, raspberry, sour cherry, strawberry, sweet cherry, tangelo, tangerine, youngberry

TREE NUTS almonds, beech nut, Brazil nut, butternut, cashew, chestnut, chinquapin, filbert, hickory nut, macadamia nut, pecan, pistachio, walnut

AGRONOMIC CROPS alfalfa, barley, buckwheat, clover, coffee, corn (field, sweet, pop, silage, seed, corn grown for meat/flour), cotton, flax, hay, hops, jojoba, millet, oats, oil seed rape (canola), peanuts, potato, rice, rye, safflower, sorghum, soybeans, sugarbeets, sugarcane, sunflower, sweet corn, sweet potato, tea, teosinte, triticale, wheat, wild rice

FORESTRY, INCLUDING TREES AND CONIFERS, and tree and forest seedlings and woody ornamentals

HERBS AND SPICES allspice, anise, basil, bay, borage, burnet, chamomile, caper buds, caraway, cardamom, catnip, celery seed, chervil, chives, chives, cilantro/coriander, cinnamon, clary, coriander, costmary, cumin, curry leaf, dill, fennel, fenugreek, ginseng, horehound, hyssop, mace, marjoram, mint, mustard, nasturtium, nutmeg, oregano, paprika, pennyroyal pepper, peppermint, rosemary, rue, sage, saffron, savory, sesame; spearmint, sweet bay leaf, tansy, tarragon, thyme, wintergreen, woodruff, wormwood

ORNAMENTALS, INCLUDING FLOWERS, FLOWERING AND FOLIAGE PLANTS, BEDDING PLANTS, GROUNDCOVERS, SHRUBS, VINES, EVERGREENS AND TREES African lily, African violet, ageratum, alyssum, anthurium, arborvitae, astil, asparagus sprengeri, aster, atlas cedar, azalea, bald cypress, balsam fir, bamboo, barberry, beech, begonia, birch, Boston fern, bougainvillea, boxwood, bridal veil, cacti, caladium, calceolaria, calendula, calla lily, camellia, camellias, carissa, carnation, ceanothus, celosia, chenille plant, chero, Christmas cactus, chrysanthemum, cineraria, cleyera, coleus, cordyline, correus avellana, cotoneaster, cottonwood, crabapple, crepe myrtle, croxna, crotan, cyclamen, cypress, daffodil, dahlia, daisy, delphinium, deodar cedar, dichondra, dieffenbachia, dogwood, Douglas fir, dracaena, dumb cane, Dusty Miller, elm, eucalyptus, ferns, ficus, fig, firethorn, fittonia, flox, flower, foliage plants, forsythia, freesia, fuchsia, gardenia, geranium, gerbera, gerber daisy, gladiolus, golinia, grape, gynura, glyosophila, hackberry, hawthorn, hedera, hemlock, hibiscus, hickory, holly, honeysuckle, hop bush, horsechestnut, hyacinth, hydrangea, iceplant, immorti, impatiens, India hawthorn, iris, ivy, Japanese aucuba, Japanese barberry, Japanese boxwood, Japanese spindle tree, Japanese yew, juniper, kalanche, lantana, larch, larkspur, laurel, leasiantus, leatherleaf fern, linden, lilac, lily, litchdora, lobelia, loquat, magnolia, mandaevilla, maple, marigold, Mediterranean fan palm, mesembryanthemum, mimosas, monstera, mother-in-law plant, mountain laurel, myrtle, mandina, narcissus, oak, oleander, olive, orchid, ornamental kale, pachysandra, palms, pany, parrotal pine, pelargonium, peony, petunia, philodendron, phlox, photina, piggyback plant, pine, pink, pittosporum, planetree, podocarpus, poinitzia, poplar, pothos ivy, prayer plant, primrose, privet, pteris fern, pycrantha, rhododendron, rose, rubber plant, salvia, scabiosa, seffleria, schluembegeta, sedum, shrub verbena, shrubby cinquefoil, smoke tree, snapdragon, spathophytum, spruce, stock, sweet gum, sweet pea, sweet William, sycamore, syngonium, taxus, Texas sage, tulip, tulip tree, verbena, viburnum, vinca, Virginia creeper, walnut, wandering Jew, willow, yew, yucca, zinnia

TURF, INCLUDING LAWN AND SOD TURF GRASSES Bermuda grass, blue grass, fescue, St. Augustine grass, zoysia grass

MIXING AND APPLICATION SHAKE WELL BEFORE USING. Apply BotaniGard ES using hand-held, ground and/or aerial spray equipment, low-volume application equipment and chemigation (follow specific directions for chemigation in this booklet). BotaniGard ES contains emulsifiers and mixes readily in water. Mix well by external mixing, in-tank mixing, or pump circulation to form an emulsion. To mix, fill spray tank with half the desired amount of water and start agitation. Shake BotaniGard ES to suspend spores then with agitator running, slowly add desired quantity of BotaniGard ES to spray tank. Add remainder of desired amount of water. Continue agitation throughout loading and spraying. Triple rinse empty BotaniGard ES container with water and add rinse water to spray tank. For best results, continue agitation during spraying. Do not mix more BotaniGard ES than needed for that day. Do not mix BotaniGard ES the day before application. Spores will die if left overnight or longer in the spray tank.

Contact your dealer or Laverlam International Corporation for instructions about specific crops, insects and spray equipment.

DOSEAGE RATE FOR GREENHOUSE, SHADEHOUSE, INDOOR/OUTDOOR NURSERY, LANDSCAPE AND INTERIORSCAPE

High volume sprays: Apply at a rate of up to 3 quarts of BotaniGard ES per 100 gallons of spray volume in high volume sprays (2-6 tsp. or 0.33 - 1.0 fluid ounces of BotaniGard ES per gallon of spray volume). Mix well by external mixing, in-tank mixing, or pump circulation to form emulsion. SPRAY TO WET, BUT AVOID RUNOFF.

Typical Application Rates/100 Gallons of Spray Volume

<table>
<thead>
<tr>
<th>Crop Description</th>
<th>Application Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat, Mistletoe, Aphis</td>
<td>1 quart to 1 quart</td>
</tr>
</tbody>
</table>

Contact your dealer or Laverlam International Corporation for specific instructions.

Cuttings Dip

Applications of BotaniGard ES can be used as pre-plant dips for cuttings as noted below. To prepare dip solution, thoroughly mix 1/2 - 1 fl. oz. BotaniGard ES per gallon of water (5 - 10 fl. oz. per 10 gallons water). Prepare only as much dip solution as can be used in one day. Do not use dip solution for more than one day. Spores in water for more than 24 hours will die. Dip a small number of plants in dip solution and observe for plant damage before using dip treatment. Do not use dip if there is any visible damage to test plants.

Unrooted Cuttings

Dip the unrooted cuttings in the BotaniGard ES solution just long enough to wet them, then removing to a flat area and allow cuttings to dry. For water-sensitive varieties, cover to protect until dry. Then proceed with normal planting and misting.

Rooted Cuttings

Holding by the roots, briefly dip in the BotaniGard ES solution just long enough to wet all surfaces, including leaves and stems. Once removed from the dip solution, cuttings can be potted, but allow plants to dry before watering.

DOSEAGE RATE FOR FIELD, AGRONOMIC AND VEGETABLE CROPS (EXCEPT CORN): RANGELAND, IMPROVED PASTURES AND FORESTRY

Ground Application

Apply 1/4 to 1 quart BotaniGard ES/acre. Apply in sufficient water to thoroughly cover foliage infested with insects, typically 5 to 100 gallons of water per acre. Final spray volume may be up to 400 gallons per acre. Water volume depends on spray equipment, crop canopy, and target pest. SPRAY TO WET, BUT AVOID RUNOFF.

Apply BotaniGard ES up to a maximum of 3 quarts per acre for extreme insect pressure or dense foliage.
Aerial Application
Apply ¼ to 1 quart BotaniGard ES/acre. Apply in sufficient water to thoroughly cover foliage infested with insects. For best results, apply in 5-10 gallons water per acre. Do not apply in less than 2 gallons water per acre.

Leaf-Feeding Lepidoptera
For use against diamondback moth, imported cabbage worm and cabbage looper. BotaniGard ES can be used alone or in a tank mix with Bacillus thuringiensis (vars. kurstaki, aizawai) to control these insects in accordance with the more restrictive of label limitations and precautions. Do not exceed label dosage rates. This product cannot be mixed with any product containing a label prohibition against such mixing. The tank mix provides control of later instars (3rd to 4th) and aids in the management of resistant populations. For additional information, contact Laverlam International Corporation.

Typical Application Rates/Acre
Diamondback moth ........................................... ¼ to 1 quart of BotaniGard ES/acre
Imported cabbage worm ................................... ¼ to 1 quart of BotaniGard ES/acre
Cabbage looper ................................................ 1 quart of BotaniGard ES/acre

Leaf-Feeding Beetles
For use against Colorado potato beetle; BotaniGard ES can be used alone or in a tank mix with Bacillus thuringiensis (vars. tenebrionis) to control Colorado potato beetle in accordance with the more restrictive of label limitations and precautions. Do not exceed label dosage rates. This product cannot be mixed with any product containing a label prohibition against such mixing. The tank mix provides control and aids in the management of resistant populations. For additional information, contact Laverlam International Corporation.

Typical Application Rates/Acre
Colorado potato beetle ......................................... ½ to 1 quart of BotaniGard ES/acre

DOSAGE RATE FOR TURF AND SOIL APPLICATIONS IN ORCHARDS AND CONTAINER ORNAMENTALS
For most soil applications, apply 2-8 fluid ounces of BotaniGard ES per 1,000 square feet. For difficult to control soil pests, especially citrus root weevil (Diaprepes abbreviatus), apply BotaniGard ES at the upper rate (8 fl. oz. of BotaniGard ES per 1,000 square feet).

Do not apply to water-saturated soil. Apply BotaniGard ES in enough water to ensure good coverage of treated area, at least one gallon of water per 1,000 square feet. Irrigate treated area after application to disperse BotaniGard ES into soil.

APPLICATION FREQUENCY
Apply BotaniGard ES at 5-10 day intervals. High insect populations, especially whitefly and aphids, may require application at 2-5 day intervals. Repeat applications for as long as pest pressure persists. There is no limit on the number of applications or total amount of BotaniGard ES which can be applied in one season.

PHYTOTOXICITY
BotaniGard ES has shown plant safety but has not been tested on all plant varieties or in all tank mixes. Use caution when making applications to open blooms, especially on varieties known to be sensitive. Test BotaniGard ES on a small number of plants to check for potential damage before applying to larger number of plants. Do not apply on polynestias after braet formation.

TANK MIX COMPATIBILITY
BotaniGard ES is physically and biologically compatible with a wide range of insecticides and spray adjuvants. It is compatible with some fungicides in tank mixtures. Fungicides may kill the spores. Do not exceed label dosage rates. Observe the most restrictive of the labeling limitations and precautions of all products used in mixtures.

Adjuvants BotaniGard ES is designed for application without additional wetting agents and spreaders. If adjuvants are needed for some other reason, contact your dealer or Laverlam International Corporation for specific instructions. Some wetting agents and spreaders kill the spores, the active ingredient in BotaniGard ES, or contribute to poor mixing and spray problems.

Compatibility With Chemical Insecticides BotaniGard ES is compatible with most chemical insecticides. However, some insecticide formulations can kill the fungal spores, the active ingredient in BotaniGard ES. If you are going to use BotaniGard ES in combination with other pesticides, contact your dealer or Laverlam International Corporation for specific information. In all cases, pesticides must be used in accordance with their labels.

Compatibility With Fungicides BotaniGard ES is compatible in tank mix with some fungicides. Contact Laverlam International or your dealer for specific instructions on using BotaniGard ES with fungicides.

MIXING AND APPLICATION FOR CORN — GROUND AND AERIAL APPLICATION
SHAKE WELL BEFORE USING. Apply BotaniGard ES using ground and/or aerial spray equipment and chemigation using overhead sprinklers. (Follow specific directions for chemigation on this label). BotaniGard ES contains emulsifiers and mixes readily in water. To mix, fill spray tank with half the desired amount of water and start agitation. Shake BotaniGard ES to suspend spores, then with agitator running, slowly add desired quantity of BotaniGard ES to spray tank. Add remainder of desired amount of water. Triple rinse empty BotaniGard ES container with water and add rinse water to spray tank. For best results, continue agitation during spraying. Do not mix more BotaniGard ES than needed for that day. Do not mix BotaniGard ES the day before application. Spores will die if left overnight or longer in the spray tank.

Contact your dealer or Laverlam International Corporation for specific instructions.

Dosage Rates for Corn
Apply 4 fluid ounces of BotaniGard ES per acre (2 ½ gallons of BotaniGard ES per 80 acres)

Application Timing for Corn
Apply to corn when plants are 12-16 inches high (V6-V8 stage). A single application is sufficient to establish bearda basiliana association with corn plants. A second application prior to second generation corn borer flight may further reduce damage from corn borers.

Ground Application for Corn
Apply with sufficient water to provide thorough coverage. Direct spray over row to obtain optimal coverage in whorl and leaf axils. The amount of water will depend on spray equipment, crop size and local conditions. Generally, a minimum of 10 gallons spray volume per acre is necessary to obtain adequate coverage.

Aerial Application for Corn
Apply with sufficient water to provide thorough coverage. Use at least 2 gallons spray volume per acre; 5-10 gallons/acre will generally improve coverage.

Contact your dealer or Laverlam International Corporation for specific instructions.

CHEMIGATION
Apply BotaniGard ES only through the following types of chemigation systems: overhead sprinkler systems including center pivot, lateral move, end tow, side (wheel) roll, traveler, big gun, solid set, or hand move; or drip (trickle and microjet) systems. Do not apply this product through any other type of irrigation system.

Apply BotaniGard ES undiluted (neat) or diluted for injection flow rate and irrigation volume. For best results, use one part water to one part BotaniGard ES. If BotaniGard ES is diluted, supply tank must be agitated to thoroughly mix BotaniGard ES in water. Add water to supply tank, start agitation, and then add BotaniGard ES. Continue supply tank agitation during chemigation cycle to maintain uniform emulsion. Supply tank agitation is not necessary if BotaniGard ES is used without dilution. Shake well to suspend spores before adding BotaniGard ES to supply tank. Use contents of supply tank within one day.

Crop injury, lack of effectiveness, or illegal pesticide residues in the crop can result from nonuniform distribution of treated water.

If you have questions about calibration, you should contact State Extension Service specialists, equipment manufacturers or other experts.

Do not connect an irrigation system (including greenhouse systems) used for pesticide application to a public water system unless the pesticide label-prescribed safety devices for public water systems are in place.
A person knowledgeable of the chemigation system and responsible for its operation, or under the supervision of the responsible person, shall shut the system down and make necessary adjustments should the need arise.

**Sprinkler Chemigation**

Use ½ to 1 quart BotaniGard ES per acre for most sprinkler chemigation applications. Apply up to 3 quarts of BotaniGard ES per acre for high insect pressure or dense foliage. For corn, apply at a rate of 4 fluid ounces of BotaniGard ES per acre.

For best results, time BotaniGard ES chemigation with the end of the irrigation water application. Time injection duration to apply BotaniGard ES in the minimum irrigation volume necessary to achieve uniform coverage immediately prior to shutting off irrigation water. Excessive irrigation during and after chemigation will wash active ingredient (spores) off foliage, reducing effectiveness.

With center pivot or other continuous move equipment, apply BotaniGard ES in ¼ to ½ inches of water per acre.

With stationary sets, wheel lines, solid sets or hand move sprinklers, apply BotaniGard ES during the last 20-30 minutes of the set.

Supply tank agitation is necessary if BotaniGard ES is diluted in water before injection into irrigation system. Tank agitation is not necessary if BotaniGard ES is used without dilution provided the product is shaken well to resuspend spores before adding the tank and those contents of tank are used the same day.

The system must contain a functional check valve, vacuum relief valve, and low pressure drain appropriately located on the irrigation pipeline to prevent water source contaminated from backflow.

The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump.

The pesticide injection pipeline must also contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.

The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops.

The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.

Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.

Do not apply when wind speed favors drift beyond the area intended for treatment.

**Drip (Trickle) and Microjet Chemigation**

Use 1½ to 3 quarts of BotaniGard ES per acre for most drip or microjet chemigation. For difficult to control pests, especially citrus root weevil (Diaprepes abbreviatus), apply BotaniGard ES at up to 8 fl. oz. of BotaniGard ES per 1,000 square feet.

Apply BotaniGard ES continuously for the duration of irrigation water application to achieve uniform distribution and penetration of active ingredient (spores) in the soil.

Supply tank agitation is necessary if BotaniGard ES is diluted in water before injection into irrigation system. Supply tank agitation is not necessary if BotaniGard ES is used without dilution provided the product is shaken well to resuspend spores before adding to the supply tank and that contents of supply tank are used the same day.

The system must contain a function check valve, vacuum relief valve and low pressure drain appropriately located on the irrigation pipeline to prevent water source contamination from backflow.

The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump.

The pesticide injection pipeline must also contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.

The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops.

The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.

Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.

Do not apply when wind speed favors drift beyond the area intended for treatment.

Supply tank agitation is necessary if BotaniGard ES is diluted in water before injection into irrigation system. Spray tank agitation is not necessary if BotaniGard ES is used without dilution provided the product is resuspended before adding to the other spray tank and that content of spray tank are used the same day.

For best results in foliar applications by sprinkler, time BotaniGard ES chemigation with the end of irrigation water application. Time injection duration to apply BotaniGard ES in the minimum irrigation volume necessary to achieve uniform coverage immediately prior to shutting off irrigation water. Excessive overhead irrigation during and after chemigation will wash active ingredient (spores) off foliage, reducing effectiveness.

For best results in soil applications by drip trickle, apply BotaniGard ES continuously for the duration of irrigation water application. Apply sufficient volume of water to carry BotaniGard ES into proximity of the target pests.

**Spray drift labeling**

The Agency has been working with the Spray Drift Task Force (made up of U.S. pesticide registrants), EPA Regional Offices, and State Lead Agencies for pesticide regulation to develop the best spray drift management practices. The Agency is now requiring the interim measures specified below for all products that can be applied by aircraft. Actions taken to reduce spray drift will help mitigate contamination of surface water, reduce risk to estuarine species, and reduce harm...
to nontarget crops and plants. The interim Spray Drift Labeling Requirements for aerial application are as follows:

**Spray Drift for Aerial Application**

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment-and-weather-related factors determines the potential for spray drift. The applicator and the grower are responsible for considering all these factors when making decisions. The following drift management requirements must be followed to avoid off-target drift movement from aerial applications to agricultural field crops. These requirements do not apply to forestry applications, public health uses or to applications using dry formulations.

1. The distance of the outer most nozzles on the boom must not exceed \( \frac{1}{2} \) the length of the wingspan or rotor.
2. Nozzles must always point backward parallel with the air stream and never be pointed downwards more than 45 degrees.

Where states have more stringent regulations, they should be observed. The applicator should be familiar with and take into account the information covered in the *Aerial Drift Reduction Advisory Information*.

**Information on Droplet Size**

The most effective way to reduce drift potential is to apply large droplets. The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control. Applying larger droplets reduces drift potential, but will not prevent drift if applications are made improperly, or under unfavorable environmental conditions (see Wind, Temperature and Humidity, and Temperature Inversions).

**Controlling Droplet Size**

- **Volume**: Use high flow rate nozzles to apply the highest practical spray volume.
- **Nozzles**: Use nozzles that produce large enough droplets.
- **Pressure**: Do not exceed the nozzle manufacturer's recommended pressures. For many nozzle types lower pressure produces larger droplets. When higher flow rates are needed, use higher flow rate nozzles instead of increasing pressure.
- **Number of Nozzles**: Use the minimum number of nozzles that provide uniform coverage.
- **Nozzle Orientation**: Orienting nozzles so that the spray is released parallel to the airstream produces larger droplets than other orientations and is the recommended practice. Significant deflection from the horizontal will reduce droplet size and increase drift potential.
- **Nozzle Type**: Use a nozzle type that is designed for the intended application. With most nozzle types, narrower spray angles produce larger droplets. Consider using low-drift nozzles. Solid stream nozzles oriented straight back produce the largest droplets and the lowest drift.

**Boom Length**

For some use patterns, reducing the effective boom length to less than \( \frac{1}{2} \) of the wingspan or rotor length may further reduce drift without reducing swath width.

**Application Height**

Applications should not be made at a height greater than 10 feet above the top of the largest plants unless a greater height is required for aircraft safety. Making applications at the lowest height that is safe reduces exposure of droplets to evaporation and wind.

**Swath Adjustment**

When applications are made with a cross-wind, the swath will be displaced downwind. Therefore, on the up and downwind edges of the field, the applicator must compensate for this displacement by adjusting the path of the aircraft upwind. Swath adjustment distance should increase, with increasing drift potential (higher wind, smaller drops, etc.).

**Wind**

Drift potential is lowest between wind speeds of 2-10 mph. However, many factors, including droplet size and equipment type determine drift potential at any given speed. Application should be avoided below 2 mph due to variable wind direction and high inversion potential. **NOTE**: Local terrain can influence wind patterns. Every applicator should be familiar with local wind patterns and how they affect drift.

**Temperature and Humidity**

When making applications in low relative humidity, set up equipment to produce larger droplets to compensate for evaporation. Droplet evaporation is most severe when conditions are both hot and dry.

**Temperature Inversions**

Applications should not occur during a temperature inversion because drift potential is high. Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions. Temperature inversions are characterized by increasing temperatures with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upwards and rapidly dissipates indicates good vertical air mixing.

**Sensitive Areas**

The pesticide should only be applied when the potential for drift to adjacent sensitive areas (e.g. residential areas, bodies of water, known habitat for threatened or endangered species, nontarget crops) is minimal (e.g. when wind is blowing away from the sensitive areas).

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**STORAGE AND DISPOSAL**

Do not contaminate water, food, or feed by storage and disposal.

**PESTICIDE STORAGE**

Store in a cool, dry place. Avoid storage below freezing temperatures or above 85°F. BotaniGard ES stability decreases with time at elevated temperatures above 85°F. Tightly reclose the container of unused product. Do not contaminate unused product with water.

**PESTICIDE DISPOSAL**

To avoid wastes, use all material in this container by application according to label directions. If wastes cannot be avoided, offer remaining product to a waste disposal facility or pesticide disposal program (often such programs are run by state or local governments or by industry).

**CONTAINER DISPOSAL**

Nonrefillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container \( \frac{1}{4} \) full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration. Do not burn, unless allowed by state and local ordinances.

**WARRANTY AND DISCLAIMER**

BotaniGard ES conforms to the description set forth on this label and is reasonably fit for the purposes described herein when used according to the label directions and specified conditions. The manufacturer disclaims any and all other express or implied warranties of merchantability and fitness for particular purpose. Buyers and users shall assume all risk and responsibility for potential loss or damage if this product is used, stored, handled or applied in a manner inconsistent with this labeling. To the extent permitted by law, manufacturer shall not be liable for more than the purchase price for the quantity involved including incidental, consequential or special damages.
Molt-X®

BOTANICALLY BASED INSECTICIDE / NEMATICIDE

For Agricultural and Commercial use, Greenhouse, Shadehouse, Interiorscape and Nursery use on outdoor food crops, indoor plants, turfgrass, outdoor shrubs, trees and ornamentals.

For controlling and repelling insects such as aphids, armyworms, beetles, budworms, cutworms, fungus gnats, leafhoppers, leafminers, leafrollers, lepidopterous larvae, loopers, sawflies, thrips, webworms, and whiteflies; and plant parasitic nematodes such as dagger, golden, and root knot nematodes.

ACTIVE INGREDIENT: Azadirachtin………………………………………………………………………....3.00%

INERT INGREDIENTS: ……………………………………………………………………...97.00%

TOTAL:………………….………………………………………...………………………………………100.00%

Contains 0.28 lb (128 grams) of azadirachtin per gallon

KEEP OUT OF REACH OF CHILDREN

CAUTION

BioWorks, Inc. EPA Reg. No: 68539-11
100 Rawson Rd, Suite 205 EPA Est. No. 68539–NY-001
Victor, NY 14564 • 800-877-9443

FIRST AID

IF ON SKIN OR CLOTHING: • Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.

IF IN EYES: • Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or Doctor, or going for treatment. You may also contact 1-800-222-1222 for emergency medical treatment information.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION: Harmful if absorbed through skin. Avoid contact with skin, eyes, or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum or using tobacco. Remove contaminated clothing and wash clothing before use.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Applicators and other handlers must wear:
• Long-sleeved shirt and long pants
• Waterproof gloves
• Socks and shoes.

Follow manufacturer’s instructions for cleaning/maintaining PPE. If no such instructions for use on washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

USER SAFETY RECOMMENDATIONS

Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet. Users should remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

ENVIRONMENTAL HAZARDS

This pesticide is toxic to fish and aquatic invertebrates. Terrestrial uses: do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not apply when weather conditions favor drift from treated areas. Runoff from treated areas may be hazardous to aquatic organisms in neighboring areas. Do not contaminate water when disposing of equipment washwaters.

FOR THE FOLLOWING EMERGENCIES, PHONE 24 HOURS A DAY:
Transportation: CHEMTREC 1-800-424-9300

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

Do not apply this product through any irrigation system unless the chemigation instructions on this label are followed. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your state or tribe, consult the agency responsible for pesticide regulation.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment and restricted entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard (WPS).

Do not enter or allow entry into treated areas during the restricted entry interval (REI) of 4 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water is:
• Long-sleeved shirt and long pants
• Water proof gloves
• Socks and shoes

NON-AGRICULTURAL USE REQUIREMENTS

These requirements apply to uses of this product that are NOT within the WPS for agricultural pestcides (40 CFR part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses. For other uses including golf courses and other non-agricultural uses, do not enter treated areas without protective clothing until sprays have dried.

PRODUCT DESCRIPTION

Molt-X is an emulsifiable concentrate containing 3.0% by weight azadirachtin. It has been evaluated on a wide variety of ornamental, forestry, and food crops. No phytotoxicity at directed field rates has been observed. Molt-X is an insect growth regulator and does not control adult insects. However, Molt-X is also effective as a repellent towards some adult species, as detailed below.

MODE OF ACTION

Molt-X controls insects in the larval, pupal, and nymphal stages by interfering with the metabolism of ecdysone. Insects typically die between larval to larval, larval to pupal, nymph to nymph molts, or during adult eclosion.

COMPATIBILITY

Molt-X has been found to be compatible with the most commonly used insecticides, fungicides and fertilizers. Check compatibility by using the correct proportion of the products in a small test container. Growers should then test the tank-mix combinations for possible adverse effects (such as settling out, flocculation, etc.) and for phytotoxic effects on a small sample of plants prior to use. As environmental conditions can alter the interactions between compounds, a compatibility test is recommend for both new and previously used combinations. Avoid mixtures of several materials and very concentrated sprays and mixtures.

Use caution when making Molt-X applications to open blooms, especially on varieties known to be sensitive. Test a small group of plants for effects on open blooms before making a large scale application.

Do not use Molt-X with Bordeaux mixture, triphenyltin hydroxide, lime sulfur, Rayplex iron or other highly alkaline materials. Use mildly alkaline mixtures immediately after mixing to prevent loss of insecticidal activity.

When using Molt-X in combination with other products, use Molt-X at the rate, or half the rate, specified in the Use Rate Recommendation table. Follow the directions for use, precautions and limitations for use on all of the product labels used in the combination. Some suggested tank mix combinations are as follows:

<table>
<thead>
<tr>
<th>Product Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molt-X plus non – phytotoxic crop oil*</td>
</tr>
<tr>
<td>Molt-X plus endosulfan*</td>
</tr>
<tr>
<td>Molt-X plus chlorpyrifos*</td>
</tr>
<tr>
<td>Molt-X plus acephate*</td>
</tr>
<tr>
<td>Molt-X plus Bacillus thuringiensis* (BT)</td>
</tr>
<tr>
<td>Molt-X plus pyrethrum + piperonyl butoxide (for fogging use)*</td>
</tr>
</tbody>
</table>

*Always follow the manufacturer’s Directions for Use and Precautionary Statements.

APPLICATION INSTRUCTIONS

READ ALL DIRECTIONS AND PRECAUTIONS BEFORE USE

Molt-X is exempt from tolerances and may be applied as directed to any food crop up to and including the day of harvest at a rate not exceeding 22.5 fl oz (20 grams active ingredient) per acre per application.

MIXING: Shake well before mixing. Always use this product promptly after mixing with water. Molt-X will break down in the spray solution if not used within 8 hours. Never allow tank mix to stand overnight. Molt-X will break down in spray tank mixtures that have pH values exceeding 7.0. The recommended pH range is between 5.5 and 6.5. For optimum performance, a buffering agent may be used. When mixing with other approved agrichemicals, always ensure proper agitation in the spray tank to ensure uniform application.

Using the use tables below, determine the amount of Molt-X required for the number of acres to be treated. To a clean spray tank add at least one half the water to be sprayed. Begin agitation and add the determined amount of Molt-X. Add the remaining water and continue agitation. Molt-X disperses freely when added to water. Always use clean equipment. For uniform distribution on plant canopy and proper dilution, always ensure proper agitation in mixing tanks or vessels. When mixing with other agrichemicals, add solid constituents (such as wettable powders, water dispersible granules or microntridges) last in the form of a slurry.
### APPLICATION METHOD AND EQUIPMENT:
Apply Molt-X as a foliar spray or a drench to soil or soil-less media (e.g., greenhouses) to control insects and nematodes. When needed, soil drenches can also be used to control soil-borne pests, including soil-borne larvae of foliar insect pests. When applying as a drench, avoid excessive leaching. Molt-X can also be applied through sub-surface soil treatment equipment (e.g. turfgrass). To repel adults, apply through fogging equipment. Always follow equipment manufacturer’s use directions.

Apply Molt-X using any powered or manual pesticide application equipment, which includes but is not restricted to: high-volume, low-volume, ultra-low volume, electrostatic, fogging, and chemigation. Follow the original manufacturer’s recommendations when using these types of equipment.

For optimum results, 2 to 3 applications made at 7 to 10 day intervals is recommended, unless otherwise specified. Foliar applications should be made to both sides of leaves. In addition, a surfactant used as per the manufacturer’s directions may improve product performance. The addition of a non-phytotoxic crop oil at rates not exceeding 1.0% (volume / volume) generally enhances insect control.

### Molt-X USE RATE RECOMMENDATIONS FOR KEY PESTS BY USE SITE
Molt-X is intended for use on outdoor plants and food crops, plants grown indoors or in greenhouses, shade cloth, interiorscapes and nurseries. Use Molt-X to control any of the following insects and nematodes.

Use the tables below to determine the appropriate use rate for your site/pest combination. Rates are provided in ounces of Molt-X per area or row-length. When infestation is heavy, or when plant canopy is dense, Molt-X may be used at a rate up to twice (2X) that shown in the above table, not to exceed 22.5 oz E.C. / acre. When combining with other insecticides, use half the recommended rate of Molt-X.

### USE RATES FOR OUTDOOR PLANTS INCLUDING: FOOD CROPS, TREES, TURFGRASS, NURSERY, AND ALL OUTDOOR ORNAMENTAL PLANTS

<table>
<thead>
<tr>
<th>PEST</th>
<th>RATE ounces of Molt-X/acre</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHITEFLIES, such as: Greenhouse whiteflies, Silverleaf whiteflies, Woolly whiteflies</td>
<td>8</td>
<td>Use in combination with 0.25 – 1.0% non-phytotoxic crop oil in sufficient water to cover undersides of leaves.</td>
</tr>
<tr>
<td>LEAFMINERS, such as: Azalea leafminers, Birch leafminers, Citrus leafminers, Serpentine leafminers, Vegetable leafminers</td>
<td>10</td>
<td>Use in combination with 0.25 – 1.0% non-phytotoxic crop oil in sufficient water to cover undersides of leaves.</td>
</tr>
<tr>
<td>SCALES, such as: Brown soft scales, California red scales, Coffee scales, Olive scales, San Jose scales</td>
<td>10</td>
<td>Use in combination with 0.25 – 1.0% non-phytotoxic crop oil in sufficient water to cover twigs and leaves.</td>
</tr>
<tr>
<td>MEALY BUGS, such as: Citrus mealybugs</td>
<td>10</td>
<td>Use in combination with 0.25 – 1.0% non-phytotoxic crop oil in sufficient water to cover twigs and leaves.</td>
</tr>
<tr>
<td>THrips, such as: Citrus thrips, Onion thrips, Thrips palmi</td>
<td>10</td>
<td>Spray when pests first appear. Repeat every 5 to 7 days.</td>
</tr>
<tr>
<td>APHIDS, such as: Cotton aphids, Green peach aphids, Pea aphids, Potato aphids</td>
<td>10</td>
<td>Spray when pests first appear. For food crops: Repeat application after 7-10 days. Use in combination with 0.25 – 1.0% non-phytotoxic crop oil in sufficient water to cover undersides of leaves. For non-food crops: Repeat application every 5 to 7 days.</td>
</tr>
<tr>
<td>PSYLLIDS, such as: Pear psylla</td>
<td>8</td>
<td>Spray when pests first appear. For food crops: Repeat application after 7-10 days. Use in combination with 0.25 – 1.0% non-phytotoxic crop oil in sufficient water to cover undersides of leaves. For non-food crops: Repeat application every 5 to 7 days.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PEST</th>
<th>RATE ounces of Molt-X/acre</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEAFHOPPERS, such as: Grape leafhoppers</td>
<td>10</td>
<td>Spray when pests first appear. For food crops: Repeat application after 7-10 days. Use in combination with 0.25 – 1.0% non-phytotoxic crop oil in sufficient water to cover undersides of leaves. For non-food crops: Repeat application every 5 to 7 days.</td>
</tr>
<tr>
<td>BUGS, such as: Boxelder bugs, Chinch bugs, Lygus bugs, Spittle bugs, Slink bugs</td>
<td>10</td>
<td>Spray nymphs early.</td>
</tr>
<tr>
<td>FLIES, such as: Blueberry maggots, Cherry maggots, Crane flies, Fruit flies, Midges, Onion maggots, Walnut husk flies</td>
<td>10</td>
<td>For food crops: Spray when pests first appear. For non-food crops: Drench soil to kill larvae.</td>
</tr>
<tr>
<td>SAWFLIES, such as: European pine sawflies, Yellow headed pine sawflies</td>
<td>10</td>
<td>Treat larvae early.</td>
</tr>
<tr>
<td>CATERPILLARS, such as: Armyworms, Artichoke plume moths, Bagworms, Bollworms, Budworms, Cabbage butterflies, Cabbage Loopers, Cankerworms, Caseworms, Corn earworms, Cutworms, Diamond-backed moths, Fruitworms, Grapeleaf skeletonizers, Gypsy moths, Hickory shuckworms, Hornworms, Imported cabbage worms, Leafperforators, Leafrollers, Melonworms, Navel Orangeworms, Oblique banded leafrollers, Omnivorous leafrollers, Oriental fruit moths, Pickleworms, Pine tip moths, Pinworms, Red-banded leaf rollers, Sod webworms, Soybean loopers, Tent caterpillars, Tobacco budworms, Tussock moths</td>
<td>8</td>
<td>Spray when pests first appear. For food crops: Repeat application after 7-10 days. Use in combination with 0.25 – 1.0% non-phytotoxic crop oil in sufficient water to cover undersides of leaves. For non-food crops: Repeat application every 5 to 7 days.</td>
</tr>
<tr>
<td>BORERS, such as: Peach twig borers, Peachtree borers, Dogwood borers, Cranberry borers</td>
<td>10</td>
<td>Spray soon after egg hatch. For food crops: Use in combination with 0.25% - 1.0% non-phytotoxic crop oil in sufficient water to cover undersides of leaves.</td>
</tr>
<tr>
<td>WEEVILS, such as: Black vine weevils, Strawberry vine weevils</td>
<td>10</td>
<td>Make foliar applications to deter adult feeding. Make at least 3 to 4 applications 10 days apart.</td>
</tr>
<tr>
<td>MOLE CRICKETS</td>
<td>10</td>
<td>Spray nymphs soon after egg hatch.</td>
</tr>
</tbody>
</table>
**PEST** | **RATE** | **REMARKS**
--- | --- | ---
Nematodes, such as: Burrowing nematodes, Dagger nematodes, Golden nematodes, Root knot nematodes | 15 | Apply in sufficient amount of water to penetrate in the soil to a depth of 12 inches. Repeat applications every 3 or 4 weeks or as needed.

*When infestation is heavy, or when plant canopy is dense, Molt-X may be used at a rate up to twice (2X) that shown in the above table, not to exceed 22.5 oz/acre. When combining with other insecticides, half the rate of Molt-X is recommended.*

**For Use Indoors or in Greenhouses**

Use the table below to determine the appropriate use rate for each pest. Foliar sprays for individual plants should thoroughly wet both sides of the leaves without causing runoff. Groups of potted plants should be sprayed at a rate of one gallon of finished spray for 500 square feet. When used as a drench apply 1 pint of finished spray for each gallon of soil in the pot.

### USE RATES FOR ANY PLANT GROWNindoORS OR IN GREENHOUSES, SHADECLOTH, INTERIORSCAPE AND NURSERIES

**PEST** | **RATE** | **REMARKS**
--- | --- | ---
WHITEFLEES, such as: Greenhouse whiteflies, Silverleaf whiteflies | 10 | Ensure good coverage to top and bottom of leaves against larvae and pupae. Can be applied after bract formation on poinsettias (test for phytotoxicity prior to large scale use).

LEAFMINERS, such as: Serpentine leafminers | 10 | Spray early. Make 2 to 3 applications in rotation with adulticides such as pyrethrins

SOFT SCALES | 10 | Use in combination with 0.5 – 1.0% non-phytotoxic crop oil in sufficient water to cover twigs and leaves.

MEALY BUGS | 8 | Always use in combination with 0.5 – 1.0% non – phytotoxic crop oil

THRIPS, such as: Western flower thrips | 8 | Spray when pests first appear. Repeat every 5 to 7 days.

APHIDS, such as: Green peach aphids, Pea aphids, Cotton aphids, Rose aphids | 8 | Spray when pests first appear. Addition of 0.5 – 1.0% non-phytotoxic crop oil will enhance efficacy.

LACE BUGS, such as: Azalea lace bugs | 8 | Spray when pests first appear.

FLIES, such as: Crane flies, Fungus gnats, Shore flies | 8 | Add at least 1 pint of mixture per gallon pot as soil drench. Repeat application every 7 days for 3 weeks. For poinsettias, lilies and bedding plants, also make 1 application 10 to 15 days prior to shipping plants to prevent adult emergence.

CATERPILLARS such as: Armyworms, Bagworms, Cutworms, Leafrollers, Loopers, Spruce budworms, Webworms | 8 | Spray when pests first appear.

**USE SITES**

Molt-X CAN BE USED ON:

**GREENHOUSE FOOD CROPS, such as:**

Brassica (cole) crops, cucurbits, eggplants, herbs and spices, legumes, peppers, tomatoes, and other miscellaneous crops grown in greenhouses.

**FOOD CROPS, including:**

Root and tuber vegetables, such as: Artichokes, beets, carrots, ginger, horseradish, potatoes, radishes, rutabagas, sweet potatoes, turmeric, turnips, yams.

Leafy vegetables (including Brassica Leafy Vegetables), such as: Amaranth, broccoli, Brussels sprouts, cabbage, cauliflower, celery, chervil, Chinese cabbage, collards, cress, endives, fennel, kale, kohlrabi, lettuce, mizuna, mustard greens, parsley, purslane, rape greens, rhubarb, spinach, Swiss chard.

Legume vegetables, such as: beans (field, kidney etc.), chickpeas, cowpeas, guar, jackbeans, lablab beans, lentils, peas, pigeon peas, soybeans, sword beans.

Fruiting vegetables, such as: Eggplants, ground cherries, pepper, peppers, pimentos, tomatillos, tomatoes.

Cucurbit vegetables, such as: bitter melons, Chayote, Chinese wax gourds, citron melons, cucumbers, gherkins, gourds, muskmelons (such as cantaloupes, casabas, craneshaw etc.), pumpkins, squash, watermelons.

Citrus fruits, such as: Calamondins, citrus citrons, citrus hybrids, grapefruits, kumquats, lemons, limes, mandarins, oranges, pummellos, Satsuma mandarins.

Pome fruits, such as: Apples, crab apples, loquats, mayhaws, oriental pears, pears, quinces.

Stone fruits, such as: Apricots, cherries, nectarines, peaches, plums, prunes.

Berries, such as: Blackberries and caneberrries, blueberries, currants, elderberries, gooseberries, huckleberries, loganberries, raspberries, strawberries, youngberries.

Cereal grains, such as: Barley, buckwheat, corn, millet, oats, popcorn, rye, rice, rye, sorghum, teosinte, triticate hybrids, wheat, wild rice.

Herbs and spices, including but not limited to: Allspice, angelica, anise, annatto, basil, balm, black and white peppers, borage, burnet, chamomile, caper buds, cardamom, caraway, casia, cassip, celery seeds, chervil, chives, cinnamon, clary, cloves, coriander (cilantro), costmary, cumin, curry leaf, dills, fennels, fenugreek, grains of paradise, horehound, hyssop, juniper berry, lavender, lemongrass, lovage, mace, marigolds, marjoram, mustard seeds, nasturtium, nutmeg, parsley, pennyroyal, poppy seeds, rosemary, rue, saffron, sage, savory, sweet bay ( bay leaf), tansy, tarragon, thyme, vanilla, wintergreen, woodruff, wormwood.

Bulb vegetables, such as: Garlic, leeks, onions, shallots

Nuts, such as: Almonds, beechnuts, Brazil nuts, butternuts, cashews, chestnuts, chinquapin, filberts, hickory nuts, lychee nuts, macadamias, pecans, pistachios, walnuts.

Oilseed crops, such as: Canola, castor, cramble, guar, jojoba, peanuts, rape, safflower, sesame, soybean, sunflower.

Tropical fruits, such as: Atemoyas, bananas, breadfruits, cherimoyas, durians, guavas, malangas, mangos, papayas, passionfruits, starfruits.

Miscellaneous food and non-food crops, such as: Asparagus, avocados, birdseed, cacao, coffee, edible flowers, feijoas, figs, ginger, grapes, guayule, hops, kiwis, okras, olives, palms, papayas, pawpaws, persimmons, pineapples, rambutans, sugarcan, tamarillos, tea, tobacco, waterchestnuts, watercress.

**PEST** | **RATE** | **REMARKS**
--- | --- | ---
BORERS, such as: Peachtree borers | 10 | Spray when pests first appear. Repeat as needed.

BEETLES, such as: Bark beetles, Flea beetles, Japanese beetles | 10 | Spray when pests first appear. Repeat as needed.

WEEVILS, such as: Black vine weevils, strawberry vine weevils | 8 | Make foliar applications to deter adult feeding. Drench soil at a rate of 1 pint per gallon pot during spring and fall periods to control larvae. Make at least 3 to 4 applications 10 days apart.

Nematodes, such as: Burrowing nematodes, Dagger nematodes, Golden nematodes, Root knot nematodes | 8 | Drench at least 1 pint of mixture per gallon pot once a week for 4 weeks. Avoid leaching – drench until moist to the touch. For heavy infestations, use twice the rate and drench more frequently.
PESTICIDE INJECTION SYSTEM

CHEMIGATION OF Molt-X

General Information
This product may be applied only through drip (trickle) or sprinkler (center pivot, lateral move, end tow, side roll, traveler, big gun, solid set, or hand move), flood (basin) irrigation systems. Do not apply this product through any other type of irrigation system.

CROP injury, lack of effectiveness, or illegal pesticide residues in the crop can result from non-uniform distribution of treated water. If you have questions about calibration, you should contact State Extension Service Specialists, equipment manufacturers, or other experts. Do not contaminate irrigation systems (including greenhouse systems) used for pesticide application to a public water system unless the pesticide labeled-prescribed safety devices for public water systems are in place. A person knowledgeable of the chemigation system and responsible for its operation or under the supervision of the responsible person, shall shut the system down and make necessary adjustments should the need arise.

Dilute Molt-X with water before introduction into the system; use the diluted mixture within 8 hours. Do not apply in irrigation water if the pH exceeds 7.0. The optimum pH for application is a range of 5.5 to 6.5. If needed, the pH of the irrigation water can be adjusted by use of a suitable buffering agent. Agitation is necessary. Apply at the rate recommended in the Directions for Use using sufficient water to achieve an even distribution within an 8 hour period. Do not apply Molt-X at a rate that exceeds 20 grams active ingredient per acre (22.5 fl oz of Molt-X). If applying Molt-X in combination with other products refer to the compatibility statement in the USE PRECAUTION section.

STORAGE AND DISPOSAL

GENERAL: Do not contaminate water, food or feed by storage or disposal. If a chemical enters water, use a water treatment system or contain the chemical on-site until it can be disposed of properly. Disposal of this product must comply with federal, state, and local laws and regulations. Intentional misuse of the product may cause severe injury or death. Do not use this product in a manner not contained in this label. Consult your local agricultural or extension service for disposal instructions in your area.

STORAGE: Store in cool, dry place. Do not store this product above 100 degrees F or below 20 degrees F for extended periods of time. Keep containers tightly closed and in original containers when not in use.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Non-Refillable Container. Triple rinse (or equivalent). Empty the remaining contents into application equipment or a mix tank. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or incinerate, or, if allowed by State and local authorities, by eg, if burned, stay out of smoke.

CONDITIONS OF SALE

NOTICE TO BUYER AND SELLER: Seller warrants that this product conforms to the description on the label and is reasonably fit for the purposes stated on the label when used and stored in accordance with directions under normal conditions of use. This warranty does not extend to use of this product contrary to label directions or under conditions not reasonably foreseeable by the Seller, and Buyer and User assume the risk of any such use. Seller disclaims all other warranties express or implied, including any warranty of fitness or merchantability. To the extent permitted by state law, Seller shall not be liable for consequential, special or indirect damages resulting from use or handling of this product and Seller’s sole liability and Buyer’s and User’s exclusive remedy shall be limited to refund of the purchase price. This product is sold only for uses stated on its label. No express or implied license is granted to use or sell this product under any patent in any country except as specified.

STATEMENTS CONCERNING THE OPERATION OF SPRINKLER CHEMIGATION: Drip (Trickle): UTILIZING A PRESSURIZED WATER AND PESTICIDE INJECTION SYSTEM

The system must contain a functional check valve, vacuum relief valve and low pressure drain tube, appropriately located on the irrigation pipeline to prevent water source contamination from back flow. The pesticide injection pipeline must contain a functional, automatic, quick – closing check valve to prevent the flow of fluid back toward the injection pump. The pesticide injection pipeline must contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down. The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops. The injection line or water pump must include a functional pressure switch that will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected. Systems must use a metering pump, such as a positive displacement injection pump (e.g. diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.

Do not apply when wind speeds favor drift beyond the area intended for treatment.

STATEMENTS CONCERNING THE OPERATION OF FLOOD (BASIN) IRRIGATION UTILIZING GRAVITY FLOW OR PRESSURIZED WATER AND PESTICIDE INJECTION SYSTEM

Systems using a gravity flow pesticide dispensing system must meter the pesticide into the water at the head of the field and downstream of a hydraulic discontinuity such as a drop structure or weir box to decrease potential for water source contamination from back flow if water flow stops.

Systems utilizing a pressurized water and pesticide injection system must meet the following requirements.

a. The system must contain a functional interlocking check valve, vacuum relief valve, and low pressure drain valve appropriately located on the irrigation line to prevent water source contamination from back flow.

b. The pesticide injection pipeline must contain a functional, automatic, quick closing check valve to prevent the flow of the fluid back toward the injection pump.

c. The pesticide injection pipeline must also contain a functional, normally closed, solenoid-operated valve located on the intake side to the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.

d. The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops.

e. The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.

f. Systems must use a metering pump, such as a positive displacement injection pump (e.g. diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS
CAUTION: Harmful if absorbed through skin. Avoid contact with eyes, skin, or clothing. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

PERSONAL PROTECTIVE EQUIPMENT (PPE)
Some materials that are chemical-resistant to this product are barrier laminate, nitrile rubber, neoprene rubber or viton. If you want more options, follow the instructions for category (G) on the EPA chemical resistance category selection chart.

Mixers, loaders, applicators, flaggers, and other handlers must wear:
• long-sleeve shirt and long pants
• chemical-resistant gloves made of Barrier Laminate or Viton, and
• shoes plus socks.

Follow manufacturer’s instructions for clean/maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry. Discard clothing and other absorbent material that have been drenched or heavily contaminated with the product’s concentrate. Do not reuse them.

ENGINEERING CONTROLS: Pilots must use an enclosed cockpit that meets the requirements listed in the WPS for agricultural pesticides [40 CFR 170.240(d)(6)].

ENVIRONMENTAL HAZARDS
Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwater or rinsate. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas.

Apply this product only as specified on the label.

DIRECTIONS FOR USE
It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

This product may be used on tree crops, vegetables (row crop and field crop), greenhouse vegetables, small fruits, shade trees, shrubs, ornamentals, flower and foliage plants, Christmas trees, and greenhouse ornaments.

Do not apply this product through any type of irrigation system (i.e., via chemigation).
AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural works on farms, forest, nurseries, and greenhouses and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted entry intervals. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow entry into treated areas during the restricted entry interval (REI) of 4 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is: coveralls, chemical resistant gloves made of any water proof material and shoes plus socks.

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are not within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries and greenhouses.

Do not enter or allow others to enter until sprays have dried.

PRODUCT INFORMATION

This insecticide’s mode of action is through suffocation of eggs, larvae and nymphs of insects and mites and adults of soft-bodied insects. This mode of action necessitates total spray coverage. As a fungicide this product interferes with the attachment of the pathogen to the host and acts as a suffocant. Use enough spray solution to completely penetrate the leaf canopy and cover both top and bottom of all of the leaves until wet without significant runoff. Most mature trees will require 20 to 500 gallons of spray solution per acre although citrus trees may require 15 to 1000 gallons of spray solution per acre. Row crops generally require 20 to 100 gallons of spray solution per acre. Greenhouse Use – Apply at the rates of 20 to 100 gallons of spray solution per acre for control of the greenhouse pest. (Be sure to check with your equipment and local recommendations.)

This product may be used to control mite and insect pests in the egg stage, including: spider mites, eriophyid mites, armored scale, soft scale, mealybugs, psyllids, whiteflies, aphids, leafrollers, leaftiers, webworms, cankerworms, plant bugs, leaffoppers and adelgids. This product will kill other immature insect forms if the spray covers the insect. See APPLICATION RATES tables for species claimed to be controlled on specific types of plants. Use this product only on the types of plants identified in the APPLICATIONS RATES tables.

USE PRECAUTIONS AND RESTRICTIONS — All horticultural oils interfere with or slow plant transpiration and respiration during periods of evaporation. DO NOT apply during periods of drought or when plants exhibit moisture stress.

SPRAY DRIFT MANAGEMENT

A variety of factors including weather conditions (e.g., wind direction, wind speed, temperature, and relative humidity) and method of application (e.g., ground, aerial, and airblast) can influence pesticide drift. The applicator and grower must evaluate all factors and make appropriate adjustments when applying this product.

WIND SPEED: Do not apply at wind speeds greater than 15 mph at the application site.

TEMPERATURE INVERSIONS: If applying at wind speeds less than 3 mph, the applicator must determine if a) conditions of temperature inversion exist, or b) stable atmospheric conditions exist at or below nozzle height. Do not make applications into areas of temperature inversions.

DROPLET SIZE: Apply as a medium or coarser spray (ASABE standard 572), and the minimum volume mean diameter (VMD) for spinning atomizer nozzles.

GROUND-BASED APPLICATIONS: Apply using a nozzle height of no more than 4 feet above the ground or crop canopy. Do not apply at wind speeds greater than 15 mph at the application site. Apply as a medium or coarser spray (ASABE standard 572), and the minimum volume mean diameter (VMD) for spinning atomizer nozzles.

AIRBLAST APPLICATIONS: For airblast applications, turn off outward pointing nozzles at row ends and when spraying outer row. To minimize spray loss over the top in orchard applications, spray must be directed into the canopy.

AERIAL APPLICATIONS OF AGRICULTURAL PRODUCTS: Do not release spray at a height greater than 10 feet above the ground, top of crops, or above the orchard canopy. Apply as a medium or coarser spray (ASABE standard 572), and the minimum volume mean diameter (VMD) for spinning atomizer nozzles.

Boom Length: The boom length must not exceed 75% of the wingspan or 90% of the rotor blade diameter.

Swath Adjustment: When applications are made with a cross-wind, the swath will be displaced downhill. The applicator must compensate for this displacement at the downwind edge of the application area by adjusting the path of the aircraft upward. Leave at least one swath unsprayed at the downwind edge of the treated field.

COMPATIBILITY — SuffOil·x is compatible with most commonly used insecticides and fungicides. Read and follow all precautions and limitations on labeling of all products used in tank mixtures. DO NOT use in combination with or immediately before or after spraying with fungicides such as captan, folpet, oxythiquinox (Morestan) or any product containing sulfur. Also do not use with Carbaryl (Sevin) or dimethoate (Cygon). Do not use with any product whose label recommends the use of no oils. Do not use in combination with NPK foliar fertilizer applications.

TIMING THE TREATMENT — You must determine the precise timing to fit local growth and climatic conditions. This product can be applied up to day of harvest.

MIXING DIRECTIONS — Add sufficient water to the mixing tank to allow proper agitation. Add the correct amount of SuffOil·x to tank. Maintain agitation until solution is used. If other pesticides are to be added, do so after SuffOil·x has been thoroughly mixed.

APPLICATION INSTRUCTIONS

Use enough spray solution to completely penetrate the leaf canopy and cover both top and bottom of all leaves until wet without significant runoff. Most mature trees will require 20 to 500 gallons of spray solution per acre, although citrus trees may require 15 to 1000 gallons of spray solution per acre. Row crops generally require 20 to 100 gallons of spray solution per acre. (Be sure to check with the instructions for the equipment used and with local Agricultural Extension agents.) Aerial application – Apply a minimum of 20 gallons of spray solution per acre.

MIXING DIRECTIONS — Add sufficient water to the mixing tank to allow proper agitation. Add the correct amount of this product to tank. Maintain agitation until solution is used. If other pesticides are to be added, do so after this product has been thoroughly mixed.
## APPLICATION RATES

### TREE CROPS

<table>
<thead>
<tr>
<th>CROP</th>
<th>PEST</th>
<th>APPLICATION RATE</th>
<th>TIME OF APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almond, Apricot, Cherry, Plum, Prune</td>
<td>Aphids, Fruit Tree Leaf Roller, Mites, Scales, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Apple (all varieties)</td>
<td>Aphids, Bugs (including Apple Red Bug), Fruit Tree Leaf Roller, Mites (including European Red Mite), Powdery Mildew, Scales (Hard, Soft, Scurfy), Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Avocado, Banana, Cocoa, Coffee, Macadamia, Papaya</td>
<td>Bugs, Leafhoppers, Scales, Sigatoka, Leafroller, Thrips</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Citrus*</td>
<td>Blackfly, Greasy Spot, Mites, Scales (Glover, Chaff, Purple, Yellow, Red, Snow, Brown and California), Sooty Mold, Whiteflies</td>
<td>1-2</td>
<td>Fall Early Winter Post-bloom March-April</td>
</tr>
<tr>
<td>Hops</td>
<td>Aphids, Leaf Roller, Mites, Powdery Mildew, Scales, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Nectarines, Peach, Pecan</td>
<td>Aphids, Fruit Tree Leaf Roller, Mites, Scales, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Pear (all varieties)</td>
<td>Aphids, Fruit Tree Leaf Roller, Mites (including Pear leaf Blister Mite), Pear Psylla, Powdery Mildew, Scales, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Pineapple</td>
<td>Aphids, Mealybugs, Mites, Scales</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Fig, Kiwi, Olive, Pistachio, Walnut**</td>
<td>Aphids, Mites, Scales</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
</tbody>
</table>

* Citrus — Oils applied after October may increase cold damage to trees; applied in August and September may affect solids content, retard color. ** DO NOT exceed a maximum of 159 pounds of active ingredient (in a maximum volume of 1500 gallons of spray mix per acre) when treating citrus in Florida and Texas. ** DO NOT exceed a maximum of 212 pounds of active ingredient (in a maximum volume of 2000 gallons of spray mix per acre) when treating citrus in California. ** Walnut — Apply late spring to mid-summer only. Do not apply after husk split.

### VEGETABLES (ROW CROP AND FIELD CROP)

<table>
<thead>
<tr>
<th>CROP</th>
<th>PEST</th>
<th>APPLICATION RATE</th>
<th>TIME OF APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asparagus, Pepper, Bean, Pumpkin, Cucumber Radish, Eggplant, Squash, Melon, Tomato, Peanut</td>
<td>Aphids, Beetle larvae, Leafhoppers, Leaf Miners, Mites, Powdery Mildew, Thrips, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Cabbage, Cauliflower, Celery, Cole Crops, Lettuce, Onion</td>
<td>Aphids, Leafhopper, Leaf Miners, Loopers, Mites, Plant Bugs, Thrips, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Corn (Sweet, Field, Seed), Popcorn, Sugar Beet</td>
<td>Aphids, Leaf Miners, Mites, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Cotton</td>
<td>Aphids, Bollworm eggs and larvae, Leafhoppers, Loopers, Mites, Plant Bugs, Thrips, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Grasses (Grown for Seed)</td>
<td>Mites, Powdery Mildew, Rust</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Potato Sweet Potato</td>
<td>Aphids, Leaf Miners, Mites, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Tobacco</td>
<td>Leaf Miners Mites Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
</tbody>
</table>
## GREENHOUSE VEGETABLES

<table>
<thead>
<tr>
<th>CROP</th>
<th>PEST</th>
<th>APPLICATION RATE Gallons of SuffOil-X Per 100 Gallons of Water</th>
<th>TIME OF APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asparagus</td>
<td>Aphids, Beetle larvae, Leafloppers, Leaf Miners, Mites, Powdery Mildew, Thrips, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Bean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cucumber</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggplant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melon</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Peanut</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pepper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumpkin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabbage</td>
<td>Aphids, Leafhopper, Leaf Miners, Loopers, Mites, Plant Bugs, Thrips, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Cauliflower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cole Crops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn (Sweet, Field, Seed)</td>
<td>Aphids, Leaf Miners, Mites, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Popcorn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar Beet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td>Aphids, Leaf Miners, Mites, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Sweet Potato</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## SMALL FRUITS

<table>
<thead>
<tr>
<th>CROP</th>
<th>PEST</th>
<th>APPLICATION RATE Gallons of SuffOil-X Per 100 Gallons of Water</th>
<th>TIME OF APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bushberries, Caneberries, Strawberry</td>
<td>Aphids, Mites, Powdery Mildew, Rust, Sawfly, Scales, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
<tr>
<td>Grape</td>
<td>Botrytis, Leafloppers, Leaf Miners, Mealybugs, Mites, Powdery Mildew, Scales, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
</tbody>
</table>

## SHADE TREES, SHRUBS, ORNAMENTALS, FLOWER AND FOLIAGE PLANTS, CHRISTMAS TREES

<table>
<thead>
<tr>
<th>CROP</th>
<th>PEST</th>
<th>APPLICATION RATE Gallons of SuffOil-X Per 100 Gallons of Water</th>
<th>TIME OF APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conifers, Flower, Foliage and Bedding Plants, Ornamentals*, Shade Trees, Shrubs, Christmas Trees*</td>
<td>Aphids, Black Spot, Leaf Miners, Mites, Plant Bugs, Powdery Mildew, Psyllids, Rust, Sawfly, Scales, Whiteflies</td>
<td>1-2</td>
<td>As Needed</td>
</tr>
</tbody>
</table>

*ORNAMENTALS, CHRISTMAS TREES - Oil might remove the glaucous (blue) bloom from such evergreens as Colorado Blue Spruce and Koster Spruce. Use with caution and reduced dosage for summer application on Japanese Red Maple, Amur Maple and Black Walnut. Use with caution and reduced dosage for dormant application on Sugar Maple and Redbud.

GREENHOUSE ORNAMENTALS
<table>
<thead>
<tr>
<th>CROP</th>
<th>PEST</th>
<th>APPLICATION RATE</th>
<th>TIME OF APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azalea, Camellia, Carnation,</td>
<td>Aphids, Fungus Gnats, Leaf Miners, Mealy</td>
<td>Gallons of SuffOil</td>
<td>As Needed</td>
</tr>
<tr>
<td>Fuchsia, Gladiola, Hibiscus,</td>
<td>Bugs, Mites, Powdery Mildew, Rust,</td>
<td>Per 100 Gallons of Water</td>
<td></td>
</tr>
<tr>
<td>Iris, Lily, Mums, Orchids,</td>
<td>Scales, Thrips, Whiteflies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poinsettia, Rhododendron,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rose, Vines</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**STORAGE AND DISPOSAL**

Do not contaminate water, food, or feed by storage or disposal.

PESTICIDE STORAGE: Store in a cool, dry, locked area out of reach of children. Protect from excessive heat. Keep container tightly closed in storage to prevent entry of water.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

*For liquid dilutable formulations in 5 gallon or larger nonrefillable containers:*

CONTAINER HANDLING/DISPOSAL: Nonrefillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure 2 more times. Offer for recycling or reconditioning if available, or puncture and dispose of in a sanitary landfill, or by incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

*For liquid dilutable formulations in nonrefillable containers small enough to shake (i.e., with capacities equal to or less than 5 gallons):*

CONTAINER HANDLING/DISPOSAL: Nonrefillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ½ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Offer for recycling if available, or puncture and dispose of in a sanitary landfill, by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

**IMPORTANT: READ BEFORE USE**

Read the entire Directions for Use, Conditions, Disclaimer of Warranties and Limitations of Liability before using this product. If terms are not acceptable, return the unopened product container at once.

By using this product, user or buyer accepts the following Conditions, Disclaimer of Warranties and Limitations of Liability.

CONDITIONS: The Directions for Use of this product are believed to be adequate and must be followed carefully. However, it is impossible to eliminate all risks associated with the use of the product. Crop injury, ineffectiveness or other unintended consequences may result because of such factors as weather conditions, presence of other materials, or the manner of use of application, all of which are beyond the control of BioWorks, Inc. To the extent permitted by applicable law, all such risks shall be assumed by the user or buyer.

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Appendix 3. Supporting preliminary data

Initial reports for the potential of entomopathogenic fungi against this group of insects are encouraging. In 2009, we responded to reports of a large infestation of scale insects that was not responding well to chemical treatments. We evaluated 26 coffee plants heavily or moderately infested with hemispherical scale 

*Saissetia coffeae* (Walker) through pre-treatments and post treatment counts of live scales. Plants were sprayed to run off (200 ml per plant) with a relatively high dosage (10^8 spores/ml) of several mycoinsecticides and label rate horticultural oil. Plants were maintained in a greenhouse. Evaluations were made after 14 days.

Although there was some control mortality, probably due to the prior chemical treatment, our treatments significantly enhanced mortality of scale insects. We noted significant mortality of scale insects feeding along stems, areas where imidacloprid accumulation was presumably low and scales were not being killed. These results are encouraging since >80% of the scale insects were adults and improved control may be expected if applications are timed against the immature stages. The testing of lower rates and repeated applications is also needed.

Table 1. Greenhouse evaluation of fungal treatments applied against 

*Saissetia coffeae*.  

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>% Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Na</td>
<td>51.4(3.2)c</td>
</tr>
<tr>
<td>Horticultural oil</td>
<td>1.25 oz/gal</td>
<td>91.9(3.8)ab</td>
</tr>
<tr>
<td><em>Beauveria bassiana</em> GHA strain</td>
<td>10^8 spores/ml</td>
<td>90.7(2.5)b</td>
</tr>
<tr>
<td><em>Isaria fumosorosea</em></td>
<td>10^8 spores/ml</td>
<td>98.9(0.5)a</td>
</tr>
<tr>
<td><em>Metarhizium anisopliae</em> F52</td>
<td>10^8 spores/ml</td>
<td>93.0(2.2)ab</td>
</tr>
</tbody>
</table>

Data are mean (SEM) for 5 plants. Letters show differences P < 0.05 Fishers LSD).  
0.5% vol/vol Silwet applied to all treatments  
2.5% emulsifiable oil (Addit) applied to all treatments except Hort. Oil.  
* obtained from dry formulation (Bio 10/20)

A supporting publication by Castillo et al. 2011 (attached) also documents that immature CAS are susceptible to *I. fumosorosea* in the laboratory. The median lethal time at 5.4 x 10^7 blastospores/ml was only 2.1 days at 30°C and 3.3 days at 20°C. The authors suggest that fungal applications will not harm non-target species and should be used early in the season to complement (rather than antagonize) the action of various predators of scale insects. Marcelino et al. 2008 (attached) also documented natural epizootics of several fungi in populations of another armored scale, the elongate hemlock scale insect. This finding is significant since it confirms that this group of insects is susceptible to fungal diseases under natural conditions and that in addition to short term mortality, these diseases may persist in the environment and spread to new scale populations under appropriate environmental conditions.

A colony of cycad aulacaspis scale has been established at MREC. I have developed a rapid screening bioassay to compare different strains of fungi under optimum conditions.
Mortality of the Cycad Aulacaspis Scale (Hemiptera: Diaspididae) by the Entomopathogenic Fungus *Isaria fumosorosea* Wize under Laboratory Conditions

José A. Castillo, Pasco B. Avery, Ronald D. Cave, and Cecil O. Monterminy

Indian River Research and Education Center, University of Florida, Fort Pierce, Florida 34945 USA

J. Entomol. Sci. 46(3): 256-264 (July 2011)

**Abstract**

The entomopathogenic fungus *Isaria fumosorosea* Wize (PFR97 strain, Certis USA, Columbia, MD) was tested as a mortality agent of the cycad aulacaspis scale, *Aulacaspis yasumatsui* Takagi, at 2 temperatures in the laboratory. First instars of *A. yasumatsui* were treated with 1 of 4 concentrations of *I. fumosorosea* (5.4 x 10⁴, 9.9 x 10⁴, 6.4 x 10⁵, or 1.8 x 10⁵ blastospores/ml of water) or a water only control. Following treatment, insects were held at either 20 or 30°C. The highest concentration treatment resulted in the highest mean infection rate at 2 d postapplication (73 ± 4.2% at 30°C; 64 ± 3.7% at 20°C). However, there was no interaction between blastospore concentration and temperature for infection rate. The lowest mortality rate was obtained with the highest concentration of blastospores under 20°C (13 ± 3%). The LC₅₀ at 20° and 30°C were 6.1 x 10⁴ and 5.3 x 10⁵ blastospores/ml, respectively. The LT₅₀ was lower at 30°C than at 20°C for the 3 highest concentrations. The radial growth of the fungus on potato dextrose agar 2d after inoculation was 37% greater at 30°C than its radial growth at 20°C. These results indicate that *I. fumosorosea* may be a new biological control weapon for suppressing infestations of cycads by *A. yasumatsui*. This is the first report of *I. fumosorosea* being evaluated to infect an armored scale insect.

**Key Words**

invasive pest, armored scale, infection rate, molting rate, biological control, entomopathogenic fungus

The cycad aulacaspis scale, *Aulacaspis yasumatsui* Takagi (Hemiptera: Diaspididae), is a pest of cycads in many countries (Howard et al. 1999, Weissling et al. 1999, Hodgson and Martin 2001, Moore et al. 2005, Germain and Hodges 2007, Segarra-Carmona and Pérez-Padilla 2007). It was accidentally introduced into Florida (USA) from Southeast Asia and quickly spread throughout the urban landscape where it infects cycads in the genera *Cycas* (Cycadaceae), *Dioon*, *Encephalartos*, *Microcycas* (Zamiaceae), and *Stangeria* (Stangeriaceae), feeding on the aerial parts and roots of host plants (Howard et al. 1999). Infestations usually appear first on the base of the rachis, then spread on the leaf until the whole plant is infested, weakens, and dies. When the plant is completely infested with the scale insect, the undersides of leaves are covered with a white waxy layer of scales of different instars, which are difficult to clean up even when the insects are dead (European and Mediterranean Plant Protection Organization 2008).

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1 Received 07 December 2010; accepted for publication 26 February 2011.
2 Address inquiries (email: rdcafe@ufl.edu).

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The first instar is the primary dispersal stage of the cycad aulacaspis scale and moves to noninfested plants by wind or animal contact (Watson 2005). The optimal temperature for development of nymphs is 30°C; whereas, their development is severely limited at <20°C (Cave et al. 2009b). The fecundity of the cycad aulacaspis scale is not quantified yet, but it is observed to be a very prolific insect and this may be one of the reasons why its natural enemies have not provided effective control on cycads in Florida.

The cycad aulacaspis scale has had a considerable impact on the ornamental plant industry in the countries it has invaded (Watson 2005). It is an unusually difficult pest to control because it forms dense populations and moves quickly to new areas via the plant trade (Howard and Haynes 2006). The most effective method of control has been the application of fish and agricultural oils on the foliage as soon as the first instars (crawlers) begin to appear; these oils do not permit the crawlers to establish on the plant and start feeding. Continuous applications of oil for several weeks may also kill some adult females (Weissling et al. 1999). Horticultural oil must be applied at 2 or 3 wk intervals to be effective, but frequent oil treatments can result in phytotoxicity and an unsightly build-up of oil and dead scales (Hodges et al. 2003). Dinotefuran is a systemic pesticide that is water soluble and can be either drenched or applied twice a year to foliage to give excellent control (Caldwell 2005, Webb 2009). Both oil and dinotefuran are considerably detrimental to natural enemies (Smith and Cave 2006a). Two natural enemies introduced into Florida to control the scale are the parasitoid *Coccobius fulvus* (Compere and Annecke), brought from Thailand in 1998 (Howard et al. 1999), and the predatory beetle *Cybocephalus nipponicus* Endrody-Younga, introduced in 1998 but already present in the state (Smith and Cave 2006b). In addition, 16 species of predatory lady beetles (Coccinellidae) have been found on scale-infested plants in south Florida, but none have been found to suppress the populations of the cycad aulacaspis scale (Cave 2006).

No entomopathogenic fungi have been observed growing on cycad aulacaspis scale in Florida. *Isaria cinnamomea* (Petch) (= *Paecilomyces cinnamomeus*) was observed and isolated from a scale insect in Thailand (Hywel-Jones 1993, Isaka et al. 2007). The use of a commercially-available entomopathogenic fungus may be an alternative for the management of the cycad aulacaspis scale. *Isaria fumosorosea* (= *Paecilomyces fumosoroseus*) (Hypocreales: Cordycipitaceae) was demonstrated to infect first instars of *Bemisia argentifolii* (Bellows and Perrin) (Lacey et al. 1999). The fungus grows optimally between 20 and 25°C in Europe and between 25 and 28°C in the southern USA and western Asia; in monsoon climates (India), it tolerates temperatures between 32 and 35°C (Vidal et al. 1997). The objective of our study was to evaluate the potential of *I. fumosorosea* as a biological control agent of first instars of *A. yasumatsui* as noted by Cave et al. (2009a). A laboratory bioassay was performed to assess the effectiveness of 4 blastospore concentrations of a commercial strain of *I. fumosorosea* for causing mortality of first instars at 2 constant temperatures of 20 and 30°C.

**Materials and Methods**

A colony of the cycad aulacaspis scale was maintained at the Indian River Research and Education Center in Fort Pierce, FL, USA. The colony was maintained by placing uninfested cycads (*Cycas revoluta* Thunberg) next to scale-infested cycads to allow first instars to move to new plants. The colony was maintained in an environmental growth chamber at 28°C, 70 - 80% RH, and 12:12 L:D photoperiod.
A blastospore suspension of *I. fumosorosea* (PFR97® 20% WDG; Certis USA, Columbia, MD, USA) was prepared by mixing 1 g of PFR97 with 100 ml of sterile distilled water in a beaker, vortexed, and allowed to stand for 20 min until the excess of inert product precipitated. The liquid part (supernatant) of the suspension, which contained the blastospores, was decanted and used in the experiments. Four different concentrations prepared by serial dilutions of PFR97 in water were used in this study: (1) 5.4 x 10⁹; (2) 9.9 x 10⁹; (3) 6.4 x 10⁹; and (4) 1.8 x 10¹⁰ blastospores/ml. The initial solution was serially diluted by mixing 5 ml of suspension with 45 ml of sterile distilled water to reach the other 3 concentrations. The number of blastospores per ml in each suspension was confirmed by using a Neubauer hemocytometer. Each 50-ml suspension was poured into separate Nalgene® (Fisher Scientific, Suwanee, GA) spray bottles (170 ml capacity) for application on infested plants.

A factorial design experiment consisted of 5 treatments (4 concentrations of PFR97 and water only control) applied at 2 temperatures (20, 30°C). Fifty leaflets infested with the cycad aulacaspis scale were detached from different cycad plants, and 10 settled first instars were left on each leaflet after carefully removing the remaining scale stages from the leaflet. To standardize the pressure inside the spray bottles, each bottle was pumped the same number of times (30) for each fungal concentration and the control. Ten leaflets per blastospore concentration were sprayed in a laboratory fume hood by making 2 pulls on the spray bottle trigger. Ten leaflets were used as controls and were sprayed with sterile distilled water only.

Treated leaflets (5 leaflets per treatment per temperature) were placed individually inside Petri dishes (10 cm diam) containing moistened filter paper and sealed with Parafilm. Petri dishes were maintained in environmental growth chambers at 20 or 30°C, 70 - 80% RH, and 16:8 L:D photoperiod. Preliminary trials indicated that cycad leaflets placed inside Petri dishes as mentioned above would remain green for 2 wks.

All leaflets were inspected at 3, 5, 6, and 8 d following treatment application. Each leaflet was examined under a dissecting microscope, and the number of cycad aulacaspis scales alive and the number apparently dead (as evidenced by purplish discoloration and/or presence of hyphae after 3 days) were recorded. In addition, the percentage of nymphs molting from first to second instar was recorded for each leaflet. The experiment was performed twice.

The radial growth of PFR97 on potato dextrose agar (PDA) was measured under the 2 experimental temperatures to determine under high moisture conditions (~100% RH) and a constant photoperiod the effect temperature has on the growth of *I. fumosorosea*. Twenty Petri dishes with PDA were inoculated with a 0.4-ml droplet of spore suspension with a concentration of 5.4 x 10⁹ blastospores/ml. Ten Petri dishes were sealed with Parafilm and stored at 20°C and the other 10 at 30°C. The fungal radial growth rings (length and width) on the PDA were measured 4, 7, 10, 13, 15, 18, and 20 d after inoculation. This experiment was performed twice.

Mortality and molting rates 8 d after treatment application were analyzed with an analysis of variance general linear model, and means were separated by the Student-Newman-Keuls method using SAS software (SAS Institute Inc. 2004) (α = 0.05). Data were transformed from percentages to a logarithmic scale to reduce variation; non-transformed data are reported. Probit software (Finney 1971) was used to determine LC₅₀ and LT₅₀. The radial growth of PFR97 on PDA was analyzed by linear regression using SAS software. All data from the 2 repetitions of each experiment were analyzed together because there were no significant differences between the 2 replicates of the 2 experiments (P > 0.05).

**Results and Discussion**

Mortality rates by PFR97 for first-instar *A. yasumatsui* increased over time in all treatments except the control (Fig. 1), probably because of a progressive germination of the blastospores and the production of new conidia by the fungus. Mortality rates at all sampling points were highest with the concentration of 5.4 x 10⁹ blastospores/ml. At both temperatures, mortality rate with the highest concentration 8 d after treatment application was significantly higher at 20°C (F = 36.79; df = 4; P < 0.001) and 30°C (F = 37.95; df = 4; P < 0.001) than the mortality rate with 9.9 x 10⁹ blastospores/ml, which was significantly higher than the mortality rates with the next lowest concentration.

![Fig. 1. Infection rates of first-instar Aulacaspis yasumatsui by Isaria fumosorosea at 2 temperatures following application of 4 blastospore concentrations.](image-url)
at 20°C, but not at 30°C. Mortality rates with the lowest concentration were not significantly different from those of the next lowest concentration. No mortality was detected in the control treatment.

The LC$_{50}$ values were not significantly different between the 2 experimental temperatures. The LC$_{50}$ of PFR97 at 20°C was $6.1 \times 10^6$ blastospores/ml (95% fiducial limits = $4.0 \times 10^6 - 9.7 \times 10^6$). The probit equation at this temperature was $Y = -1.3 + 0.75\log_{10} B$ ($P < 0.0001$), where $Y$ is the estimated mortality rate and $B$ is concentration of blastospores/ml. The LC$_{50}$ at 30°C was $5.3 \times 10^6$ blastospores/ml (95% fiducial limits = $2.8 \times 10^6 - 11.8 \times 10^6$). The probit equation at this temperature was $Y = -0.8 + 0.44\log_{10} B$ ($P < 0.0001$).

The LT$_{50}$ at 20°C varied from 3.3 d at the highest concentration to 35.8 d at the lowest concentration (Table 1). At this temperature, the LT$_{50}$ at the highest concentration was significantly higher than the LT$_{50}$ at the next highest concentration, which was significantly higher than the LT$_{50}$ of the 2 lowest concentrations. The LT$_{50}$ at 30°C varied from 2.1 d at the highest concentration to 35.9 d at the lowest concentration (Table 1). At this temperature, the LT$_{50}$ at the highest concentration was significantly higher than the LT$_{50}$ at the next highest concentration, which was not significantly higher than the LT$_{50}$ of the 2 lowest concentrations. The LT$_{50}$ values for the highest concentration were similar between the 2 experimental temperatures.

The percentage of first instars molting to second instar decreased with increasing blastospore concentration (Table 2). However, there was an interaction between

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Blastosposes/ml</th>
<th>% molting$^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°C</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>$5.35 \times 10^7$</td>
<td>27 ± 4.2 a</td>
</tr>
<tr>
<td></td>
<td>$9.90 \times 10^6$</td>
<td>55 ± 5.0 b</td>
</tr>
<tr>
<td></td>
<td>$6.38 \times 10^6$</td>
<td>58 ± 4.7 b</td>
</tr>
<tr>
<td></td>
<td>$1.70 \times 10^5$</td>
<td>59 ± 7.7 b</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>93 ± 2.6 c</td>
</tr>
<tr>
<td>20°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$5.35 \times 10^7$</td>
<td>13 ± 3</td>
</tr>
<tr>
<td></td>
<td>$9.90 \times 10^6$</td>
<td>27 ± 7.75</td>
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<tr>
<td></td>
<td>$6.38 \times 10^6$</td>
<td>42 ± 7.9</td>
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<tr>
<td></td>
<td>$1.70 \times 10^5$</td>
<td>46 ± 10.1</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>48 ± 9.6</td>
</tr>
</tbody>
</table>

$^*$ Means with the same letters are not statistically different ($P > 0.05$, Student-Newman-Keuls). Analysis of variance detected differences among treatments at 20°C, but Student-Newman-Keuls test was unable to separate the means.
blastospore concentration and temperature. The lowest percentage of molting was obtained with the highest concentration at 20°C, but it was not significantly (F = 4.28; df = 1; P = 0.0532) different from the percentage of molting with the same concentration at 30°C. This may be due to the combination of greater mortality at the highest blastospore concentration (this study) and the suboptimal lower temperature for scale development (Cave et al. 2009b).

The radial growth of I. fumosorosea on PDA at 15 d at 20 (18.8 ± 0.2 mm) and 30°C (23.1 ± 0.7 mm) were significantly different (F = 30.99; df = 1; P < 0.0001) (Fig. 2). The following linear models show the relationship of radial growth with time after inoculation.

Linear model for 20°C: Y = 0.68089 + 1.14243X R² = 0.95
Linear model for 30°C: Y = 1.31583 + 1.45097X R² = 0.875

where:

Y = radius (mm) of fungus
X = days after inoculation

This in vitro technique theoretically indicates which temperature would allow for the fastest rate of germination and subsequent growth either on the leaf surface or on the insect cuticle. Results from this study indicate that the spermatophore phase of I. fumosorosea that grew fastest at the higher temperature in vitro also had the fastest rate of infection and death of the scale insects. Positive correlation between the optimum temperature for fungal growth in vitro and the infection rate in vivo has been reported by other researchers (Maniania and Fargues 1992, Yeo et al. 2003, Taylor and Khan 2010). Our results confirmed this hypothesis under constant laboratory conditions; however, this needs to be tested under field conditions which can vary considerably.

This is the first report of I. fumosorosea infecting an armored scale insect. Results presented here are the first evidence of I. fumosorosea as a potential biological control agent for suppressing populations of the cyad aulacaspis scale. The scale matures quickly at 30°C, but I. fumosorosea provided a high mortality rate at this temperature, which indicates that I. fumosorosea may be used under the conditions by which the scale optimally develops. If the temperature is near 20°C, the cyad aulacaspis scale has problems molting (Cave et al. 2009b), to which an application of fungus would result in fewer first instars molting to second instar. However, the pathogen’s efficacy is lower at 20°C compared with 30°C.

Because I. fumosorosea is a highly infective fungus, it may have negative effects on nontarget organisms. This suggests that the interaction between the fungus and other natural enemies of the cyad aulacaspis scale warrants further study. The interaction between predators or parasitoids and I. fumosorosea has been shown to be benign, and the fungus is compatible with beneficial organisms (Sterk et al. 1995a, b, Avery et al. 2008). If there is no antagonism between the fungus and predators and parasitoids of the cyad aulacaspis scale, the fungus may be applied to the initial stages of an infestation so as to render the pest populations more manageable for predators and parasitoids. The fungus should be applied at first-instar cyad aulacaspis scales because the waxy cover that the scale develops when it molts to second instar is likely a formidable barrier to penetration by germ tubes.

Acknowledgments

The authors thank Phyllis Hebert for providing PDA plates and her technical assistance and Instruction concerning the spraying technique and evaluation for determining the fungial radial growth of Isaria fumosorosea. We also thank Rodrigo Díaz for his assistance with the probit analysis and Bradley Smith for construction of the graphs in Fig. 1. This research was funded by a grant from the Florida Department of Agriculture and Consumer Services.

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Manilana, N. K. and J. C. Pimentel. 1992. Susceptibility of Mamestra brassicae (L.) and Spodoptera littoralis (Boisd.) (Lepidoptera: Noctuidae) larvae to the hyphomycete Paecilomyces fumosoroseus (Brown and Smith) and Nomuraea rileyi (Samson) at two temperatures. J. Appl. Entomol. 113: 518-524.


Note

Incidence of Craesus castaneae (Hymenoptera: Tenthredinidae) on Chestnut Seedlings Planted in the Daniel Boone National Forest, Kentucky1

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Key Words Craesus castaneae, American chestnut, silviculture

American chestnut [Castanea dentata (Marshall) Borkhausen, Fagales: Fagaceae] was a dominant forest tree in the eastern forests of the U.S. until it was eliminated as a canopy tree species by 2 exotic pathogens: Ink disease, a root rot caused by Phytotithora cinnamomi; and Rands (Pythiales: Pythiaceae), began to destroy chestnut populations on bottomland and poorly-drained sites in the mid-1800s, and the chestnut blight fungue [Cryptosporiata parasitica (Murrill) Barr, Diaporthales: Cytphomycetaceae] reduced the species to short-lived survivors on upland sites in the first half of the 20th Century (cf. Campbell and Schlarbaum 2002, Fading Forests II: Trading Away North America’s Heritage, Healing Stones Found., Knoxville, TN). Various organizations have used a backcross breeding approach to integrate blight resistant trees from Australian chestnut species into American chestnut in an effort to restore the species to eastern forests (Anagnostakis 1999, In Proc. 2nd Intern. Symp. Chestnut; Hebard 2001, Ecol. Restor. 19: 252 - 254), Putatively blight-resistant hybrid chestnuts became available for planting in 2008 (Clark et al. 2010, In Proc. 17th Central Hardwoods Forest Conf.). American chestnut was eliminated from eastern forests before the species’ silvics were clearly defined, leaving the silvicultural parameters important to the initial stages of restoration largely unknown. Consequently, an increasing number of studies have examined the silvicultural requirements for chestnut restoration (Anagnostakis 2007, N. J. Appl. For. 24: 317 - 318; Clark et al. 2008, Tree Planters’ Notes 53: 13 - 21; Jacobs and Severid 2004, Forest Ecol. and Manag. 191: 111 - 120; McCormant and McCarthy 2005, 1Received 29 October 2010; accepted for publication 31 January 2011.
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8The American Chestnut Foundation, Meadowview, Virginia.

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Fungi associated with a natural epizootic in *Fiorinia externa* Ferris (Hemiptera: Diaspididae) populations

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**Introduction**

Evidence of significant decline and death of eastern hemlocks [*Tsuga canadensis* (L.) Carrière] has been observed in the northeastern United States. It has been attributed in part to feeding by the elongate hemlock scale, *Fiorinia externa* Ferris (Hemiptera: Diaspididae). From 2001 to the present, a natural epizootic has been observed in populations of *F. externa*. Initially discovered at the Mianus River Gorge Preserve in Bedford, New York, the epizootic has also been detected in Pennsylvania, New Jersey and Connecticut. Understanding and assessing the identity of the pathogenic micro-organisms responsible for this natural mortality is crucial for developing biological controls for this pest.

We have isolated and taxonomically and genetically identified entomopathogens, phytopathogens and endophytic fungi associated with *F. externa*. Isolates of the following were obtained: *Colletotrichum* sp., *Lecanicillium lecanii*, *Beauveria bassiana*, *Metarhizium microspora*, *Mycosphaerella* sp. anamorph, *Nectria* sp., *Botrytis* sp., *Phialophora* sp. and *Fusarium* sp.

**Keywords**

biological control, epizootic, entomopathogenic fungi, *Tsuga canadensis*

**Abstract**

Stands of eastern hemlock [*Tsuga canadensis* (L.) Carrière] in the northeastern United States are in decline, in part from the attack of elongate hemlock scale, *Fiorinia externa* Ferris (Hemiptera: Diaspididae). From 2001 to the present, a natural epizootic has been observed in populations of *F. externa*. Initially discovered at the Mianus River Gorge Preserve in Bedford, New York, the epizootic has also been detected in Pennsylvania, New Jersey and Connecticut. Understanding and assessing the identity of the pathogenic micro-organisms responsible for this natural mortality is crucial for developing biological controls for this pest. We have isolated and taxonomically and genetically identified entomopathogens, phytopathogens and endophytic fungi associated with *F. externa*. Isolates of the following were obtained: *Colletotrichum* sp., *Lecanicillium lecanii*, *Beauveria bassiana*, *Metarhizium microspora*, *Mycosphaerella* sp. anamorph, *Nectria* sp., *Botrytis* sp., *Phialophora* sp. and *Fusarium* sp.

High parasitism rates of *F. externa* by the aphelinid parasitoid, *Encarsia citrina* Craw (*Aspidiotiphagus citrinus* Howard) (Hymenoptera: Aphelinidae) have been observed in its native region of Japan (McClure 1986), but this does not occur in the northeastern United States (McClure 1977). It is believed that the armoured test (shield) of *F. externa* most likely protects these insects from insecticides, natural enemies and adverse weather conditions (Rosen 1990).

Given the rapid decline in eastern hemlock, it is imperative that control methods are devised that are ecologically sound and cost effective. In 2001, an epizootic within populations of *F. externa* was discovered in the Mianus River Gorge Preserve in Bedford, New York, where 13–27% of sampled insects were covered by profuse sclerotic masses, which often concealed the insects’ body (McClure 2002). Forested areas with similarly infected scales have been found in several counties in New York,

To evaluate the role of epizootics in the suppression of insect pests, it is essential to determine the causal agent(s) involved in the disease process. The objective of this study was to morphologically characterize and molecularly identify the mycobiota associated with the epizootic of *F. externa*.

**Materials and Methods**

**Sampling**

Thirty-six sites were surveyed and collections of infected *F. externa* adults (i.e. with sclerotic masses or other visible signs of mycoses) were made throughout the summer seasons of 2004–2006 (June–August) in New York (nine counties), Pennsylvania (three counties), Connecticut (two counties) and New Jersey (one county) (fig. 1). Surveys were made in areas with a high percentage of eastern hemlock trees, based on land cover maps from the New York Department of Environmental Conservation, and in hemlock stands in state and county parks, camping areas, city-owned reservoirs, forest preserves, sanctuaries, historic sites and arboreta. In each eastern hemlock stand, a minimum of 100 hemlocks were randomly sampled by taking five 40-cm-long branches per tree, from which we obtained infected scales and isolate fungi. In six sites in New York and four in Pennsylvania, a sub-sample of 10 twigs from five random branches at each site were used to make a visual estimate, using a stereomicroscope, of the percentage of *F. externa* individuals on the needles of the twigs displaying evidence of fungal infection, i.e. sclerotic masses on the scale surface, abnormal pigmentation, loss of turgor or mycelium arising from the body of the insect.

**Isolation of fungi**

Scale-infested twigs were inspected under a stereomicroscope, and those with signs of mycosis were surface sterilized by dipping in a solution of 2.5% sodium hypochlorite with 0.1% Silwet L-77 for 45 s, rinsed with sterile distilled water and placed on potato dextrose agar supplemented with Penicillin (5 ml/l) and Streptomycin (12.5 ml/l). Media used for isolation of fungi also included: Sabouraud dextrose agar and yeast, Sabouraud dextrose agar supplemented with egg yolk and milk, bacto-agar with beef extract, bacto-agar with liver extract, and modified media supplemented with Schneider’s insect medium (Sigma Chemical Co., St. Louis, MO). All isolates were purified using standard dilution techniques (Schmithenner and Hilty 1962), from which monosporic lines were generated for the most commonly retrieved fungi, using a stage-mounted DC3001 micromanipulator (World Precision Instruments, Inc., Sarasota, FL).

**Molecular identification of fungi**

DNA of the most commonly isolated fungi was extracted from 1-week-old cultures of the fungi isolated from the insect pest, from sclerotia and also *F. externa* enclosed in sclerotia (table 1). The PowerSoil™ DNA kit (Mo Bio Laboratories, Inc., Carlsbad, CA) was used according to the manufacturers’ instructions with the following exceptions:
(i) samples were shaken for 5 min at 5.5 m/s to facilitate opening of the fungal cell walls using a FastPrep™ FP120 machine (Thermo Savant, Holbrook, NY); and (ii) DNA was eluted using 100 μl of diluted elution buffer (1 : 15) (Quiagen, Valencia, CA) and concentrated to 20 μl with a speed vacuum (Eppendorf Centrifuge 5415C, Vaudaux, Switzerland) prior to downstream applications. Polymerase chain reaction (PCR) was performed using Ready-To-Go RT-PCR beads (Amersham Biosciences Inc., Piscataway, NJ). The D1/D2 region of the 28S ribosomal DNA commonly used for phylogenetic analysis at the genus level and above (Hillis and Dixon 1991) was amplified with primers NL1 and NL4 (O’Donnell 1992, 1993).

The internal transcribed spacers (ITS) variable region was amplified using primers ITS1 and ITS4 (White et al. 1990) for within-species differentiation (Talhinhas et al. 2002; Afanador-Kafuri et al. 2003). The 28S ribosomal DNA gene was amplified using the following protocol: initial denaturation at 95°C for 2 min followed by 30 cycles of 95°C for 30 s, annealing at 50°C for 30 s and elongation at 72°C for 1 min. The protocol used for the amplification of the ITS region was the same as above, except that the annealing temperature was raised to 52°C. Polymerase chain reaction products were purified using the QIAquick™ PCR purification kit (Qiagen, Valencia, CA) or Centri Spin™ columns (Princeton Separation, Adelphia, NJ). DNA was stored at 4°C.

Polymerase chain reaction products were sequenced using BigDye v1 (Applied Biosystems, Foster City, CA) according to the following protocol: initial denaturation at 95°C for 3 min followed by 30 cycles of 95°C for 10 s, annealing at 50°C for 5 s, and elongation at 60°C for 2 min.

Sequencing reactions were run on a 3130xl Genetic Analyzer (Applied Biosystem, Foster City, CA). Chromatograms were examined, and contiguous sequences were generated, using Sequencher™ (Gene Codes Corporation, Ann Arbor, MI). Sequences generated from this study were compared to related sequences in GenBank® using BLAST (Altschul et al. 1990). Matches obtained from these searches were checked against our preliminary morphological identifications. Sequences obtained for this study were deposited in GenBank® (accession numbers included in table 1).

### Table 1: Pure fungal isolates recovered from Fiorinia externa

<table>
<thead>
<tr>
<th>Fungal group</th>
<th>Species/genus</th>
<th>Geographic origin</th>
<th>Year collected</th>
<th>Reference code</th>
<th>DNA extraction from</th>
<th>GenBank accession numbers</th>
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<td>Entomopathogens</td>
<td>Myriangium sp. (n = 62 isolates)</td>
<td>Bayberry Lane, NY*</td>
<td>2006</td>
<td>CEHS208</td>
<td>1. Culture</td>
<td>EF464574 EF464585</td>
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<tr>
<td></td>
<td></td>
<td>Litchfield, CT</td>
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<td>SEHS208</td>
<td>2. Sclerotia</td>
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<td></td>
<td>Litchfield, CT</td>
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<td>SINEHS208</td>
<td>3. Sclerotia + F. externa</td>
<td>EF464576 EF464587</td>
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<tr>
<td></td>
<td>Metarhiziosis microspora (n = 41 isolates)</td>
<td>Valley Forge, PA</td>
<td>2005</td>
<td>CEHS133a</td>
<td>1. Culture</td>
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<td></td>
<td></td>
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<td>2. F. externa</td>
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<td>EHS163</td>
<td>1. Culture</td>
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<tr>
<td></td>
<td>Nectria sp. (n = 1 isolate)</td>
<td>Valley Forge, PA</td>
<td>2006</td>
<td>EHS164</td>
<td>1. Culture</td>
<td>EF464570 EF464588</td>
</tr>
<tr>
<td></td>
<td>Botrytis sp. (n = 1 isolate)</td>
<td>Bayberry Lane, NY</td>
<td>2006</td>
<td>EHS265</td>
<td>1. Culture</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Fusarium sp. (n = 1 isolate)</td>
<td>South Salem, NY</td>
<td>2006</td>
<td>EHS290</td>
<td>1. Culture</td>
<td>–</td>
</tr>
<tr>
<td>Endophyte</td>
<td>Phialophora sp. (n = 1 isolate)</td>
<td>South Salem, NY</td>
<td>2006</td>
<td>EHS291</td>
<td>1. Culture</td>
<td>EF464577 EF464590</td>
</tr>
</tbody>
</table>

*Counties: New York (Columbia, Dutchess, Kings, Orange, Putnam, Queens, Rockland, Ulster and Westchester); Pennsylvania (Bucks, Chester and Northampton); New Jersey (Passaic); Connecticut (Fairfield and Litchfield).

-Origin of samples used in DNA extraction.

–, only morphological identification was performed.
Morphological identification

Pure cultures of fungi from *F. externa* were prepared for microscopic morphological identification using the methods of Humber (1997) and contrasted with reference taxonomical guides (Carmichael et al. 1980; Samson et al. 1988; Barnett and Hunter 1998). Scales with superficial signs of mycosis were also prepared for morphological identification of fungal propagules using scotch tape impressions according to the method of Gouli et al. (2005). All fungal isolates were deposited in the entomopathogenic fungal germplasm collection at the Department of Plant and Soil Sciences, Entomology Research Laboratory, University of Vermont, Burlington, VT, USA.

Results and Discussion

In the site where the epizootic was first reported, up to 36.8% of the sampled scales were partially or completely covered with sclerotia in 2004. These sclerotia appear associated with the new generation scales and turn black after several months presenting an irregular texture (fig. 2). No evidence of fungal hyphae penetrating hemlock needles was detected. An approximate estimate of the percentage of infected scales was determined by scoring the number of individuals with sclerotic masses. Scales were scored based on the number infected on sample twigs (10 hemlock twigs/5 branches). The proportion of new generation scales with sclerotia, indicative of fungal infection varied among different sites. In the

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**Fig. 2** *Fiorinia externa* showing typical symptoms of fungal infection, and representative propagules from several entomopathogenic fungi found associated with *F. externa* in epizootic areas. (a) Scale covered with a fresh fungal sclerotium; (b) Old, weathered sclerotia covering scale adults; (c) *Myriangium* sp. hyphae (CEHS290); (d) *Beauveria bassiana* mycosis; (e) *B. bassiana* conidia (EHS143); (f) *Lecanicillium lecanii* (EHS143) mycosis; (g) *L. lecanii* conidia; (h) *Metarhizium microspora* mycosis; (i) *M. microspora* conidia (CEHS133); (j) *Colletotrichum* sp. conidia (EHS133); (k) *Fusarium* sp. macroconidia (EHS290) and (l) *Mycosphaerella* anamorph sp. conidia (EHS201). Bars: a, b, d, f, h = 0.5 mm; e, g, i = 40 μm; j, k, i, c = 25 μm.
sites sampled within New York, the percentage of infected scales were found to be 2% in Esopus, 10.9% in Ward Pound Ridge Reservation, 15% in Bedford, 36.8% in the Mianus River Gorge, 42% in Mohonk and 61.8% in South Salem. In Pennsylvania, the percentage of infected scales on sampled twigs was 0.8% in Jacobsburg Park, 4.8% in Valley Forge, 5.5% in Bowman’s Hill Wild Flower Preserve and 27.6% in the Ralph Stover State Park. The disparity in the rates of infection may be due to the dispersal pattern of the epizootic. Although we do not know whether the epizootic began from a single or multiple points, we observed a trend of higher rates of infection in localities close to the initially reported site of the Mianus River Gorge (fig. 1). Infections appear to attenuate with distance from this locality. A variety of fungi were cultured and microscopic observations of conidia, conidiophores, mycelium and appressoria were made. Molecular analysis using the 28S and ITS sequences facilitated the identification of the genera of the fungi. In many cases, molecular analyses confirmed morphological identifications. A total of 180 pure fungal cultures were obtained from infected F. externa adults, comprising four entomopathogens, five phytopathogens and one endophytic species. Myriangium sp. was molecularly identified with DNA extracted from a pure fungal culture and also from single sclerotia, with no insect body parts, as well as sclerotia with enclosed mummified F. externa. Using DNA extracted from both a pure fungal culture and F. externa adults with signs of mycosis, we also molecularly identified a fungus closely related to the genus Cordyceps. This fungus was concurrently identified in F. externa by Li et al. (2008), who erected a new genus Metarhiziosps to accommodate the new species Metarhiziosps microspora Li, Cowles and Vossbrinck gen. et sp. nov. For all other fungi identified molecularly, DNA was obtained from pure fungal cultures. A total of 20 molecular identifications were obtained from F. externa with signs or symptoms of disease (table 1).

**Entomopathic fungi**

A total of 121 fungal isolates known as entomopathogenic species were collected comprising 16 isolates of Beauveria bassiana, two Lecanicillium lecanii, 41 M. microspora and 62 isolates of Myriangium sp.

The entomopathogenic isolates identified are among the most well-known and commercially available fungi. For example, B. bassiana has been reported to naturally occur in approximately 700 species of insects (Inglis et al. 2001), of which 100 are potential candidates for biological control using B. bassiana (McCoy et al. 1988). Lecanicillium lecanii has been used to control coccids, aphids and whiteflies (Feng et al. 2000). Metarhiziosps microspora belongs to a subclade within the genus Cordyceps (Li et al. 2008) known primarily as a parasite of insects (Nikoh and Fukatsu 2000), and the genus Myriangium is also known as an insect pathogen and an effective natural biocontrol agent in eradicating populations of scales (Van Epenhuijsen et al. 2000).

Myriangium sp. was the most prevalent entomopathogenic fungus isolated from F. externa. It was isolated from fresh and old weathered single sclerotia (i.e. portion of sclerotia with no insect body parts) and from sclerotia enclosing F. externa. This fungus was not recovered from all of the sample sites, which may be due to the difficulty in isolating this organism, rather than non-occurrence. Myriangium spp. are usually exclusive pathogens of scale insects and form a stromata identical to the one present in all the epizootic sites sampled (Miller 1940). Earlier studies described the presence of Myriangium spp. on scale insects in Florida but its existence in latitudes other than tropical and sub-tropical is unusual (Fisher et al. 1949). The use of Myriangium spp. for the management of scale insects has been limited due to the difficulties associated with its culture in vitro. Its host specificity makes it an optimal candidate for management of F. externa.

**Phytopathogenic and endophytic fungi**

Fifty-nine phytopathogenic isolates were recovered from F. externa: 54 isolates of Colletotrichum sp., two Botrytis sp., one Nectria sp., one Mycosphaerella sp. anamorph and one Fusarium sp. One endophytic fungal isolate of Phialophora sp. was also recovered (table 1).

Given the mode of action of phytopathogenic and endophytic fungi, it is possible that these isolations are a result of secondary infections in host insects by other pathogens that may have overtaken the immune system of the host. Colletotrichum sp., a well-known phytopathogen, was the most prevalent fungus associated with the F. externa epizootic and was present in all localities sampled. In addition, this strain was topically applied to F. externa in controlled bioassays and recovered after surface sterilization, confirming Koch’s postulates (Marcelino et al. 2008a). The above suggests that this Colletotrichum strain could have a key role in the epizootic. This genus has been widely associated with...
phytopathogenicity (Latunde-Dada 2001), not entomopathogenicity. However, *C. gloeosporioides*, has been reported to infect the scale *Orthezia praelonga* Douglas (Hemiptera: Ortheziidae) on citrus in Brazil (Cesnik and Ferraz 2000) where it is currently under development for commercialization as a myco-pesticide (R. Cesnik, pers. comm.). Because of the detrimental phytopathogenic activity of some species in the genus *Colletotrichum* (Bailey and Jeger 1992; Prusky et al. 2000; Horowitz et al. 2004; Sreenivasapurasad and Talhinhas 2005), it is critical to evaluate the agent–host–plant interactions (Sands and Van Driesche 2000), and to conduct a comprehensive assessment of its biology and genetics. A detailed molecular characterization of this strain has been conducted to further evaluate its genetics. A detailed molecular characterization of this strain has been conducted to further evaluate its genetics. A detailed molecular characterization of this strain has been conducted to further evaluate its genetics. A detailed molecular characterization of this strain has been conducted to further evaluate its genetics. A detailed molecular characterization of this strain has been conducted to further evaluate its genetics.

The fungal complex

It is possible that more than one fungal species is responsible for the epizootic occurring in *F. externa*. The virulence and infectivity of pathogens are known primary factors involved in the initiation and the development of epizootics. It is common for epizoological studies to only consider one pathogen infecting an insect population, although an insect can be affected simultaneously by multiple pathogenic species (Fuxa and Tanada 1987; Tanada and Kaya 1993). Several fungi have been implicated in the wide dissemination of mycoses of several species of scale insects in citrus orchards (Watson and Berger 1937; Fawcett 1948; McCoy 1985), especially the fungal genera *Aschersonia*, *Aegerita*, *Verticillium*, *Sphaerosisthbe*, *Podoneectria*, *Myriangium* and *Hirsutella* (Lord 2005). A complex of entomophthoralean fungi has been reported to infect other hemipteran insects (Barta and Cagan 2003). However, there are no data showing synergistic effects of pathogenic agents on mortality or spread of disease. Future research should focus on the virulence and infectivity of individual pathogens associated with *F. externa*. It is equally important to determine the combined effects of multiple infections as these may accelerate the progress of disease and the spread of this epizootic. The fungi described in this paper associated with *F. externa* may be functioning as a natural regulatory factor in populations of this pest. Enhancing the impact of this complex of fungi through augmentative techniques could help to suppress *F. externa* populations in areas where the epizootic has not reached. This control could be achieved with low production costs and minimal environmental safety concerns.

Understanding the patterns and processes of the epizootic in *F. externa* populations in the Northeast will provide opportunities for the management of this pest in the future. Moreover, a better understanding of the possible synergistic actions among the fungi identified may elucidate the aetiology of epizootics and fungal diseases in other insects. The entomopathogenic fungal species isolated from *F. externa* adults may prove to be good candidates for the management of other hemipteran pests of hemlock forests, i.e. the hemlock woolly adelgid.

Acknowledgements

We thank Lora Schwartzberg (New York State Department of Environmental Conservation) and Teri Hata (University of Vermont, Entomology Research Laboratory) for valuable help collecting specimens and for technical assistance. We also thank Drs David TeBeest (University of Arkansas) and Roberto Cesnik (EMBRAPA, Brazil) for their scientific input and insights, as well as, Drs Stefan Vidal, Christine Denys and two anonymous reviewers who provided valuable comments and suggestions. This work was funded in part through a grant awarded by the Northeastern Area State and Private Forestry, USDA Forest Service (# 04-CA-11244225286) and is in partial fulfilment of requirements for the PhD degree of J.M. at the University of Vermont.

References


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Mid-Florida Research and Education Center
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Tel. (407) 884-2034; Fax (407) 814-6186;
Email: spa@ufl.edu
http://mrec.ifas.ufl.edu/faculty/spa/spa.asp

EMPLOYMENT
Apr. 2008-present  Assistant Professor, University of Florida, Mid-Florida Research and
                Education Center, Apopka, FL 32703
2003 - 2008   Research Entomologist (Postdoctoral GS12), USDA-ARS, Yakima
                Agricultural Research Laboratory, Wapato, WA 98951
2001 - 2003   Research Associate (Postdoctoral), Department of Entomology, Texas
                A&M University, TX 77843

EDUCATION
University of London, U.K.  PhD  2000  Insect Pathology
University of Plymouth, U.K.  BSc (Hons)  1992  Rural Resource Management

RESEARCH INTERESTS
• Evaluation of insect pathogens as microbial pesticides
• IPM of arthropod pests in nurseries and landscapes
• Use of insectary reared beneficial arthropods
• Tools for conservation biological control, e.g. banker plants and HIPVs

GRADUATE STUDENTS
Chair, 1 Ph.D. Tofangsazi, Microbial control of tropical sod webworm,
Chair, 3 Masters Committees, Aristizabal, Stauderman, Moffis

CURRENT GRANTS
2014-2015  USDA-NIFA: Alternative Approaches for Economically Feasible Management of
            Chilli Thrips, an Emerging Pest for Ornamental Nursery Production
2012-2013  USDA-NIFA. Predator in first*: A novel bio-control strategy for managing thrips
            and other key pests in pepper crops

AWARDS
2012  Best Poster Award, Florida Academy of Sciences, Meeting, Miami
2006/2007  Co-nominated for USDA-ARS Technology Transfer Award Pacific West Area
2004  Fellow of the Royal Entomological Society (FRES)
RELEVANT PUBLICATIONS


December 5th, 2013

Eric R. Smith
Big Trees Plantation, Inc.
1401 SW 143rd ST
Newberry, FL
32669

To Whom it May Concern

As manager at Big Trees Plantation, Inc. I recommend and support research into cycad scale that is devastating cycads in nurseries and throughout the landscape. This pest requires continued management to prevent it from reaching high densities that can quickly spread to surrounding plants.

There are very few insecticides that are reliable against this pest and research into alternative control methods is needed. Big Trees Plantation, Inc. is willing to cooperate in this project and has already provided discounted plant materials valued at approx. $1000 for the use of Dr. Arthurs.

The findings of this research would benefit the many container nurseries in our industry selling cycads and other palms that are susceptible to infestation of armored scales.

Sincerely,

[Signature]

Eric R. Smith
Multiple FI Project: Yes

Project Title: Biopesticide management of armored scales in ornamental palms

Funding Agency: Rutgers University (IRI)

Type of Request: New

Region: New Brunswick

Category: Research

US Dept Person to discuss Application: Taryn Coy

Tel: 845-356-8608

E-mail: centralsgrants@nias.ufl.edu

PI: David @uf.edu

Check all that apply:

Yes

HUMAN SUBJECTS (IRB) ☐

ANIMAL SUBJECTS (IACUC) ☐

RESEARCH IN VITRO (DNA) ☐

Accession Number: 13/12/09/10

Date: 12/09/13

Application Status: Revert ☐

See Revert Note

Cost Sharing:

Yes ☐

No ☐

Mandatory: $ 0.00

Voluntary: $ 6,000.00

Attach the required cost share letter and agency guidelines.

Multiple PI/Co-PI Project: [ ]

PI/Co-PI Staff:

Received: [ ]

Action: [ ]

Date: [ ]

Multiple Principal Investigators: Projects involving more than one Principal Investigator (PI) must be designated as a Multiple PI Project as noted on the form. The Principal Investigator (PI) is responsible for ensuring that the project is conducted in accordance with University and Sponsor policies and procedures. The PI will also be responsible for providing any documentation to all the PIs, University Officers, and the Sponsor.

Principal Investigator Endorsement: By signing below, you agree to perform the work and manage the project in accordance with University and Sponsor policies and procedures. The Principal Investigator (PI) is responsible for ensuring that the project is conducted in accordance with University and Sponsor policies and procedures. The PI will also be responsible for providing any documentation to all the PIs, University Officers, and the Sponsor.

Investigator's Assurance Statement as Required by Federal Regulation: The Principal Investigator (PI) certifies that: (1) the information submitted is true, complete, and accurate to the best of his/her knowledge, (2) that all persons associated with the application are capable and accurate to the best of their knowledge, (3) that any false statements or fraudulent statements on the form, or in any applications or proposals submitted by the Principal Investigator (PI) to the Sponsor, and the final decision of the Sponsor, will be considered as a violation of the application.

University endorsement: This project has been reviewed by the officials whose signatures appear below and are satisfied that all policies and procedures are acceptable.

Indirect Cost Distribution: Upon receipt of USA, the Principal Investigator (PI) certifies that the indirect costs charged under the award shall be distributed. The indirect costs charged shall be based on the indirect cost formula and are based on the indirect costs collected from grants.

LIMITED REVIEW

Principal Investigator: Steven Arburans

Date: 12/9/13

Co-Principal Investigator: Natercia Principe

Date: 12/9/13

Natercia Principe

Signing Official Pre-Award Services
December 9, 2013

Michael Braverman, Ph.D.
Manager, Biopesticide and Organic Support Program
IR-4 Project, Rutgers University
500 College Road East, Suite 201W
Princeton, New Jersey 08540

Dear Dr. Braverman:

Please consider this letter an official declaration of BioWorks’ support for the proposal of Dr. Steven Arthurs, titled: *Biopesticide management of armored scales in ornamental palms*. Dr. McRoberts will be evaluating efficacy of our products BotaniGard ES, Molt-X, and SuffOil-X, which are already used by growers to control a wide variety of insect pests on other crops. Armored scale insects can be very difficult to control and growers and other end-users are looking for sustainable ways to manage these pests.

Once again, BioWorks fully supports this proposed study. We will provide any technical assistance and products needed for completing this project.

Respectfully,

Matthew S. Krause, Ph.D.
Product Development Manager
100 Rawson Road, Suite 205
Victor, NY 14564
Appendix 6—Registrant Questionnaire

Please fill out the first page of this form for each crop/biopesticide combination and send to the registrant.

Registrant please return to IR-4 Project Headquarters, Michael Braverman, Biopesticide and Organic Support Program Manager, 500 College Road East; Suite 201 W; Princeton, NJ 08540-6635, Tel: (732) 932-9575 ext. 4610, Fax: (609) 514-2612, braverman@aesop.rutgers.edu

Principal Investigator: Steven Arthurs
Address: University of Florida
          Mid-Florida Research and Education Center
          2725 Binion Road
          Apopka, FL 32703-8504
Telephone: 407.410.6947

Proposal Title: Biopesticide management of armored scales in ornamental palms

Registrant Name: BioWorks, Inc.
Address: 100 Rawson Road, Suite 205
          Victor, NY 14564

Product Name: BotaniGard ES
Active Ingredient: Beauveria bassiana Strain GHA

Trade Name: BotaniGard ES
The following section is to be completed by the Biopesticide Registrant. The PCR form is to be completed by the researcher for Early and Advanced Stage Proposals (Due Oct. 21, 2013)

1) Is this product EPA registered through BPPD? Yes   x    No
Is this use covered by your current label? Yes   ________ No  x

If this product is not yet registered with EPA, describe where you are at in collecting the toxicology data or Stage of the registration process. If this project was previously funded, describe how the registration status has changed since last year.

Is label and toxicology work currently limiting product only to non-food uses?  **NA**

2) Assuming the efficacy data are favorable, what is the likelihood that this use will be added to your label? **High**

3) Considering the use rate(s), what is considered to be the farm-level cost for the treatment in $/acre? **Estimated cost is $150 per acre per application. Number of applications will depend on environmental conditions and pest pressure.**

4) How would you rank the importance of the proposed use compared to other potential uses? **High: The availability of more effective tools and strategies for integrated management of chilli thrips and other arthropod pests is essential to organic, sustainable and conventional palm growers, alike.**

5) If you are only considered a potential registrant (do not currently own rights to the product), rank your degree of interest in this product. **High**

6) Were you involved or consulted in the development of the treatments or proposal? **Yes**

7) What financial support are you planning on providing, if any? **None – only in-kind contributions (needed product and technical support)**

Matthew S. Krause  

Name of Registrant Representative  

12.09.10  

Date  

Product Development Manager  

Title  

Other comments – Please attach a letter of support for this project by October 21, 2013
Appendix 1—Registrant Questionnaire

Please fill out the first page of this form for each crop/biopesticide combination and send to the registrant.

Registrant please return to IR-4 Project Headquarters, Michael Braverman, Biopesticide and Organic Support Program Manager, 500 College Road East; Suite 201 W; Princeton, NJ 08540-6635, Tel: (732) 932-9575 ext. 4610, Fax: (609) 514-2612, braverman@aesop.rutgers.edu

Principal Investigator: Steven Arthurs

Address:
University of Florida
Mid-Florida Research and Education Center
2725 Binion Road
Apopka, FL 32703-8504 USA

Telephone: 407-410-6947

Proposal Title: Biopesticide management of armored scales in ornamental palms

Registrant name and address:

Novozymes - Natural Industries, Inc.
12320 Cutten Rd.
Houston, TX 77066

George Stallings, PhD
Product Development
Novozymes - Natural Industries
360-216-6080 (NEW cell)
208-841-9850 (work)
gss@novozymes.com (NEW)

Product Name: NoFly™ WP Active ingredient: Isaria fumosorosea
(= Paecilomyces fumosoroseus) strain FE 9901

Trade name: NoFly™ WP
1) Is this product EPA registered through BPPD? Yes ___ No ___

Is this use covered by your current label? Yes _____ No ___ X

If this product is not yet registered with EPA, describe where you are at in collecting the toxicology data or Stage of the registration process. If this project was previously funded, describe how the registration status has changed since last year.

Is label and toxicology work currently limiting product only to non-food uses? No

2) Assuming the efficacy data are favorable, what is the likelihood that this use will be added to your label?
   Excellent

3) Considering the use rate(s), what is considered to be the farm-level cost for the treatment in $/acre?
   $15-30

4) How would you rank the importance of the proposed use compared to other potential uses?
   High

5) If you are only considered a potential registrant (do not currently own rights to the product), rank your degree of interest in this product.
   N/A

6) Were you involved or consulted in the development of the treatments or proposal?
   Yes

7) What financial support are you planning on providing, if any?
   Material and technical support

George Stallings, PhD
Name of Registrant representative ___________________________ Date __________

Director, Product Development ____________________________ Title

Other comments – Please attach a letter of support for this project by December 9, 2013
December 08, 2013

George Stallings  
Novozymes  
Product Development

Dr. Michael Braverman  
Biopesticide Manager  
IR-4 Project, Rutgers University  
Technology Centre of New Jersey  
681 U.S. Highway 1 South  
North Brunswick, New Jersey 08902-3390

Dr. Braverman,

I am writing to recommend and support Dr. Steven Arthurs, Assistant Professor of Entomology, Mid-Florida Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida, 2725 Binion Rd, Apopka, FL 32703-8504 USA; (407-884-2034 x 113) spa@ufl.edu; to pursue research, with support of the IR-4 program, towards better understanding in the management and control of armored scales on cycads. Armored scales encompass a number of scale insect pests. These are significant pests throughout the U.S., and especially on cycads in the SE U.S. and Florida.

I believe Dr. Steven Arthurs is well positioned at the University of Florida to perform research looking at managing these important insect pests.

Regional control tools are required to get a handle on managing pests such as armored scales. More importantly, utilizing and incorporating biological tools into the management programs of these pests are critical, and benefit resistance management, environmental chemical load, etc. Please give strong consideration to supporting Steven Arthurs’ project for the 2013 season.

Thank you.
Have a nice day.

George Stallings, PhD  
Novozymes, Inc.  
Product Development –Customer Solutions  
208-841-9850  cell  
360-216-6080  work  
GSS@novozymes.com