GRANDEVO® Best Practices and Pipeline Update

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Vice President, Product Development
Marrone Bio Innovations

Ag Innovations Meeting
26 March 2014
GRANDEVO®—Selective, Cross-Spectrum Protection

- Cross-spectrum insecticidal/miticidal activity
- Naturally derived from Chromobacterium subtsugae and spent fermentation media
- Complex modes of action
- Activity includes repellency, reduced fecundity, reduced egg hatch, and death via ingestion
- Doesn't interfere with most beneficial insect activity
- 4-hour REI, 0-day PHI
- MRL tolerance exempt
- NOP compliant/OMRI approved
- Field or greenhouse, ground or aerial applications

Photos courtesy of: Cabbage Looper RJ Reynolds Tobacco Company, Bugwood.org; aphid Whitney Cranshaw, CO State University, Bugwood.org; citrus leaf miner Center for Invasive Species Research, UC Riverside; pepperweevil Alton N. Sparks, Univ. of GA Boxwood.org; twospotted spider mite Clemson EDU
Fill tank with 3/4 of the desired amount of water.

Start mechanical or hydraulic agitation

Add the desired volume of GRANDEVO® to the mix tank

Continue circulation while adding the remainder of the water.

Maintain circulation while loading and spraying.

Consider mixing a pre-slurry if standard instructions are not compatible with your equipment.
GRANDEVO®—Minimal, to No Effect, on Beneficials

- Non target LR$_{50}$
  - Amblyseius califonicus – Minimal effect at labeled rates
  - Aphidius colemani – No effect at nearly 3x the high labeled rate
  - Aphidoletes aphidimyza – No effect at nearly 3x the high labeled rate
  - Cryptolaemus montrouzieri – No effect at nearly 3x the high labeled rate
  - Orius insidiosus – No effect at nearly 3x the high labeled rate
  - Parastic wasps (e.g., Diglyphus isaea) - No effect at labeled rates

- Contact local Marrone rep for complete/latest list

Photos courtesy of: Amblyseius californicus, proyecto-integrado3er-semestre.wikispaces.com; Cryptolaemus montrouzieri, Bugwood Image Database System; Aphidius colemani, http://biobee.in/
GRANDEVO®—No Adverse Effects to Honey Bees

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 8 3 2013

MEMORANDUM

SUBJECT: Review of data to support labeling statements from the label of GRANDEVO, active ingredient Chromobacterium violaceum strain F04-1 T; PC Code 016329; EPA Reg. No. 75232-102-02; DP Barcodes 472382, DP Barcodes 409022 and 409024, MRIDs 4899820, 472382, 4899820, 4899821, 427107 and 931687; MRIDs 48998201,

TO: Thais Borges, Lead Biologist Microbial Pesticides Branch Biopesticides and Pollution Prevention Division, 7511P

Jeannine Kausch, Regulatory Action Leader Microbial Pesticides Branch Biopesticides and Pollution Prevention Division, 7511P

Conclusion: ...adverse effects to honey bees were not observed in the study...
• Research shows that GRANDEVO has no adverse effects on honey bee health, survival, or brood development

• However, the majority of honey bees will avoid treated plants for the first 48 hours after GRANDEVO application

• Manage your crop’s flower biology in conjunction with the GRANDEVO application timing to maximize successful pollination when necessary
• Avoid carrier volumes and/or adjuvants alone or in combination that result in spray runoff or drip accumulation

• Use a carrier volume that balances between adequate spray coverage and spray solution concentration

• Some adjuvants have been shown to increase or decrease the effectiveness of GRANDEVO. Be sure to test before applications.

• Use of a quality surfactants is highly recommended.
GRANDEVO® and the Effect of Adjuvants on Efficacy

Cabbage Looper Bioassay Test Results

LC 50 (ppm)

Grandeo + Water Control
Grandeo + Adjuvant 1
Grandeo + Adjuvant 2
Grandeo + Adjuvant 3
Grandeo + Adjuvant 4
Grandeo + Adjuvant 5
Grandeo + Adjuvant 6
Grandeo + Adjuvant 7
Grandeo + Adjuvant 8
Grandeo + Adjuvant 9
Grandeo + Adjuvant 10
Twospotted Spider Mite in Strawberry (Tetranychus urticae)
Mean Number of Nymphs per Leaf
Biological Applied Research, Inc.
NC, 2013

- Application Timing: May 6 (A), May 13 (B), May 20 (C), May 27 (D), June 3 (E), June 10 (F).
Twospotted Spider Mite in Strawberry
(Tetranychus urticae)
Mean Number of Adult Mites per Leaf
Biological Applied Research, Inc.
NC, 2013

- Application Timing: May 6 (A), May 13 (B), May 20 (C), May 27 (D), June 3 (E), June 10 (F).
Twospotted Spider Mite in Strawberry

*Tetranychus urticae*

Mean Marketable Fruit Harvested (#)

Biological Applied Research, Inc.
NC, 2013

- Application Timing: May 6 (A), May 13 (B), May 20 (C), May 27 (D), June 3 (E), June 10 (F).
Twospotted Spider Mite in Strawberry
(*Tetranychus urticae*)
Mean Marketable Fruit Harvested (g)
Biological Applied Research, Inc.
NC, 2013

- Application Timing: May 6 (A), May 13 (B), May 20 (C), May 27 (D), June 3 (E), June 10 (F).
To maintain product properties, the optimal spray solution pH is between 7 and 8.
Effect of Water Hardness on GRANDEVO®

- Lab bioassays have shown that adding AMS (ammonium sulfate) at levels of 1-2% (w/w) or 8.5 to 17 pounds per 100 gallons of water helps maintain repellency in presence of hard water.

<table>
<thead>
<tr>
<th>Water Condition</th>
<th>Grandevo</th>
<th>% AMS</th>
<th>Aphid Count/Treated Leaf Disk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dionized</td>
<td>No</td>
<td>0</td>
<td>21.3</td>
</tr>
<tr>
<td>300 ppm hardenss</td>
<td>No</td>
<td>1</td>
<td>12.7</td>
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<tr>
<td>300 ppm hardenss</td>
<td>No</td>
<td>2</td>
<td>4.7</td>
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<tr>
<td>300 ppm hardenss</td>
<td>Yes</td>
<td>0</td>
<td>2.7</td>
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<tr>
<td>300 ppm hardenss</td>
<td>Yes</td>
<td>1</td>
<td>2.0</td>
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<tr>
<td>300 ppm hardenss</td>
<td>Yes</td>
<td>1.5</td>
<td>0.7</td>
</tr>
<tr>
<td>300 ppm hardenss</td>
<td>Yes</td>
<td>2</td>
<td>0.0</td>
</tr>
</tbody>
</table>

- If you know or suspect you have hard water, a spray test should be conducted to determine if your crop/variety is compatible with these AMS levels.
- Pre-test tank mixtures with nutrients containing elements associated with hard water.

Photos courtesy of: chinaserniorsupplier.com
Lab bioassays have shown that adding AMS (ammonium sulfate) at levels of 1-2% (w/w) or 8.5 to 17 pounds per 100 gallons of water helps maintain efficacy in presence of hard water.

If you know or suspect you have hard water, a spray test should be conducted to determine if your crop/variety is compatible with these AMS levels.

Pre-test tank mixtures with nutrients containing elements associated with hard water.
VENERATE™ Bioinsecticide
Product Overview
About VENERATE™

• Broad-spectrum protection against chewing and sucking insects, and certain mites
  • Multiple modes of action
  • Active via exposure and by ingestion

• Ideal partner in resistance management

• Several patent pending active compounds, different chemical classes, some novel, produced by the bacteria
  • Derived from new patent-pending species of *Burkholderia rinojensis*¹

• Nontoxic to fish, birds, and most beneficials ... including honey bees

• Easy-to-use liquid formulation

• Registered for conventional and organic production uses across a broad range of crops

¹No relationship to pathogenic *Burkholderia* species

Photos courtesy of: Pepper weevil Alton N Sparks, Univ of GA; Boxwood.org; Beet armyworm Clemson Univ. USDA Cooperative Extension Slide Series Bugwood.org; Western flower thrip Frank Peairs, CO St. Univ. Bugwood.org; Cabbage Looper RJ Reynolds Tobacco Company, Bugwood.org; Twospotted spider mite Clemson EDU
VENERATE™ - Key Features and Benefits

Ideal for IPM and insect resistant management programs

• Broad-spectrum protection against sucking and chewing insects and certain mites
• Activity against adults and nymphs
• Multiple modes of action
• Non-toxic to fish, birds, and most beneficial insects...including honey bees

Manage residues

• 0-day PHI
• MRL tolerance exemption

Convenient and easy to use

• 4-hour REI
• No spray buffer required
• Easy-to-use liquid formulation

Maximum operational flexibility

• OMRI approved and NOP compliant
• Approved for field and greenhouse applications
• Apply by ground or aerial
VENERATE™ Activity

Chewing insects
- difficulties molting
- loss of larvae exoskeleton integrity
- induces loose stools in larvae (potential feeding disruptant)
- stunting

Piercing/sucking insects
- loss of exoskeleton integrity
VENERATE™—Minimal to No Effect on Beneficials

Predatory Mite on Strawberry
Number of Eggs per Leaflet
University of California Cooperative Extension, S. Dara
Santa Maria, CA, 2013

- Application Timing: May 16 (A), May 23 (B)

Predatory Mite on Strawberry
Post-Treatment Average
University of California Cooperative Extension, S. Dara
Santa Maria, CA, 2013

- Application Timing: May 16 (A), May 23 (B)
VENERATE™ Trial Results
VENERATE™ vs. Asian Citrus Psyllid

Asian Citrus Psyllid
(*Diaphorina citri*)

# of Nymphs per Shoot

P. Stansly
University of Florida
Immokalee, FL, 2011

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Date</th>
<th># of Nymphs per Shoot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>Aug 25</td>
<td>0</td>
</tr>
<tr>
<td>Danitol® 2.4EC</td>
<td>Aug 22</td>
<td>16 oz. (1) + 435 oil 2%</td>
</tr>
<tr>
<td></td>
<td>Sep 5</td>
<td>2 gal (1,2) + surfactant</td>
</tr>
<tr>
<td>Agri-Flex® 8.5 oz.</td>
<td>Sep 1</td>
<td>2 gal (1) + 435 oil 2%</td>
</tr>
<tr>
<td></td>
<td>Sep 8</td>
<td>2 gal (1) + 435 oil 2%</td>
</tr>
<tr>
<td></td>
<td>Sep 15</td>
<td>2 gal (1) + 435 oil 2%</td>
</tr>
</tbody>
</table>

- Treatments applied 1= Aug 22, 2= Sep 5.
- Treatments evaluated on Aug 25, Sep 1, Sep 8, Sep 15.

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Plum Cucurlio on Apples
*(Conotrachelus nenuphar)*
Average Stings per Fruit

C. Becker
BAAR Scientific LLC
Phelps, NY, 2013

- Treatments applied 3 times.
- Treatments evaluated on Jun 15.
VENERATE™ vs. Western Flower Thrips

Western Flower Thrips on Strawberry (Frankliniella occidentalis)
Avg. # per Flower

Pacific Ag Research
Guadalupe, CA, 2010

- Treatments applied 1= Oct 12, 2= Oct 19.
- Treatments evaluated on Oct 18, Oct 27, Nov 1, Nov 8, Nov 15.
- All applications included surfactant Silwet L-77 at 0.05%.
Pepper Weevil on Jalapeno Peppers
(*Anthonomus eugenii*)

# of Insects on Fallen Fruit

D. Seal
University of Florida
Homestead, FL, 2012

- Treatment applied Dec 14, Dec 21, Dec 28, Jan 5.
- Treatments evaluated on Dec 16, Dec 23, Dec 30, Jan 7.
Leafhopper in Grapes (Erythroneura bigemina)
Total Leafhoppers per Leaf
Agriculture Development Group
Eltopia, WA, 2013

- Application Timing: Aug 27 (A), Sept 3 (B).
Navel Orangeworm in Nonpareil Almonds
(*Amyelois transitella*)

Nut Damage (0-10 scale)

Pacific Ag Research
Sanger, CA, 2013

- Application Timing: May 6 (A), July 12 (B), July 25 (C)
- All Applications included surfactant at 0.25% v/v
- Nut damage 0-10 scale, where 0 is undamaged and 10 is extraordinary insect damage
Beet and Fall Armyworm on Tomato
(*Spodoptera exigua and S. frugiperda*)

Mexico, 2012

% Control

- **VENERATE™**
  - 1 gal
  - 1.5 gal
  - 2 gal

- **Avaunt®**
  - 200 gm/ha

Treatments applied - Treatments evaluated on
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