Emerging seed treatment technology
Introduction of the Anthranilic diamides

Seed Central Seminar
Feb. 12th 2014, Davis, CA

Presented by:
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Director R&D
DuPont Seed Treatment Enterprise
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1. Historical overview of ST current state
2. History of Diamide seed treatment at DuPont
3. Modes of Action
4. Introduction to ST performance
5. Registrations
6. Q&A
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Evolution of seed treatment technology

Seed Applied Insecticide adoption exploded with the introduction of neonics in the early 2000’s
An Integrated approach: The total solution

**Dye/Colorant**
Seeds need to be colored by law so that they don’t enter the food chain.

**Polymer/Binder**
Adheres active to the seed, controls release. Improves appearance, plantability and handling.

**Micro-nutrients**
Reduce fertilizer usage.

**Inoculants**
Enhances nitrogen fixation.

**Biologicals**
Enhance germination and vigor.

**Insecticide**
Protection from insect damage during storage, in the soil and/or during early stages of growth (post emergence).

**Fungicide**
Protection from disease damage during storage, in the soil and during growth of the plant.

DuPont Lumigen seed sense
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Anthranilic Diamides

Potent Broad-spectrum Insecticides

Chlorantraniliprole

Synthesis of Lower Log P Analogs

Cyantraniliprole

Outstanding Lepidopteran Control

Excellent Cross-spectrum Activity

Development of a new Insecticide Seed Treatment tool

2009 – 1st registration on **Rice** - Chlorantraniliprole

2013 – registration on **Canola** - Cyantraniliprole

2013 – emergency registration on **Soybean & Cotton** - Chlorantraniliprole

2014 – registration on **Corn** - Chlorantraniliprole

Future registrations anticipated for **Cyantraniliprole** on **OSR, Corn, Sunflower, and Soybean**
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Impacts insect behavior by impairing muscle function
Rapid Cessation of Pest Feeding – Cyantraniliprole

Fluorescein technique studies with *Bemisia tabaci* (sweetpotato whiteflies), *Myzus persicae* (green peach aphid), and *Frankliniella occidentalis* (western flower thrips)

**Untreated Control:** Digestive system fluorescing!

**Treated with Cyantraniliprole:** Digestive system NOT fluorescing!

**Untreated Aphids**

**Aphids Treated with Cyantraniliprole:** 24 h after exposure.

**Untreated Thrips**
DuPont Chlorantraniliprole and Cyantraniliprole Technical Background

1. Broad spectrum control
2. Rapid protection
3. Resistance management
4. Excellent environmental profile
5. Flexible application
<table>
<thead>
<tr>
<th>Tradename</th>
<th>Crops</th>
<th>Geography</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorantraniliprole</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dermacor®</td>
<td>Corn/Soy</td>
<td>LATAM</td>
<td>Best Intrinsic activity for pest spectrum</td>
</tr>
<tr>
<td>Dermacor</td>
<td>Rice</td>
<td>USA</td>
<td>High intrinsic activity for key pest</td>
</tr>
<tr>
<td>Lumivia™</td>
<td>Rice</td>
<td>Italy</td>
<td>High intrinsic activity for key pest</td>
</tr>
<tr>
<td>Lumivia</td>
<td>Corn</td>
<td>USA</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Launch in 2015</td>
</tr>
<tr>
<td>Cyantraniliprole</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumiderm™</td>
<td>Canola</td>
<td>Canada</td>
<td>Cutworm is main pest with enhancement for flea beetle</td>
</tr>
<tr>
<td>Lumiposa™</td>
<td>OSR/WOSR</td>
<td>EMEA</td>
<td>Flea Beetle/Cabbage Root Fly</td>
</tr>
</tbody>
</table>
### Lepidoptera & Coleoptera Activity

**Chewing insects**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Spodoptera Fugiperda (Fall Armyworm)</th>
<th>Plutella Xylostella (Diamond-back Moth)</th>
<th>Heliothis Virescens (Tobacco Budworm)</th>
<th>Spodoptera Exigua (Beet Armyworm)</th>
<th>Trichoplusia Ni (Cabbage Looper)</th>
<th>Leptinotarsa Decemlineata (Colorado Potato Beetle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyantraniliprole</td>
<td>0.35</td>
<td>0.07</td>
<td>0.21</td>
<td>0.75</td>
<td>0.26</td>
<td>&lt; 0.06</td>
</tr>
<tr>
<td>Chlorantraniliprole</td>
<td>0.06</td>
<td>0.05</td>
<td>0.04</td>
<td>0.1</td>
<td>0.06</td>
<td>&lt; 0.1</td>
</tr>
</tbody>
</table>

- **EC$_{50}$ (PPM)**

Intrinsic activity has translated to performance differences against key pests and has driven active selection by market.
Systemic movement of the diamides confers above and below ground protection

Figure 2. Phosphor images of distribution of 14C-DPX-E2Y45 within corn seedling (V2 stage) following seed treatment application of 250 µg a.i./seed
DuPont Lumivia insecticide seed treatment
Selective against Target Corn Pests with minimal impact on beneficials

Laboratory and field studies show that Chlorantraniliprole has low to no significant impact on pollinators, parasitoids and predators when applied using Good Agricultural Practices
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### FST/IST *plus* Lumivia™ Efficacy Summary

#### Insecticide Seed Treatments

<table>
<thead>
<tr>
<th>Pest</th>
<th>FST/IST 250</th>
<th>FST/IST 250 <em>plus</em> Lumivia™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wireworm</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>White Grub</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Grape Colapsis</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Black Cutworm</td>
<td>+¹</td>
<td>+++</td>
</tr>
<tr>
<td>Seed Corn Maggot</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Fall Armyworm (early season)</td>
<td>–</td>
<td>+++ +</td>
</tr>
<tr>
<td>Flea Beetle</td>
<td>+ + +</td>
<td>+++</td>
</tr>
<tr>
<td>Corn Rootworm</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Corn Nematodes</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>–</td>
<td>No Protection</td>
</tr>
<tr>
<td>+</td>
<td>Suppression</td>
</tr>
<tr>
<td>++</td>
<td>Protection</td>
</tr>
<tr>
<td>+ +++</td>
<td>Above Average Protection</td>
</tr>
<tr>
<td>+ +++ +</td>
<td>Excellent Protection</td>
</tr>
</tbody>
</table>

¹labeled for protection

Source: STE Agronomy Research evaluations & product labels
Healthier Stand: Long residual for Seedling Protection against Black Cutworms (9 DAI)

FST/IST plus Lumivia provides excellent protection against black cutworm

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent (%) Plant Mortality 9 DAI</th>
</tr>
</thead>
<tbody>
<tr>
<td>FST only</td>
<td>46.6 A</td>
</tr>
<tr>
<td>FST plus IST</td>
<td>4.5 B</td>
</tr>
<tr>
<td>FST/IST plus Lumivia</td>
<td>0 B</td>
</tr>
</tbody>
</table>

**STE. May 5, 2014. 19 DAP. McAllen, TX. 2014.** All treatments included base fungicide treatment (FST). **Soil Texture:** Fine Clay Loam; **Insect species:** *Agrotis ipsilon*; **Planting date:** Apr 16, 2014; **Infestation:** 2, 3rd instar larva/plant; **Plot size:** 6 rows X 20 feet; **Seeding rate:** 39,000/acre; **Experimental design:** RCB; 9 trtms X 4 reps
Lumivia™ features and benefits for growers

**Efficacy:** Long residual for better seedling protection against Wireworms (29 DAP)

<table>
<thead>
<tr>
<th>FST/IST plus Lumivia</th>
<th>FST/IST</th>
</tr>
</thead>
<tbody>
<tr>
<td>STE. May 22, 2014. 29 DAP. Jefferson City, MO. 2014. All treatments included FST. <strong>Soil Texture:</strong> Loam; <strong>Insect species:</strong> <em>Melanotus depressus</em>; <strong>Planting date:</strong> Apr 23, 2014; <strong>Plot size:</strong> 4 rows X 20 feet; <strong>Seeding rate:</strong> 40 seeds per row (20 feet); <strong>Experimental design:</strong> RCB; 9 trtms X 4 reps</td>
<td></td>
</tr>
</tbody>
</table>
Brazil soybeans: Lepidopteron pests

Untreated  Standard 1  Standard 2

Paraná, Brazil, Nov 2011

Dermacor™ insecticide seed treatment
DuPont Dermacor™* & Grubs in Soybeans

Source: Brazil Soy & Global R&D Seed Trt Brazil visit 02/2011: Main pests in test: grubs (Lyogenis fuscus; Phyllophaga cuyabana)
Dermacor results in recent trialing

Dermacor® 100 ml/100kg

Untreated Control

Market standard

Dermacor® 100 ml/100kg
**Broad spectrum control**

Lumiposa™ provides protection against many different insect species, including the cabbage root fly *(Delia radicum)* which is known to be a significant pest across Europe. Lumiposa™ is an ideal choice to start your oilseed rape crop protection programme.

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**Lumiposa (™) - Excellent control of *Delia brassicae* on Oil Seed Rape**

- **Laboratory studies**
- **Field results**
Study n° 1: Close-up photos of representative OSR plants
Study n° 2: Close-up photos of all OSR plants tested

- Untreated check
- Cyantraniliprole 50 UAT
- Standard 1
- Standard 2
Study n° 2: Plants comparison between UTC and Cyantraniliprole at 50 UAT
Control of *Delia brassicae*

Field Studies (12 locations)

Control of damaged root area (severity)
DuPont Lumiderm™
insecticide seed treatment

• A new mode-of-action insecticide containing the active ingredient – cyantraniliprole – a unique, proprietary IRAC group 28 insecticide

• First seed treatment product to deliver BOTH early season cutworm (lepidoptera) & flea beetle protection

• Residual control – up to 35 days protection from flea beetle & cutworms

• Improved early season stand establishment & vigor of canola
Lumiderm™ enhancement of standard performance

- Alberta - Keller - Flea Beetle Site 21 Days after seeding  Low Pest Pressure

Lumiderm+standard treatment  Standard treatment
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ST Registration – Approved

<table>
<thead>
<tr>
<th>Country</th>
<th>Active Substance</th>
<th>Product</th>
<th>Crops</th>
<th>Registration Date</th>
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</thead>
<tbody>
<tr>
<td>Italy</td>
<td>Chlorantraniliprole</td>
<td>Lumivia</td>
<td>rice</td>
<td>Oct-13</td>
</tr>
<tr>
<td>Mexico</td>
<td>Chlorantraniliprole</td>
<td>Dermacor</td>
<td>corn</td>
<td>Oct-11</td>
</tr>
<tr>
<td>Argentina</td>
<td>Chlorantraniliprole</td>
<td>Dermacor</td>
<td>corn</td>
<td>Oct-12</td>
</tr>
<tr>
<td>Argentina</td>
<td>Chlorantraniliprole</td>
<td>Dermacor</td>
<td>soybean</td>
<td>Feb-14</td>
</tr>
<tr>
<td>Brazil</td>
<td>Chlorantraniliprole</td>
<td>Dermacor</td>
<td>soybean, cotton, emergency registration</td>
<td>Nov-13</td>
</tr>
<tr>
<td>Brazil</td>
<td>Chlorantraniliprole</td>
<td>Dermacor BR (blue, on-farm)</td>
<td>soybean, cotton, emergency registration</td>
<td>Nov-13</td>
</tr>
<tr>
<td>USA</td>
<td>Chlorantraniliprole</td>
<td>Dermaco X-100</td>
<td>rice</td>
<td>Feb-10</td>
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<tr>
<td>USA</td>
<td>Chlorantraniliprole</td>
<td>Dermaco X-101</td>
<td>corn</td>
<td>Sep-11</td>
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<td>Canada</td>
<td>Cyantraniliprole</td>
<td>Lumiderm</td>
<td>canola, mustard (oil seed group)</td>
<td>Aug-13</td>
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<tr>
<td>USA</td>
<td>Cyantraniliprole</td>
<td>Lumiderm</td>
<td>canola, mustard (oil seed group)</td>
<td>Jan-14</td>
</tr>
</tbody>
</table>

Approval in 2014
## ST Registration – Submitted and Pending Approval

<table>
<thead>
<tr>
<th>Country</th>
<th>Active Substance</th>
<th>Product</th>
<th>Crops/Uses</th>
<th>Actual Submission Date</th>
<th>Current Projection Date for Approval (50% Case)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>Chlorantraniliprole</td>
<td>Lumivia</td>
<td>corn</td>
<td>MAR-2014</td>
<td>APR-2016</td>
</tr>
<tr>
<td>Spain, Greece</td>
<td>Chlorantraniliprole</td>
<td>Lumivia</td>
<td>Rice</td>
<td>Nov 2012 / Jun 2013</td>
<td>Jun-2014</td>
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<tr>
<td>Brazil</td>
<td>Chlorantraniliprole</td>
<td>Dermacor</td>
<td>corn, soybean, full registration</td>
<td>SEP-2011</td>
<td>Apr-2015</td>
</tr>
<tr>
<td>Brazil</td>
<td>Chlorantraniliprole</td>
<td>Dermacor BR (blue, on-farm)</td>
<td>soybean, full registration</td>
<td>DEC-2012</td>
<td>Aug-2016</td>
</tr>
<tr>
<td>Canada</td>
<td>Chlorantraniliprole</td>
<td>Dermacor</td>
<td>Corn</td>
<td>FEB-2014</td>
<td>DEC-2015</td>
</tr>
<tr>
<td>Germany (RMS), FR, UK, PL, HU, RO, AT</td>
<td>Cyantraniliprole</td>
<td>Lumiposa</td>
<td>WOSR</td>
<td>Dec-13</td>
<td>2019</td>
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Questions
DuPont Lumiderm™ and Lumivia insecticide seed treatments are developmental products for which an application has not yet been filed with EPA. These developmental products are not registered for use and sale in the United States and no sale, offer for sale or use of these products may be made unless and until all necessary federal and state registrations have been obtained.