E.E. Muir & Sons P/L

- Australian distribution partners for leading global suppliers of PH products;
  Decco US, Syngenta & Janssen PMP
- Quality / proprietary Brands
- Best (global) technical advice
- New Product development
- Testing and analysis services
PH Fungicides - A key Stage in a Complete System

“Consumers buy with their eyes”

- Competitive appearance at retail
- Pre-harvest crop protection
- Transportation
- Warehousing
- Picking process
- Transport
- Post-harvest processing
- Clean, sanitise, fungicide & wax Applications
- Unitizing
- Sizing
- Packing
- 1

E.E. Muir & Sons
Australian Owned - Since 1927
Major postharvest decays of citrus

Green mold caused by *Penicillium digitatum* (most important on citrus)

Blue mold caused by *P. italicum* and green mold

*Sour rot caused by Geotrichum citri-aaurantii*

*Penicillium* spp. and *G. citri-aaurantii* are wound pathogens

Penicillium soilage
PH FUNGICIDES – Issues?

MRL’s / Residue Issues
- Export markets

Application & Rates
(Monitor & Measure)

Resistance Issues
- Groups 1, 2, 3 (???)
# Use new products & rotate

New Products (program in)
- Scholar (FLUDI)
- Philabuster (Dual A.I.)
- Others? (Chairman)
CITRUS - PH FUNGICIDES

- **PHILABUSTER**
  - Imazalil + Pyrimethanil
  - Group 3 + 9

- **SCHOLAR**
  - Fludioxonil
  - Group 12

- **Imazalil**
  - Fungaflor / ImazaCure, etc.
  - Group 3

- **Thiabendazole (TBZ)**
  - Tecto (Group 1)

- **Panoctine**
  - Guazatine (Grp. M7)
DIFFERENCE BETWEEN FUNGICIDES & SANITISERS

- FUNGICIDES are **specific** in that they only control fungi (E.g. Fungaflor targets Blue & Green Mould (Penicillium spp.) and they also control fungi over extended periods, even if fungus is present after treatment.

- SANITISERS are **non specific** and control fungi, bacteria and yeasts. E.g. Chlorine or PAA in a wash water.

- Sanitisers are highly reactive and kill pathogens in the water on contact.

- Once inactivated they provide no residual protection on the fruit.

- Sanitisers keep the water clean and pathogen free but don’t provide extended disease control. Very Important for food safety.
<table>
<thead>
<tr>
<th>Product</th>
<th>Group</th>
<th>Active Ingredient</th>
<th>Label Rate Per 100L</th>
<th>Diseases controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scholar LIQUID</td>
<td>12</td>
<td>Fludioxonil</td>
<td>260 - 520 ml (600 ppm)</td>
<td>Blue mould (<em>P. italicum</em>), Green mould (<em>P. digitatum</em>), Diplodia Stem End Rot</td>
</tr>
<tr>
<td>Philabuster LIQUID</td>
<td>3 &amp; 9</td>
<td>Imazalil + Pyrimethanil</td>
<td>200 ml (400ppm each A.I.)</td>
<td>Blue mould (<em>P. italicum</em>), Green mould (<em>P. digitatum</em>)</td>
</tr>
<tr>
<td>Fungaflor 500 LIQ. (ImazaCure, etc.)</td>
<td>3</td>
<td>Imazalil</td>
<td>100ml (500 ppm)</td>
<td>Blue mould (<em>P. italicum</em>), Green mould (<em>P. digitatum</em>)</td>
</tr>
<tr>
<td>Fungaflor 750 SG (ImazaCure, etc.)</td>
<td>3</td>
<td>Imazalil</td>
<td>68g (500 ppm)</td>
<td>Blue mould (<em>P. italicum</em>), Green mould (<em>P. digitatum</em>)</td>
</tr>
<tr>
<td>Panoctine</td>
<td>M7</td>
<td>Guazatine</td>
<td>130 ml (500 ppm)</td>
<td>Blue mould (<em>P. italicum</em>), Green mould (<em>P. digitatum</em>), Sour Rot (<em>Geotrichum. Spp.</em>)</td>
</tr>
<tr>
<td>Tecto SC Vorlon</td>
<td>1</td>
<td>Thiabendazole</td>
<td>200 ml (1000 ppm)</td>
<td>Blue mould (<em>P. italicum</em>), Green mould (<em>P. digitatum</em>), Stem End Rot</td>
</tr>
</tbody>
</table>
Current and future postharvest fungicides for decay control of citrus - Australia

M7

Phenylpyrroles (12)
- Guazatine (e.g. Panoctine)
  - Benzimidazoles (1)
    - Thiabendazole (e.g. Tecto, TBZ)
  - SI-triazoles
    - Propiconazole (Chairman Soon?)
  - Anilinopyrimidines (9)
    - Fludioxonil (Scholar, Registered)
    - Pyrimethanil (Philabuster, Registered)
    - Qols
      - Azoxystrobin

SI-imidazoles (3)
- Imazalil (IMZ) (Fungaflor, ImazaCure & Philabuster – combo (IMZ + PYR))

Future?

- Reduced risk fungicides
Post Harvest Fungicide evolution & development

**Postharvest fungicides for citrus in the US**

- **1930s**
  - Phenol
  - Sodium ortho-phenyl phenate (SOPP)

- **1970s**
  - Benzimidazole - 1
    - Thiabendazole (TBZ)

- **1980s**
  - DMI-Imidazole - 3
    - Imazalil

- **2006**
  - Phenylpyrrole - 12
    - Fludioxonil (Graduate)

- **2010**
  - Anilinopyrimidine - 9
    - Pyrimethanil (Penbotec)
  - QoI - 11
    - Azoxystrobin (Diploma)

- **2012**
  - Phosphonate - 33
    - KPO₃

- **2013**
  - DMI - 3
    - Propiconazole (Mentor)

- **2016 and beyond**
  - Biopesticides – Exempt from residue tolerance
    - (KPO₃, pimaricin)

Each oval is a unique mode of action (No. = FRAC No.).

- Reduced Risk
- Conventional
### Spectrum of activity of postharvest fungicides on citrus

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Trade name</th>
<th>Active Ingredient</th>
<th>Penicillium decay</th>
<th>Penicillium sporulation</th>
<th>Sour rot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fungaflor</td>
<td>Imazalil</td>
<td>+++*</td>
<td>+++*</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Tecto</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diploma</td>
<td>Azoxystrobin</td>
<td>++</td>
<td>+/+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Scholar</td>
<td>Fludioxonil</td>
<td>+++</td>
<td>+++</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Penbotec</td>
<td>Pyrimethanil</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Propiconazole</td>
<td>--</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td></td>
</tr>
</tbody>
</table>

* NOTE - Efficacy against decay dependent on sensitive of *Penicillium* spp. Populations, which will be variable. 
  
  +++ = high, ++ = moderate, + = low efficacy
Decayed Fruit – Fungicide Resistance = Poor Control
PHILABUSTER® 400 SC

- Support & service
- Broad regulatory approvals
- Strong anti-resistance tool
- High level of efficacy and broad spectrum
- Curative and preventive activity
- Worldwide MRLs available
Postharvest treatments of lemons for management of green mold

The study was conducted at Saticoy Lemon Packing. Fruit were wound-inoculated with *P. digitatum*. Aqueous fungicide flooder treatments were preceded by a heated soda ash treatment and were followed by either a fungicide CDA treatment (in D202) or by a hand spray with diluted D202.
Citrus use

**Bulk dip, flood etc**

- **200 mL/100 L water**
  - Use as bulk dip, flood or drench for 30 seconds. 200 mL/100 L of water provides 400 ppm of each active constituent.

**Non-return spray**

- **0.5-1.0 L/100 L water**
  - Use as a non-return spray before waxing. 1 L/100 L of water provides 2000 ppm of each active constituent. Use higher rates when previous disease history is high.

**In wax treatment**

- **1.0 - 1.5 L/100 L wax**
  - Apply in wax (without further dilution in water) using conventional waxing equipment. Do not 'top up' wax. 1.5 L/100 L of wax provides 3000 ppm of each active constituent. Use higher rates when previous disease history is high.
What is SCHOLAR?

- A new broad spectrum postharvest fungicide
- Unique mode of action (no known cross resistance)
- Broad disease spectrum across range of crops
- Long residual activity
- Provides sporulation control, reducing the spread of disease in the packinghouse and during shipment
- Low use rates
- Compatible with most waxes
- Suited to most postharvest application systems
- Stable in chlorine and heat and wide pH range
Flexibility in application methods

Flexible application

- Drench
- Dip/bin filler
- Flood
- Spray
- Heated option

Can be mixed in

- Water
- Wax / oil
- Aqueous wax / oil emulsion

Compatible with chlorine and other sanitizers

*SCHOLAR may be applied as a post-harvest dip, drench, flood or spray in citrus or as a dip or drench in pome/stone fruit and Mangoes (refer to label).*
Effect of Scholar on Lemon Storage

58 days old fruit – With Scholar

63 days old fruit – Without Scholar
Chairman Fungicide Trials
# Citrus Rot Management – Propiconazole MRL’s

<table>
<thead>
<tr>
<th>Top Export Markets</th>
<th>Propiconazole MRL, ppm</th>
<th>Additional MRL Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>USA Codex</strong></td>
<td>8</td>
<td>Review in 2017</td>
</tr>
<tr>
<td>1. Canada</td>
<td>8</td>
<td>Citrus group CXL anticipated 3Q2018</td>
</tr>
<tr>
<td>2. Japan</td>
<td>0.05</td>
<td>FA designation anticipated 2019&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>3. Korea</td>
<td>6&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>4. Australia</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>5. Hong Kong</td>
<td>CXL</td>
<td>Codex deferral anticipated</td>
</tr>
<tr>
<td>6. China</td>
<td>CXL?</td>
<td>No import tolerance process, possible conversion from Codex when established</td>
</tr>
<tr>
<td>7. New Zealand</td>
<td>Current 0.1 default</td>
<td>Defer to Codex in absence of domestic MRL</td>
</tr>
<tr>
<td>8. Chile</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>9. Philippines</td>
<td>CXL</td>
<td>Codex deferral anticipated</td>
</tr>
<tr>
<td>10. Mexico</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Other Countries of Interest:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EU</strong></td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Source: Syngenta
Fungicide Application
Trends in US & OZ Citrus Industry

Moving toward heated fungicide applications
Heated Fungicide Example
Constant auto dosing

- **Fungaflor in Drench**
  - 6am: 240
  - 7.30am: 322
  - 10.30am: 320
  - 2pm: 346

- **Tecto in Drench**
  - 6am: 652
  - 7.30am: 920
  - 10.30am: 810
  - 2pm: 680

- **Fungaflor in Fruit**
  - 6am: 1.5
  - 7.30am: 1.7
  - 10.30am: 1.8
  - 2pm: 2.1

- **Tecto in Fruit**
  - 6am: 2
  - 7.30am: 4.1
  - 10.30am: 4.4
  - 2pm: 4.5
Manual Dosing - Recharge

**Fungaflor in Drench**

<table>
<thead>
<tr>
<th>Time</th>
<th>7am</th>
<th>10am</th>
<th>10.15am</th>
<th>12noon</th>
<th>12.15pm</th>
<th>3pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>245</td>
<td>181</td>
<td>268</td>
<td>155</td>
<td>264</td>
<td>122</td>
</tr>
</tbody>
</table>

**Fungaflor in Fruit**

<table>
<thead>
<tr>
<th>Time</th>
<th>7am</th>
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<th>3pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>2</td>
<td>1.3</td>
<td>2.1</td>
<td>1.2</td>
<td>2.1</td>
<td>0.9</td>
</tr>
</tbody>
</table>
Imazalil on Fruit in ppm

ppm in Citrus using Imazalil
Imazalil on Fruit

• Results were taken from Oranges & Mandarins
• Many Citrus Packers are getting around 2ppm of Imazalil on their Fruit when sending for Export
• Although some concerning Results under 1ppm (potential for resistance and poor control)
• 2 results getting close to Maximum 5ppm MRL
• Consistent LOW results can bring on Resistance more quickly and result in poor control.
• Again MRL’s are VERY Important to the Industry. Regular or Auto dosing will help control the levels of Fungicide on the Fruit.
• Monitor and measure levels in drench and on fruit
ppm in TBZ (Thiabendazole)
TBZ - Thiabendazole on Fruit

• Results from Oranges & Mandarins.
• Results ranging from 1ppm to 8ppm.
• With potential resistance to TBZ you may need higher fruit residues (ppm) later in the season to achieve control.
• Consider rotations with other Fungicides and mixtures
Graph 1. Imazalil (IMZ) fludioxonil (FLU) and thiabendazole (TBZ) fungicide residues (mg/Kg) on citrus fruit treated at surveyed packing lines during June and early September 2016, and their relationship to the CODEX maximum residue limit (MRL) for IMZ.
Scholar – Fludioxonil

Strip Out Trial – 1st Test

Topped up & re-charged at 1pm
Label rate plus 10% Recharge

Aim – to maintain drench rates to produce fruit residue of 1.0 - 1.5 ppm
Scholar (Fludioxonil) Trial – 2\textsuperscript{nd} Run

7.30am Filled Tank
360L Water & added 1100ml Scholar & 360ml Imazalil

Start up at 7.45am Fruit Running

9am – Added 50ml Scholar & 18ml Imazalil

Morning Break 9.45 till 10am

10am – Added 50ml Scholar & 18ml Imazalil

11am – Added 50ml Scholar & 18ml Imazalil

Lunch Break 12 till 12.30pm

12.30pm – Top Up Water 200lts & added 520ml Scholar & 200ml Imazalil

2pm – Added 50ml Scholar & 18ml Imazalil

3pm – Added 50ml Scholar & 18ml Imazalil

Fungicide strip out or Recharge rate was 15\% of Label Rate.
Summary of Scholar Trial

- Mixing & Agitation is critical to achieve correct drench concentrations.
- With the Heating of the Fungicide uptake in the Fruit is good.
- Scholar/FLUDI was measured around 400ppm to 500ppm in Drench which typically produced between 1.0 to 1.5ppm in the Fruit.
- Initial Mix was at 310ml/100lts = 710ppm but only got to approx. 500ppm in drench tests, so mixing and agitation needs to be improved.
- Regular Recharging & Top Up or auto dosing will even out the residues on the Fruit.
- Safe MRL for export citrus is Critical to the Industry.