INTEGRATED MANAGEMENT OF POWDERY AND DOWNY MILDEWS IN ZUCCHINI

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Foliar diseases in zucchini in North Queensland, Australia

- Queensland grows 73% of a total area (2,219 ha) with zucchini & squash in Australia
- In North Qld., field crops grow from March-November
- Warm and dry; light morning dews; few rain events

**Issues with disease spread and control**
- Sequential plantings
- Proximity between crops; different growth stages
- Infected crops sometimes abandoned
- Carryover inoculum becomes exposed to multiple sprays of the same active ingredient
- Overuse of systemic fungicides favour the survival and proliferation of resistant pathogen strains
- Disease control sometimes ineffective

**Powdery mildew**
*Podosphaera xanthii*

**Downy mildew**
*Pseudoperonospora cubensis*
Objectives of this and related research presented in this symposium

**Poster # 1**

- To screen cultivars for low reaction to foliar diseases

**Oral Session 9**

- To measure efficacy of spray products alternative to conventional systemic and contact fungicides

**Poster # 41**

- To monitor and detect loss of sensitivity or resistance of powdery mildew strains to systemic fungicides

**Oral Session 5**

- To identify programs that reduce the use of conventional systemic and contact fungicides by including alternative spray products and cultivars with disease resistance

**Oral Session 9**

- To screen cultivars for low reaction to foliar diseases

**Poster # 1**

- To screen cultivars for low reaction to foliar diseases
Reactions of zucchini cultivars to powdery mildew and downy mildew in field trials conducted at Bowen and Ayr in 2008

Relative severity of POWDERY MILDEW (Bowen – Planting 19 June)

Relative severity of DOWNY MILDEW (Ayr – Planting 29 April)
Relative effectiveness of alternative spray products for management of foliar diseases in zucchini. North Queensland field trials.

<table>
<thead>
<tr>
<th>Spray product</th>
<th>Downy</th>
<th>Powdery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bion</td>
<td>●●● *</td>
<td>●● *</td>
</tr>
<tr>
<td>Microthiol</td>
<td>●●●</td>
<td>●●●</td>
</tr>
<tr>
<td>Tricop</td>
<td>●●</td>
<td>●●●</td>
</tr>
<tr>
<td>Trilogy</td>
<td>●</td>
<td>●●</td>
</tr>
<tr>
<td>AgriFos 600</td>
<td>●●●</td>
<td>●●</td>
</tr>
<tr>
<td>milk</td>
<td>●</td>
<td>●●</td>
</tr>
<tr>
<td>Synertrol Hori Oil</td>
<td>●</td>
<td>●●</td>
</tr>
<tr>
<td>Timorex</td>
<td>●</td>
<td>●●</td>
</tr>
<tr>
<td>Enhance KCS</td>
<td>●</td>
<td>●●</td>
</tr>
<tr>
<td>Stand SKH</td>
<td>●</td>
<td>●●</td>
</tr>
<tr>
<td>Peratec</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>CalAgri 50NF</td>
<td>● *</td>
<td>●● *</td>
</tr>
<tr>
<td>Ecocarb</td>
<td>●</td>
<td>●●</td>
</tr>
</tbody>
</table>

Relative disease suppression to conventional fungicides and unsprayed controls. Weekly sprays at runoff volumes.

- ●●● Good to medium
- ●● Medium to low
- ● Low to none
- * Some phytotoxicity or yield reduction observed
Main constituent ingredients and commercial products used in spray programs

<table>
<thead>
<tr>
<th>Commercial product</th>
<th>Acronym</th>
<th>Active ingredient</th>
<th>Formulation</th>
<th>Distribution in AU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agri-Fos 600®</td>
<td>AF</td>
<td>Phosphorus acid</td>
<td>600 g/L</td>
<td>Agrichem</td>
</tr>
<tr>
<td>Bion® (= Actigard 50WG®)</td>
<td>BN</td>
<td>Acibenzolar-s-methyl</td>
<td>500 g/L (= 500 g/kg)</td>
<td>Syngenta Crop Protection</td>
</tr>
<tr>
<td>Tricop®</td>
<td>TP</td>
<td>Copper octanoate</td>
<td>18 g/L</td>
<td>Colin Campbell Chemicals</td>
</tr>
<tr>
<td>Conventional</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrobat SC® + Mancozeb</td>
<td>AMZ</td>
<td>Dimethomorph + Mancozeb</td>
<td>500 g/L + 750 g/kg</td>
<td>BASF Australia Farmoz</td>
</tr>
<tr>
<td>Amistar 250 SC®</td>
<td>AR</td>
<td>Azoxystrobin</td>
<td>250 g/L</td>
<td>Syngenta Crop Protection</td>
</tr>
<tr>
<td>Mancozeb 750®</td>
<td>MZ</td>
<td>Mancozeb</td>
<td>750 g/kg</td>
<td>Farmoz</td>
</tr>
<tr>
<td>Nimrod®</td>
<td>ND</td>
<td>Bupirimate</td>
<td>250 g/L</td>
<td>Farmoz</td>
</tr>
<tr>
<td>Bravo®</td>
<td>BV</td>
<td>Chlorotalonil</td>
<td>720 g/L</td>
<td>Syngenta Crop Protection</td>
</tr>
<tr>
<td>Different sulphur formulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microthiol Disperss®</td>
<td>MD</td>
<td>Micronized sulphur</td>
<td>800 g/kg</td>
<td>Nufarm</td>
</tr>
</tbody>
</table>
• Four cultivars under 4 spray programs and an unsprayed control

• Selected zucchini cultivars with different reactions to foliar diseases

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Seed company</th>
<th>Powdery mildew</th>
<th>Downy mildew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houdini</td>
<td>Syngenta</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Calida</td>
<td>Clause</td>
<td>Medium</td>
<td>Medium to Low</td>
</tr>
<tr>
<td>Nitro</td>
<td>SPS</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Paydirt</td>
<td>Syngenta</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>

• Selected foliar disease spray programs used on zucchini cultivars

<table>
<thead>
<tr>
<th>Weeks from planting</th>
<th>Spray dates</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>First crop planted</td>
<td>2 June 2010</td>
<td>10 June</td>
<td>17 June</td>
<td>24 June</td>
<td>1 July</td>
<td>7 July</td>
<td>14 July</td>
<td>21 July</td>
<td>28 July</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spray program</th>
<th>Sprays</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) BN-BN-BN-TP-MD-TP-MD-TP</td>
<td>Bion</td>
<td>Bion</td>
<td>Bion</td>
<td>Tricop</td>
<td>M.Sulf.</td>
<td>Tricop</td>
<td>M.Sulf</td>
<td>Tricop</td>
<td>Tricop</td>
</tr>
<tr>
<td>b) AF-AF-AF-TP-MD-TP-MD-TP</td>
<td>AgriFos</td>
<td>AgriFos</td>
<td>AgriFos</td>
<td>Tricop</td>
<td>M.Sulf.</td>
<td>Tricop</td>
<td>M.Sulf</td>
<td>Tricop</td>
<td>Tricop</td>
</tr>
<tr>
<td>c) AF-AF-AMZ-TP-MD-TP-MD-TP</td>
<td>AgriFos</td>
<td>AgriFos</td>
<td>Acro+MZ</td>
<td>Tricop</td>
<td>M.Sulf.</td>
<td>Tricop</td>
<td>M.Sulf</td>
<td>Tricop</td>
<td>Tricop</td>
</tr>
<tr>
<td>d) AMZ-AR-MZ-ND-BV-MD-BV-MD</td>
<td>Acro+MZ</td>
<td>Amistar</td>
<td>Mancozeb</td>
<td>Nimrod</td>
<td>Bravo</td>
<td>M.Sulf</td>
<td>Bravo</td>
<td>M.Sulf</td>
<td></td>
</tr>
<tr>
<td>e) No spray</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
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<td>--</td>
</tr>
</tbody>
</table>
Maximum and minimum day air temperatures and air relative humidity and rainfall, in Ayr in 2010

- **Powdery mildew**: 115 %-days
- **Downy mildew**: 195 %-days
- **Severity in unsprayed plants**: 65 %-days, 1115 %-days

Rainfall:
- **1st Crop planted**: 6 mm
- **2nd Crop planted**: 165 mm

Crop planting dates:
- **1st Crop**: 2 June
- **2nd Crop**: 3 August
Cumulative severity (AUDPC) of powdery mildew and downy mildew in 4 zucchini cultivars under 5 spray programs for foliar disease management

First planting, 2 June 2010

- **Calida**: 91% reduction in powdery mildew
- **Houdini**: 95% reduction in powdery mildew
- **Nitro**: No effects from spray programs
- **Paydirt**: No effects from spray programs

Spray programs only reduced powdery mildew in Houdini.
Cumulative severity (AUDPC) of powdery mildew and downy mildew in 4 zucchini cultivars under 5 spray programs for foliar disease management

Second planting, 3 August 2010

Calida
- Program with Bion decreased downy mildew severity

Houdini
- No effects from spray programs

Nitro
- No effects from spray programs

Paydirt
- Program with Bion decreased downy mildew severity

a) BN-BN-BN-TP-MD-TP-MD-TP
b) AF-AF-AF-TP-MD-TP-MD-TP
c) AF-AF-AMZ-TP-MD-TP-MD-TP
d) AMZ-AR-MZ-ND-BV-MD-BV-MD
e) No Spray
Fruit yield main effects for cultivars

**First planting, 2 June 2010**
Under low downy mildew pressure, yields were greater in sensitive cultivars

**Second planting, 3 August 2010**
Under high downy mildew pressure, yields were greater in cultivars with moderate resistance
Marketable fruit yield and estimated costs of spray programs

Second planting, 3 August 2010

- e) No Spray
- d) AMZ-AR-MZ-ND-BV-MD-BV-MD
- c) AF-AF-AMZ-TP-MD-TP-MD-TP
- b) AF-AF-AF-TP-MD-TP-MD-TP
- a) BN-BN-BN-TP-MD-TP-MD-TP

**Total yield (t/ha)**
- a
- ab
- b
- e

**Cost of spray program ($/ha)**
- 0
- 223
- 309
- 348
- 444

[Includes spray product only]
Conclusions

- Under high disease pressure, the use of both, cultivars with moderate resistance and programs with alternative fungicides, were as effective as a selected program with conventional fungicides.

- Some of the tested alternative products are available and can be cost effective if used in programs with other spray products.

- An area-wide plan for managing these diseases should integrate the use of crop genetic resistance to the diseases, products alternative to conventional fungicides, effective conventional fungicides, and crop hygiene practices.

- Integrated programs should also prolong the life of effective systemic fungicides.
Acknowledgments

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Plant Pathology team
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Seed companies
Clause
Lefroy Valley
Terranova
Syngenta
Seminis
SPS

Chemical companies
Colin Campbell (Chemicals) Pty Ltd
Organic Crop Protectants Pty Ltd
Agrichem Mfg. Co.
Jaegar Australia Pty Ltd
Nufarm
Syngenta Crop Protection Pty
Cal Agri, Products LLC
Bayer Australia Ltd