Understanding Fungicides to Improve their Use and Efficacy

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DON’T FORGET CULTURAL PRACTICES AND THE DISEASE TRIANGLE!

Fungicides are simply a part of an integrated disease management plan
• Disease only occurs if three things exist all at the same time
  - Pathogen
  - Host
  - Environment
• Manipulating a component or combinations of triangle components influences the incidence and severity of disease
Disease Management by Manipulating the Host

- Genetic resistance is the most powerful disease management tool
- Use varieties/hybrids well adapted to an area – less likely to be predisposed to disease
- Stress management – stress also predisposes plants to disease
Disease Management by Manipulating the Environment

• Environment very hard to change
• Maintain adequate soil fertility – ex. some diseases are worse if N is high, while others are worse if N is low
• Microelements can also be important e.g. Sulfur and the severity of Aphanomyces root rot??
• Plant population
• Plant spacing
• Irrigation management
Disease Management by Manipulating the Pathogen

• Exclusion – Preventing the introduction of a pathogen (e.g. pathogen-free seed)
• Eradication – removing the pathogen after it was brought in; very difficult to do, especially for field crops
• Sanitation – Removing or burying pathogen infested material
• Fungicide use
Fungicides

• Different than insecticides and herbicides, which kill the target pest

• Most fungicides are actually ‘fungistats’
  – Inhibit the growth or reproduction of a fungus and are not directly toxic to the organism

• Typically used to protect a healthy plant

• Generally applied before (or immediately after) infections occur
Fungicide Mode of Action

Mode of Action – defines how the product actually affects the fungus
Separate from fungicide mobility – how the fungicide moves in plants

Examples

Demethylation inhibitor (DMI) or FRAC 3 compounds – inhibits a specific enzyme in fungi that is important in sterol production
- Sterols are necessary in fungal cell walls
- Lack of Sterols result in abnormal fungal growth

Quinone outside inhibitors (QoI) or FRAC 11 (Strobilurins) – inhibit mitochondrial respiration, stopping energy production, and resulting in fungal death
- Effective on germinating spores and early fungal growth only
Some Major Reasons for Poor Control when using a Fungicide

• Fungicides applied after infection
• Improper crop phenology application timing
• Inherently low effectiveness of the fungicide on the target pathogen
• Development of fungicide resistance
Fungicide Applied After Infection
Fungicide Mobility

• Contacts (ex. Bravo or Dithane)
  – Applied to the surface of a plant
  – Do not move on the surface or into the plant
  – Can be readily washed from the plant surface
  – New plant growth must be protected
  – Used preventatively only

• Penetrants (ex. Headline or Tilt)
  – Local penetrant; can move into the waxy cuticle ONLY
  – Translaminar penetrant; can move from one side of the leaf to the other
  – Acropetal penetrant; move only upwards in a plant in a water potential gradient
  – Systemic penetrant; move upwards and downwards in a plant; very few fungicides actually move systemically
**Basic Infection and Fungicides**

- **Contact (Preventative)**
- **Penetrant (Eradicative?)**

  **Infection**
  - **Symptom Appearance**
  - **Spores develop**
  - **Spores spread**

**Fungicide application at this stage in the epidemic is used to protect plants not already infected.**
- **Plants already infected can not be cured**
- **Important to scout and catch the epidemic early**
Sclerotinia Fungicide Timing Trials

- Omega (Fluazinam; 29) vs. Endura (Boscalid; 7)

- If limited to one or two fungicide applications; which is most important (limited to three applications by the label)

2004 Disease Index Yield
First Application Effects
1. Check vs. Expt. Treats. 6.84 ns -792.20 *
2. No fungicide vs. Fungicide 5.75 ns -975.65**

2005 Disease Index Yield
Second Application Effects
1. Check vs. Expt. Treats. 2.80 ns -264.60 ns
2. No fungicide vs. Fungicide 3.68 ** 11.82 ns

2006 Disease Index Yield
Third Application Effects
1. Check vs. Expt. Treats. 3.85 * -263.63 ns
2. No fungicide vs. Fungicide 1.43 ns -171.60 ns

Field Crops Pathology
Controlled Greenhouse Evaluations

No fungicide or fungicide applied (Endura or Omega 500F)

- 4 day pre-inoculation
- 2 day pre-inoculation
- At inoculation
- 2 day post-inoculation
- 4 day post-inoculation
### Treatments vs. Untreated Check

- Overall difference in the performance of fungicide formulations was negligible
- Fungicide applied 4 days post-inoculation did not control Sclerotinia any better than the untreated check

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Estimated Difference</th>
<th>Significance of Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endura 4-day pre-inoculation</td>
<td>-1.5989</td>
<td>**</td>
</tr>
<tr>
<td>Endura 2-day pre-inoculation</td>
<td>-2.1002</td>
<td>**</td>
</tr>
<tr>
<td>Endura at inoculation</td>
<td>-1.3275</td>
<td>**</td>
</tr>
<tr>
<td>Endura 2-day post-inoculation</td>
<td>-1.3106</td>
<td>**</td>
</tr>
<tr>
<td>Endura 4-day post-inoculation</td>
<td>-0.4002</td>
<td>NS</td>
</tr>
<tr>
<td>Omega 4-day pre-inoculation</td>
<td>-1.4078</td>
<td>**</td>
</tr>
<tr>
<td>Omega 2-day pre-inoculation</td>
<td>-1.5098</td>
<td>**</td>
</tr>
<tr>
<td>Omega at inoculation</td>
<td>-1.0507</td>
<td>**</td>
</tr>
<tr>
<td>Omega 2-day post-inoculation</td>
<td>-0.9373</td>
<td>**</td>
</tr>
<tr>
<td>Omega 4-day post-inoculation</td>
<td>-0.2666</td>
<td>NS</td>
</tr>
<tr>
<td>Untreated Check</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

** = Statistically different; NS = Not Statistically different
Improper Crop Phenology Application Timing: The Case of Sclerotinia Stem Rot of Soybean
Sclerotinia Stem Rot (SSR) or White Mold
Field Crops Pathology

Host

Environment

Pathogen

Infection court
SSR Fungicide Recommendations

• Maintain excellent records of field history and disease incidence of white mold
• Fungicides may be warranted in fields with history of white mold and where risk of white mold is high
  – Should be applied at R1 for best results
• R3 applications of fungicide were not as effective at controlling white mold applications as were R1 applications
• Applications after flowering generally ineffective

Inherently Low Effectiveness of the Fungicide: Proper Disease Identification is Critical
Consider Diseases of Wheat

- Consider crop phenology and corresponding diseases during that time
- Proper ID of disease is important
- No “silver bullet” fungicide
- Wide variation in efficacy among fungicides on various diseases of wheat
Winter dormancy
Management of Small Grain Diseases
Fungicide Efficacy for Control of Wheat Diseases (Revised 4-17-12)

The North Central Regional Committee on Management of Small Grain Diseases (NCERA-184) has developed the following information on fungicide efficacy for control of certain foliar diseases of wheat for use by the grain production industry in the U.S. Efficacy ratings for each fungicide listed in the table were determined by field testing the materials over multiple years and locations by the members of the committee. Efficacy is based on proper application timing to achieve optimum effectiveness of the fungicide as determined by labeled instructions and overall level of disease in the field at the time of application. Differences in efficacy among fungicide products were determined by direct comparisons among products in field tests and are based on a single application of the labeled rate as listed in the table. Table includes most widely marketed products, and is not intended to be a list of all labeled products.

### Efficacy of fungicides for wheat disease control based on appropriate application timing

<table>
<thead>
<tr>
<th>Class</th>
<th>Active ingredient</th>
<th>Product</th>
<th>Rate/A (fl oz)</th>
<th>Powdery mildew</th>
<th>Stagonospora leaf/gum blotch</th>
<th>Septoria leaf blotch</th>
<th>Tan spot</th>
<th>Stripe rust</th>
<th>Leaf rust</th>
<th>Stem rust</th>
<th>Head scab</th>
<th>Harvest Restriction</th>
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<tbody>
<tr>
<td>Strobilurin</td>
<td>Fluoxastrobin 40.3%</td>
<td>Evito 480 SC</td>
<td>2.0 – 4.0</td>
<td>G</td>
<td>-3</td>
<td>-3</td>
<td>VG</td>
<td>-3</td>
<td>VG</td>
<td>-3</td>
<td>NL</td>
<td>40 days</td>
</tr>
<tr>
<td></td>
<td>Pyraclostrobin 23.6%</td>
<td>Headline SC</td>
<td>6.0 – 9.0</td>
<td>G</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>G</td>
<td>NL</td>
</tr>
<tr>
<td>Triazole</td>
<td>Metconazole 8.6%</td>
<td>Caramba 0.75 SL</td>
<td>10.0 – 17.0</td>
<td>VG</td>
<td>VG</td>
<td>-3</td>
<td>VG</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>G</td>
<td>30 days</td>
</tr>
<tr>
<td></td>
<td>Propiconazole 41.8%</td>
<td>Tilt 3.6 EC</td>
<td>4.0</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>P</td>
<td>Feakes 10.5</td>
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<tr>
<td></td>
<td>Prothioconazole 41%</td>
<td>Proline 480 SC</td>
<td>5.0 – 5.7</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>G</td>
<td>30 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tebuconazole 38.7%</td>
<td>Follicur 3.6 F</td>
<td>4.0</td>
<td>G</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>F</td>
<td>30 days</td>
</tr>
<tr>
<td></td>
<td>Prothioconazole 19%</td>
<td>Prosaro 421 SC</td>
<td>6.5 – 8.2</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>G</td>
<td>30 days</td>
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<tr>
<td></td>
<td>Metconazole 7.4%</td>
<td>TwinLine 1.75 EC</td>
<td>7.0 – 9.0</td>
<td>G</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>VG</td>
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<tr>
<td></td>
<td>Pyraclostrobin 12%</td>
<td>Triazole 1.0%</td>
<td>4.0</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>VG</td>
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<td></td>
<td>Propiconazole 11.7%</td>
<td>Quilt 200 SC</td>
<td>14.0</td>
<td>VG</td>
<td>VG</td>
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<td>VG</td>
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<tr>
<td></td>
<td>Azoxystrob tin 7.0%</td>
<td>Quilt Xcel 2.2 SE</td>
<td>10.5 – 14.0</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
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<td></td>
<td>Propiconazole 11.7%</td>
<td>Strate gico 250 EC</td>
<td>10.0</td>
<td>VG</td>
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<td>NL</td>
<td>35 days</td>
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<tr>
<td></td>
<td>Azoxystr obin 11.4%</td>
<td>Trioxystrobin 11.4%</td>
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<td>NL</td>
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<tr>
<td></td>
<td>Prothioconazole 10.8%</td>
<td>Strate gico YLD</td>
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<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
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<td>VG</td>
<td>VG</td>
<td>NL</td>
<td>35 days</td>
</tr>
<tr>
<td></td>
<td>Trioxystrobin 22.8%</td>
<td>Absolute 500 SC</td>
<td>5.0</td>
<td>G</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>VG</td>
<td>NL</td>
<td>35 days</td>
</tr>
</tbody>
</table>

1. Efficacy categories: NL=Not Labeled and Not Recommended; P=Poor; F=Fair; G=Good; VG=Very Good; E=Excellent.
2. Efficacy may be significantly reduced if slow strobilurin products are applied after stripe rust infection has occurred.
3. Insufficient data to make statement about efficacy of this product.
4. Multiple generic products containing the active ingredients propiconazole and tebuconazole may also be labeled in some states. Products including tebuconazole include: Embrace, Monsoon, Muscle 3.6 F, Onset, Orlis 3.6 F, Tebucon 3.6 F, Tebus ter 3.6 F, Tegal, and Toledo. Products containing propiconazole include: Bumper 41.3 EC, Fitness, Propiconazole E-AG, and PropiMax 3.6 EC.

This information is provided only as a guide. It is the responsibility of the pesticide applicator by law to read and follow all current label directions. No endorsement is intended for products listed, nor is criticism meant for products not listed. Members or participants in the NCERA-184 committee assure no liability resulting from the use of these products.
Fungicide Resistance
Fungicide Resistance

Genetic adjustment of a fungus that leads to reduced sensitivity to a fungicide
- Repeated use of the same fungicide mode of action
- Improper spray volume
- Off-label rates are used, etc.

Recommended Fungicide Use Patterns

Non-recommended Fungicide Use Patterns

= Sensitive Individuals

= Resistant Individuals
MANAGING FUNGICIDE RESISTANCE

- Plant disease resistant hybrids/varieties whenever possible.
- Maintain proper soil fertility
- Scout fields on a regular basis noting incidence and severity of diseases. Use this information to develop a field history for future disease management decisions.
- Avoid sites with a history of high disease pressure
- Utilize a crop rotation that fits your area and field history
- Tank mix high-risk fungicides with fungicides that have different modes of action, are active against the targeted disease(s), and have similar lengths of residual activity.
- Do not use reduced rates of fungicides.
- Alternate or tank mix fungicides with different modes of action when multiple applications are required.
- Apply fungicides preventively or early in the disease cycle and when a disease threat is warranted.
- Avoid curative fungicide applications, especially with high-risk fungicides.
- Always read and follow the pesticide label
  - for maximum number of sprays per season
  - for recommended application rates
  - for application timing for both target disease and plant growth stage.
Updated Resources
Available at UW IPCM Website - http://ipcm.wisc.edu/downloads/pest-management/

What's on your seed?
Seed treatment chemicals and the number of treatments can vary depending on the disease pressure. Chemicals can be used to control plant pathogens, selective plant pathogens, or non-selective plant pathogens. The number of treatments can be varied according to the disease pressure and the number of treatments can be varied depending on the disease pressure.

Updated and available

Updated and soon to be available

Guidelines for fungicide resistance management

- Plant disease resistant hybrids/varieties whenever possible
- Scout fields; on a regular basis, noting incidence and severity of diseases. Use this information to develop a field history for future disease management decisions.
- Tank mix high-risk fungicides with fungicides that have different modes of action, are active against the targeted diseases, and have similar lengths of residual activity.
- Do not use reduced rates of fungicides.
- Alternates or mix fungicides with different modes of action when multiple applications are required.
- Apply fungicides preventively or early in the disease cycle, and when a disease threat is monitored.
- Avoid curative fungicide applications, especially with high-risk fungicides.

Always read and follow the pesticide label
- For maximum number of sprays per season.
- Do not recommended application rates.
- For application timing for both target disease and plant growth stages.
QUESTIONS?

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