Fungicides 101
**Fungicide**: A chemical substance that destroys or inhibits the growth of fungi

**Product name**: Every pesticide has a product name or a trade name.

**active ingredient**: chemically active component of a formulated product usually doubles as the common name of the product

e.g.  Quadris ®, Abound ®
active ingredient:  azoxystrobin
common name:  azoxystrobin
Pesticide labels

Note: Section 18 label will differ from Section 3 label

By law, certain kinds of information must appear on a pesticide label. People who use pesticides have the **LEGAL** responsibility to read, understand and follow the label directions.

Type of info on label includes:

- Hazards to humans and animals, environment
- Agricultural use requirements
- Storage and disposal
- Management –resistance, spray drift
- Spraying and mixing
- Tank mix compatibility
Categories

- chemical group
- mode of action
- breadth of activity
- mobility within the plant
- role in protection
Chemical group:

- name given to a group of chemicals that share common mode of action
  e.g. Strobilurins – inhibit respiration
       Triazoles – inhibit sterol biosynthesis
- may or may not have similar chemical structure
**Mode of action (MOA)**

Fungicides kill by:

• Damaging cell membranes
• Inactivating critical enzymes or proteins
• Interfering with key metabolic processes, e.g. respiration

***IMPORTANT:***

Know mode of action of fungicide because:

• know which diseases can be controlled by the fungicide
• use different MOA in disease management program to delay fungicide resistance development
Breadth of activity

Single-site:

• active against only one point in one metabolic pathway of pathogen or a single enzyme or protein needed by the fungus

  • e.g. specific enzyme: demethylase – triazoles
    succinate dehydrogenase -strobilurins
    ubiquinol oxidase – carboxamides

  • highly specific therefore increased chance of fungus becoming resistant

Multi-site:

• e.g. chlorothalonil
Mobility within the plant

Fungicide applied
Mobility within the plant

Contact (protectant)

Droplets spread out on the surface where deposited; do not move inside

Leaves produced after the application are not protected

No chemical = no protection
Mobility within the plant

Locally systemic (translaminar)

Droplets spread out on and move inside leaf tissue = external and internal protection

Leaves produced after the application are not protected

No chemical = no protection
Mobility within the plant

Systemic (acropetal)

Droplets spread out on and move inside leaf tissue = external and internal protection; Fungicide on the stem moves upwards in the xylem to new growth

Leaves produced after the application protected

No chemical = rely on fungicide via xylem
Role in Protection

**Preventative:**
- contact action
- prevent spore germination and infection
- contact and systemic fungicides

**Curative:**
- kill mycelium and fruiting bodies within the leaf
- systemic fungicides
Strobilurins (= QoI fungicides)

- Common mode of action (inhibits respiration) but definite practical differences:

<table>
<thead>
<tr>
<th></th>
<th>azoxystrobin</th>
<th>pyraclostrobine</th>
<th>trifloxystrobin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>e.g. Quadris®</td>
<td>e.g. Headline®</td>
<td>e.g. in Stratego®</td>
</tr>
<tr>
<td>Uptake into leaf</td>
<td>low</td>
<td>very low</td>
<td>very low</td>
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<tr>
<td>Metabolic stability</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>within leaf</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Translaminar</td>
<td>yes</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>movement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xylem systemic</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Phloem mobile</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>
Redistribution of strobilurins in wheat to control PM

Bartlett et al, 2002

e.g. Quadris ®
e.g. in Stratego ®
Strobilurins (cont.)

- Broad spectrum

- Inhibit spore germination therefore excellent preventatives

- Best time to apply: prior to infection or very early stages of disease development
  
  Bartlett et al, 2002

- Quadris ® = 22-30d activity

- Even at lowest recommended rate = Quadris ® most expensive treatment for rust (could this result in growers using reduced rates?)

  Draper et al, 2004
Strobilurins (cont.)

Additional effects

- “greening effect” – maintain green leaf area longer
- Cereal fungicide programs: stobilurin-based vs triazole-based
  - disease control = similar
  - yield response = different
- two hypotheses:
  1. Physiological – e.g., PS activity, chlorophyll content, plant hormone levels, nitrase reductase activity, ethylene biosynthesis
  2. Stops host defense response (energy demanding)
- Soybean ???
**Triazoles** (= DMI fungicides)

- common mode of action (inhibit cell membrane ergosterol synthesis)
- Broad spectrum
- does not prevent spore germination and early germ tube growth because reserves in spore
- Rapidly penetrates young leaf and stem tissue (↑ warm T°)
- Xylem systemic – i.e. upward movement
- $T_{1/2}$ inside plant = 14 days
- Must be inside plant tissue to be absorbed by fungus
Preventative is key (Preventative, Not Curative)

- If lesions or pustules are present its too late for preventative – Must have curative MOA included

Two MOA’s are best overall program in Brazil

Strobilurins have long residual and give preventative control

Triazoles provide strobilurins a short curative affect to stop sporulation on current foliage

Prevention, Protection, Profit
Strobilurins
Fungicide MOA’s for SBR Control

- Pyraclostrobin (Headline) best strobi in rust efficacy and duration of control
- Preventative application is KEY
- Provide control of germinating spores prior to infection
- Little control of existing infections once in plant
- Offer residual control to prevent new infection
  - New foliage requires new application

Relative SBR control as part of program
- Pyraclostrobin > Azoxystrobin >> Trifloxystrobin

= Headline ® > Quadris ® >> one of a.i. in Stratego ®
Triazoles
Fungicide MOA’s for SBR Control

- Provides control of existing infections
- May prevent sporulation from internal infections
- Short residual 7-10 days
  - New foliage requires new applications
  - Will not prevent new infections unless multiple applications
  - Propiconazole limited to 2 applications with Section 18 exemption
- Triazole rates raised to highest max levels on label
  - Ex: Propiconazole 4-8 oz/a vs. 2-4 oz for other uses

Relative SBR control
Metconazole = Tebuconazole = Tetraconazole > Mycobutanil >> Propiconazole

? = Folicur ® = Domark™ > Laredo™ >> Tilt (®)/Propimax™ /Bumper ®/a.i. in Stratego ®
Alternatives to fungicides

Brazil – rotation with corn
  avoid volunteer soybeans (inoculum source)
  plant early maturing varieties (avoidance)
  “look promising”
  J. Yorinori

Zimbabwe – breeding program: in progress
  adjust planting date: unsuccessful

South Africa - plant spacing (between row and density)
  different maturity groups
  no benefit
  maybe???

Rouging infected plants
Other foliar fungicides registered in U.S. on legumes
(some for organic use?)

- carbonic acid, monopotassium salt (Armicarb) – soybeans, lima beans, green beans, dry beans
- cinnamaldehyde (Cinnacure) – soybeans (for rust)
- coppers – soybeans, lima beans, dry beans, green beans
- harpin (Messenger) – soybeans, dry beans
- hydrogen peroxide (Rezistox) – dry beans (for rust)
- neem oil – soybeans (for rust)
Other foliar fungicides - Continued

• potassium phosphate, monobasic (Nutrol) – soybeans, lima beans, dry beans
• potassium salts of fatty acids (M-pede) – soybeans
• sulfur – soybeans; lima beans, dry beans, green beans, and cowpeas (for rust)
• thiabendazole (Mertect) – soybeans
• thiophanate-methyl (Topsin M) – soybeans
• ziram – lima beans
Avoiding Resistance

- Limit number of sprays
- Spray only when needed
- Spray early when populations small
- Use proper rates; ensure good coverage
- Rotate with different MOA and non-systemic compounds
- Mix with different groups or non-systemic compounds
Suggested product use regime
(National Soybean Rust Working Group NC504)

Growth stages: R1(flowering) – R5 (full pod)

A. Preventative / Conservative

Reliable reports – rust potential high in your area but not yet detected locally

1\textsuperscript{st} application: strobilurin or premix product *

2\textsuperscript{nd} application (If needed): triazole or chlorothalonil

(3 weeks after 1\textsuperscript{st} application)

3\textsuperscript{rd} application (If needed):

(2 weeks after chlorothalonil) triazole

(3 weeks (premix used 1\textsuperscript{st} applic.)) strobilurin

* Section 18 still pending
Proposed edits (Monte Miles) to NC504 scenarios:

1. Sipcam Agro – chlorothalonil only use before rust is present
2. Strobilurins should only be used as preventatives
3. FRAC (Fungicide Resistance Action Committee) recommendations (and section 18 requirements!):
   * total of 2 applications of strobilurin and or triazole per season *
   Therefore no 3rd application unless chlorothalonil used 1st
Suggested product use regime
(National Soybean Rust Working Group NC504)

Growth stages: R1 (flowering) – R5 (full pod)

C. Curative

Rust is present at low levels in lower to mid-canopy in yours or a neighbor's fields

1\textsuperscript{st} application: triazole

2\textsuperscript{nd} application (If needed): minimal level disease strobilurin premix product *

3\textsuperscript{rd} application (If needed): chlorothalonil

* Section 18 still pending
BASF Recommendation
Asian Soybean Rust

Rust NOT Present in Field or Area

Application 1: Headline 6-12 oz/acre + adjuvant
   *R1 – R3 stage

Application 2: Headline 6 oz/acre + Triazole + Adjuvant
   * 21-28 days after 1st application or monitoring shows disease (if required)

Rust Present or Suspected in Field or Area

Application 1: Headline 6-12 oz/acre + Triazole + adjuvant
   *Monitoring shows disease or local presence of spores

Application 2: Headline 6 oz/acre + Triazole + Adjuvant
   * 21-28 days after 1st application or if monitoring shows disease

- Headline residual activity prevents rust spore germination
- All triazoles compatible with Headline
- Triazole provides curative control of infections occurring on new foliage emerged since 1st application

Headline not registered for use on soybeans yet!!!

Alison says:
Timeline to assess the risk of soybean rust for a growing season

X.B. Yang (see www.soybeanrust.info)

**January February**
- Assessments = little value

**March**
- Monitor information for rust outbreaks in Florida and S. Texas

**April May**
- Rust in LA, MA or AL - spores likely to reach NC region by July

**June**
- Rust in LA, MA or AL - still important but decreased risk

**July August**
- Normal to below normal $T^o$
- Normal to above normal moisture
- Increased risk for NC region