Impact of Fungicides on Plant Health

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Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties.

In addition, such an application may also result in illegal residues that could subject the crop to seizure or embargo action.

It is your responsibility to check the label before using any product to ensure lawful use, and obtain all necessary permits in advance.
Fungicides

- Modes of action
- Broad spectrum vs. narrow spectrum
- Contact vs. systemic
- Protectant vs. curative
- Efficacy also affected by:
  - Timing of application, coverage, rate

- **Management of resistance to fungicides:**
  - Fungicide Resistance Action Committee (FRAC) Groups
  - Single-site mode of action = high risk groups
  - Rotate groups, don’t use reduced application rates, minimize
  - # of applications of a FRAC Group back-to-back & per season

PNW Disease Management Handbook
https://pnwhandbooks.org/plantdisease/pesticide-articles
Prior to 2000: Rare foliar applications of fungicides in corn in USA (Vincelli 1999)
- No appreciable losses to foliar fungal diseases, crop rotation & disease resistance sufficed

Since 2000: Major increase in foliar fungicide use (Esker et al. 2018)
- Increased risk of foliar fungal diseases (shorter rotations, reduced tillage)
- Grain prices increased
- Hybrids with greater yield potential
- Less yield response needed to pay for fungicides
- Registration of strobilurin fungicides (FRAC Group 11)
- Aggressive marketing & promotion of these fungicides for enhancing plant health & yield in absence of disease

By 2011, fungicides applied to >10 million acres corn in USA, including 22.5% of corn acres planted in Illinois
Strobilurin Fungicides

- **FRAC Group 11 = QoI inhibitors**
- **Mode of action:**
  - interfere with energy production in fungal cell
  - block electron transfer at quinol oxidation site (QoI) in cytochrome $bc_1$ complex, preventing ATP formation
- **Azoxystrobin, pyraclostrobin, trifloxystrobin, kresoxim-methyl, picoxystrobin, fluoxastrobin, oryzastrobin, dimoxystrobin, ...**
- Suppresses fungi, inhibits electron transfer in mitochondria, disrupts metabolism, prevents fungal growth

http://www.apsnet.org/edcenter/advanced/topics/pages/strobilurinfungicides.aspx

Vincelli 2012
Mobility of Trifloxystrobin

1. Surface redistribution
   Trifloxystrobin is redistributed locally on the surface of the turfgrass plant.

2. Penetration of waxy cuticle
   Trifloxystrobin has a high affinity with the plant surface and is absorbed by the waxy layers of the plant.

3. Translaminar activity
   Trifloxystrobin penetrates plant tissue using translaminar activity but there is little or no transport within the vascular system of the plant.

4. Vapor phase redistribution
   Trifloxystrobin redistributes on the plant surface and adjacent blades by limited vapor movement and reabsorption.

Vincelli 2012
Strobilurins & Plant Health

• Several cause growth-promoting effects in some plants, independent of disease pressure
• Example: Kresoxim methyl
  • Changes in wheat hormonal balance
  • Delayed leaf senescence
  • Water-conserving effects
  • Increased grain yield
• Effects influenced by:
  • Crop species
  • Specific strobilurin fungicide
  • Environmental conditions

Vincelli 2012
For use in registered crops for disease control and plant health

EPA Reg. No. 7969-186

Active Ingredient*: pyraclostrobin (carbamic acid, [2-[[1-(4-chlorophenyl)-1H-pyrazol-3-yl] methoxy-, methyl ester])

Preventive applications of **Headline** optimize disease control and provide improved plant health. The plant health benefits may include improved host plant tolerance to yield-robbing environmental stresses, such as drought, heat, cold temperatures, and ozone damage. **Headline** can improve plant utilization of nitrogen and can increase tolerance to bacterial and viral infections. These benefits often translate to healthier plants producing greater yields at harvest, especially under stressful conditions. Additional examples of specific benefits that can occur include:

- **Barley, Rye, Wheat.** Improved straw strength and better harvestability. In wheat, better tolerance to hail.
- **Citrus.** Increased fruit size, earlier fruit maturity and coloration.
- **Corn.** Improved stalk strength and better harvestability, induced tolerance to stalk diseases, better tolerance to hail, more uniform seed size.
- **Mint.** Improved tolerance to frost.
- **Potatoes.** Improved quality, such as reduced sugar ends and larger tubers.
- **Soybeans and Edible Legumes.** Better seed quality, more uniform seed size.
Fungal Resistance to Strobilurins

- Widespread use of FRAC 11 products in absence of disease:
  - Violation of core principles of IPM? (Wise & Mueller 2011)
  - Many research trials demonstrated inconsistent profitability under low foliar disease pressure (Esker et al. 2018)

- Mode of action = site-specific
- One mutation at target biochemical site can result in a resistant strain
- Repeated applications can build fungicide-resistant pathogen subpopulation
- QoI fungicide use worldwide has revealed high risk of resistant isolates developing for many pathogens

http://www.apsnet.org/edcenter/advanced/topics/pages/strobilurinfungicides.aspx
Strobilurins & Plant Health

Effects of foliar applications on hail-damaged corn

1. Bradley & Ames (2010) study = response to supplementary label for Headline:
   - 2007, 2008 field trials simulated hail damage
   - Applied Headline & Quadris (azoxystrobin)
     - Fungicides reduced gray leaf spot severity but did NOT increase yield
     - Simulated hail increased disease, reduced yield

2. Sisson et al. (2016): 5 site-years in IA
   - Slight economic benefit from Headline AMP (pyraclostrobin + metconazole) applied 8 days after simulated hail damage
Meta-analysis of yield response of field corn to foliar fungicide applications in U.S. corn belt (Paul et al. 2011)

- 2002-2009 trials in 14 states, 4 fungicide treatments + control
- Yield differences highly variable
- All fungicides increased yield
- Probability of failure to recover fungicide application cost ($16-$38/A):
  - 0.55-0.98 if disease severity <5%
  - 0.25-0.95 if disease severity >5%
- Foliar applications unlikely profitable when disease severity is low & yield expectations are high
Soybean studies with foliar fungicide applications in the absence of foliar disease pressure

- Swoboda & Pedersen (2009):
  - 2005-2006 trials, tebuconazole, pyraclostrobin, or both
    - No physiological effects or yield increases
    - Environ. conditions & disease levels should guide applications
- Kyveryga et al. (2013):
  - 282 on-farm trials in IA with pyraclostrobin from 2005-09
    - 218 trials – fungicide-induced greening effect
    - 35% more likely profitable yield responses
    - Rainy spring conditions enhance effect
  - Inconsistent effect among FRAC groups 3, 7, 11
  - Yield responses can occur but market prices & application costs limit profitability when low disease/insect pressure
- Kandel et al. (2018): on-farm trials & small plot trials
  - Yield response observed in absence of foliar disease
Other crops

• Khan & Carlson (2009): SUGAR BEET
  • 2005-2008 trials, 5 fungicides, no foliar diseases
    • No differences in root yield, recoverable sucrose, sucrose concentration, & respiration in storage
• Mahoney & Gillard (2014): DRY BEAN
  • 2006-2009 trials with pyraclostrobin & azoxystrobin, with & without simulated hail damage
    • Fungicides reduced incidence of discolored seeds but not seed weight or yield, regardless of hail injury or not
• Craven et al. (2017): SORGHUM
  • Triazole & strobilurin fungicide combinations, 4 cultivars, 2 years, 3 sites/year in South Africa
    • Foliar applications did not result in reliable impact on senescence, biomass, or yield to warrant prophylactic applications
Perceptions of midwestern crop advisors & growers on foliar fungicide use in corn (Esker et al. 2018)

Surveyed certified crop advisors (CCAs) & corn growers (CGs) in IA, IL, OH, WI re. foliar fungicide use perceptions (2005-09)

84% of CGs = 1st time use of foliar fungicide applications in 2005-2009
Fig. 2. Proportions of CCAs & CGs who perceived these factors as very or extremely important to corn production (Esker et al. 2018)
Fig. 4A. Proportions of CCAs who recommended foliar fungicide applications, & CGs who made foliar applications during 2005-2009 (Esker et al. 2018)

- 73% of CCAs recommended foliar applications
- Only 35% of CGs used foliar fungicide applications
- Positive & negative yield responses observed by CCAs & CGs
- Diseases were more important to CGs than CCAs, CGs more conservative about perceived benefits
• CCAs overestimated how much CGs willing to spend
• 60% of CGs not willing to spend more than $37/ha ($15/A)
Other effects of fungicides on plants

Effect of Tanos (famoxadone + cymoxanil, FRAC Groups 11+27) on efficacy of copper hydroxide for control of carrot bacterial blight

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**du Toit & Derie (2008) PDMR 2:V009**

- **Non-inoculated control**
- **Inoculated control**
- **Tanos**
- **Kocide 3000**
- **Kocide + Tanos**
- **ManKocide DF**
- **ManKocide + Tanos**

**Severity of bacterial blight (0-5)**

- '2 weeks after inoculation
- '3 weeks after inoculation
- '4 weeks after inoculation
- '5 weeks after inoculation

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Fungicides & Plant Health

• Foliar applications of fungicides for enhanced plant health in absence of disease remains controversial
  • Violation of core principles of IPM (Wise & Mueller 2011)
  • Inconsistent benefits observed
  • Economic profitability doesn’t seem to warrant use under low foliar disease pressure (Esker et al. 2018)
  • Various studies to account for variability in responses – small plot trials vs. large-scale, on-farm trials, plot border effects, etc.

• Enhanced risk of resistance to site-specific fungicides, particularly when used on extensive acreage
• Cannot afford increased risk, especially specialty crops with fewer fungicide registrations