AZOLES:

Importance for Food Safety and Security - A Case Example

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

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CROP PROTECTION NETWORK
A Product of Land Grant Universities

Fungicide mode of action
Group 11 QoI Strobilurins
Group 3 DMI Triazoles
Group 7 SDHI

Fungicide Efficacy for Control o Corn Diseases Table (04/2022)

	Active Ingredient (%)	Product/Trade name
11	Azoxystrobin 22.9%	Quadris 2.08 SC, multiple gen
11	Pyraclostrobin 23.6%	Headline 2.09 EC/SC
11	Picoxystrobin	Aproach 2.08 SC
3	Flutriafol 20.9%	Xyway LFR 1.92 SC Xyway 3D 2.5 SC
3	Propiconazole 41.8%	Tilt 3.6 EC, multiple generics
3	Prothioconazole 41.0%	Proline 480 SC
3	Tebuconazole 38.7%	Folicur 3.6 F, multiple generic
3	Tetraconazole 20.5%	Domark 230 ME
11	Azoxystrobin 13.5%	Quilt Xcel 2.2 SE,
3	Propiconazole 11.7%	multiple generics
7	Benzovindiflupyr 2.9%	
11	Azoxystrobin 10.5%	Trivapro 2.21 SE
3	Propiconazole 11.9%	
3	Cyproconazole 7.17%	Aproach Prima 2.34 SC
11	Picoxystrobin 17.94%	
3	Flutriafol 19.3%	Fortix 3.22 SC
11	Fluoxastrobin 14.84%	Preemptor 3.22 SC
3	Flutriafol 26.47%	Lucento
7	Bixafen 15.55%	
3	Flutriafol 18.63%	TopGuard EQ
11	Azoxystrobin 25.30%	
3	Mefentrifluconazole 17.56%	Veltyma
11	Pyraclostrobin 17.56%	
3	Mefentrifluconazole 11.61%	
11	Pyraclostrobin 15.49%	Revytek
7	Fluxapyroxad 7.74%	
3	Prothioconazole 16.0%	Delaro325 SC
11	Trifloxystrobin 13.7%	
3	Prothioconazole 14.9%	
7	Trifloxystrobin 13.1%	Delaro Complete 3.83 SC
11	Fluopyram 10.9%	
7	Pydiflumetofen 7.0%	
11	Azoxystrobin 9.3%	Miravis Neo 2.5 SE
3	Propiconazole 11.6%	
11	Pyraclostrobin 28.58%	Priaxor 4.17 SC
7	Fluxapyroxad 14.33%	
11	Pyraclostrobin 13.6%	Headline AMP 1.68 SC
3	Metconazole 5.1%	
11	Trifloxystrobin 32.3%	Stratego YLD 4.18 SC
3	Prothioconazole 10.8%	
3	Tetraconazole 7.48%	Affiance 1.5 SC
11	Azoxystrobin 9.35%	

Indicates product with mixed fungicide classes

[1] Fungicide application timing is extremely important and needs to be made ne
restrictions are listed for field corn harvested for grain. Restrictions may vary for
is available for several fungicides for control of tar spot, however efficacy data a
only as a guide. It is the applicator's legal responsibility to read and follow all cu
only and does not constitute an endorsement or recommendation by the CDWG
manufacturer. Members or participants in the CDWG assume no liability resultin

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Fungicide Efficac Soybean Foliar D

	Active Ingredient (%)	Pro
11	Azoxystrobin 22.9%	Luc
11	Fluoxastrobin 40.3%	Fort
11	Picoxystrobin 22.5%	
11	Pyraclostrobin 23.6%	
3	Cyproconazole 8.9%	
3	Flutriafol 11.8%	
3	Propiconazole 41.8%	Del
3	Prothioconazole 41.0%	
3	Tetraconazole 20.5%	
7	Boscalid 70%	
7	Inpyrfluxam 31.25%	
1	Thiophanate-methyl	Mir
29	Fluazinam 40.0%	
11	Azoxystrobin 25.3%	Pria
3	Flutriafol 18.63%	
11	Azoxystrobin 18.2%	
3	Difenoconazole 11.4%	
11	Azoxystrobin 19.8%	
3	Difenoconazole 19.8%	
11	Azoxystrobin 7.0%	
3	Propiconazole 11.7%	
11	Azoxystrobin 13.5%	
3	Propiconazole 11.7%	
7	Benzovindiflupyr 2.9%	
11	Azoxystrobin 10.5%	
3	Propiconazole 11.9%	
3	Cyproconazole 7.17%	
11	Picoxystrobin 17.94%	
7	Fluopyram 17.4%	
3	Prothioconazole 17.4%	

Indicates product with mixed fungicide classes

[1] Multiple fungicides are labeled for soybe
as chlorothalonil may also be labeled for
[3] Cercospora leaf blight efficacy relies on a
or later applications; however, efficacy ha
resistance has been detected in the funga
fungicides may be more effective than in
disease symptoms are already present at
etc.) and soybean for other uses such as f
based on two applications of a 9 fl oz/A ra

Many products have specific use restrictio
read and follow all specific use restriction
current label directions. Reference to prod
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Table continued from previous page

Fungicide Efficacy Soybean Foliar Dis

	Active Ingredient (%)	Pro
7	Bixafen 15.5%	Luc
3	Flutriafol 26.47%	
11	Fluoxastrobin 14.84%	Fort
3	Flutriafol 19.3%	
11	Trifloxystrobin 13.7%	Del
3	Prothioconazole 16.0%	
7	Fluopyram 10.9%	
11	Trifloxystrobin 13.1%	Del
3	Prothioconazole 14.9%	
7	Pydiflumetofen 6.9%	Mir
3	Difenoconazole 11.5%	
11	Pyraclostrobin 28.58%	Pria
7	Fluxapyroxad 14.33%	
7	Fluxapyroxad 14.33%	
11	Pyraclostrobin 28.58%	Pria
3	Tetraconazole 20.50%	
11	Trifloxystrobin 32.3%	Stra
3	Prothioconazole 10.8%	
11	Azoxystrobin 9.35%	Affi
3	Tetraconazole 7.48%	
11	Fluoxastrobin 17.76%	Zole
3	Tetraconazole 17.76%	
1	Thiophanate-methyl 21.3%	Acr
3	Tetraconazole 4.2%	
7	Fluxapyroxad 7.74%	
11	Pyraclostrobin 15.49%	Rev
3	Mefentrifluconazole 11.61%	
11	Pyraclostrobin 17.56%	Velt
3	Mefentrifluconazole 17.56%	

[1] Multiple fungicides are labeled for soybean rus
as chlorothalonil may also be labeled for use.
[3] Cercospora leaf blight efficacy relies on accurat
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UNITED SOYBEAN BOARD
The CPN would like to thank the United Soybean Board for their support of this publication.

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Fungicide mode of action groups:
Group 11 QoI Strobilurins
Group 3 DMI Triazoles
Group 7 SDHI Carboxamides

Efficacy categories:
P=Poor; F=Fair; G=Good; VG=Very Good; E=Excellent;
NL = Not Labeled for use against this disease; NR=Not Recommended;
U = Unknown efficacy or insufficient data to rank product

Efficacy of Fungicides for Wheat Disease Control Based on Appropriate Application Timing (03/2021)

	Active Ingredient (%)	Product/Trade name	Rate/A (fl oz)	Powdery mildew	Stagonospora leaf/glume blotch	Septoria leaf blotch	Tan spot	Stripe rust	Leaf rust	Stem rust	Head scab[4]	Harvest restriction
11	Picoxystrobin 22.5%	Aproach SC	6.0 – 12.0	G[1]	VG	VG[2]	VG	E[3]	VG	VG	NL	Feekes 10.5
11	Pyraclostrobin 23.6%	Headline SC	6.0 – 9.0	G	VG	VG[2]	E	E[3]	E	G	NL	Feekes 10.5
11	Azoxystrobin 22.9%	Quadris 2.08 SC	4.0 – 12.0	G	VG	VG	E	E	E	G	NL	Feekes 10.5.4
3	Metconazole 8.6%	Caramba 0.75 SL	10.0 – 17.0	VG	VG	--	VG	E	E	E	G	30 days
3	Tebuconazole 38.7%	Folicur 3.6 F, multiple generics	4.0	NL	NL	NL	NL	E	E	E	F	30 days
3	Prothioconazole 41.0%	Proline 480 SC	5.0 – 5.7	--	VG	VG	VG	VG	VG	VG	G	30 days
3	Prothioconazole 19.0% Tebuconazole 19.0%	Prosaro 421 SC	6.5 – 8.2	G	VG	VG	VG	E	E	E	G	30 days
3	Propiconazole 41.8%	Tilt 3.6 EC, multiple generics	4.0	VG	VG	VG	VG	VG	VG	VG	P	Feekes 10.5.4
11	Trifloxystrobin 22.6%	Absolute Maxx SC	5.0	G	VG	VG	VG	VG	E	VG	NL	35 days
3	Tebuconazole 22.6%											
11	Picoxystrobin 17.9%	Aproach Prima SC	3.4 – 6.8	VG	VG	VG	VG	E	VG	--	NR	45 days
3	Cyproconazole 7.17%											
11	Trifloxystrobin 13.7%	Delaro 325 SC	8.0	G	VG	VG	VG	VG	VG	VG	NL	Feekes 10.5 35 days
3	Prothioconazole 16.0%											
7	Pydiflumetofen 13.7%	Miravis Ace SE	13.7	VG	VG	VG	VG	VG	VG	VG	G[5]	Feekes 10.5.4
3	Propiconazole 11.4%											
7	Fluxapyroxad 2.8%	Nexicor EC	7.0 – 13.0	VG	VG	E	E	E	E	VG	NL	Feekes 10.5
11	Pyraclostrobin 18.7%											
3	Propiconazole 11.7%											
7	Fluxapyroxad 14.3%	Priaxor	4.0 – 8.0	G	VG	VG	E	VG	VG	G	NL	Feekes 10.5
3	Pyraclostrobin 28.6%											
11	Azoxystrobin 13.5%	Quilt Xcel 2.2 SE, multiple generics	10.5 – 14.0	VG	VG	VG	VG	E	E	VG	NL	Feekes 10.5.4
3	Propiconazole 11.7%											
11	Trifloxystrobin 32.3%	Stratego YLD	4.0	G	VG	VG	VG	VG	VG	VG	NL	Feekes 10.5 35 days
3	Prothioconazole 10.8%											
7	Benzovindiflupyr 2.9%	Trivapro SE	9.4 – 13.7	VG	VG	VG	VG	E	E	VG	NL	Feekes 10.5.4
11	Azoxystrobin 10.5%											
3	Propiconazole 11.9%											
11	Azoxystrobin 25.30%	Topguard EQ	4.0 – 7.0	VG	NL	VG	VG	E	E	VG	NL	Feekes 10.5.4 35 days
3	Flutriafol 18.63%											

Indicates product with mixed fungicide classes

[1]Efficacy categories: NL=Not Labeled; NR=Not Recommended; P=Poor; F=Fair; G=Good; VG=Very Good; E=Excellent; -- = Insufficient data to make statement about efficacy of this product. [2]Product efficacy may be reduced in areas with fungal populations that are resistant to QoI fungicides. [3]Efficacy may be significantly reduced if solo QoI products are applied after stripe rust infection has occurred. [4]Application of products containing QoI fungicides may result in elevated levels of the mycotoxin deoxynivalenol (DON) in grain damaged by head scab. [5]Based on application timing at the beginning of anthesis (Feekes 10.5.1).

Important for Disease Management


Northern Corn Leaf Blight


Southern Rust


Septoria leaf spot


Rusts


Tar Spot

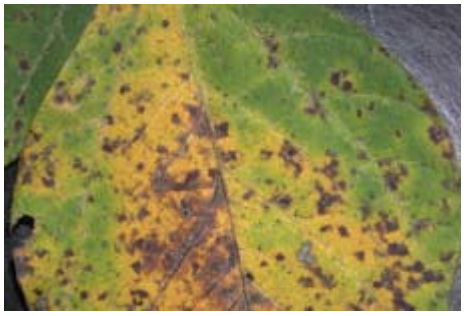

Gray leaf spot


Stagonospora


Powdery mildew


Soybean rust


Frogeye leaf spot


Septoria brown spot

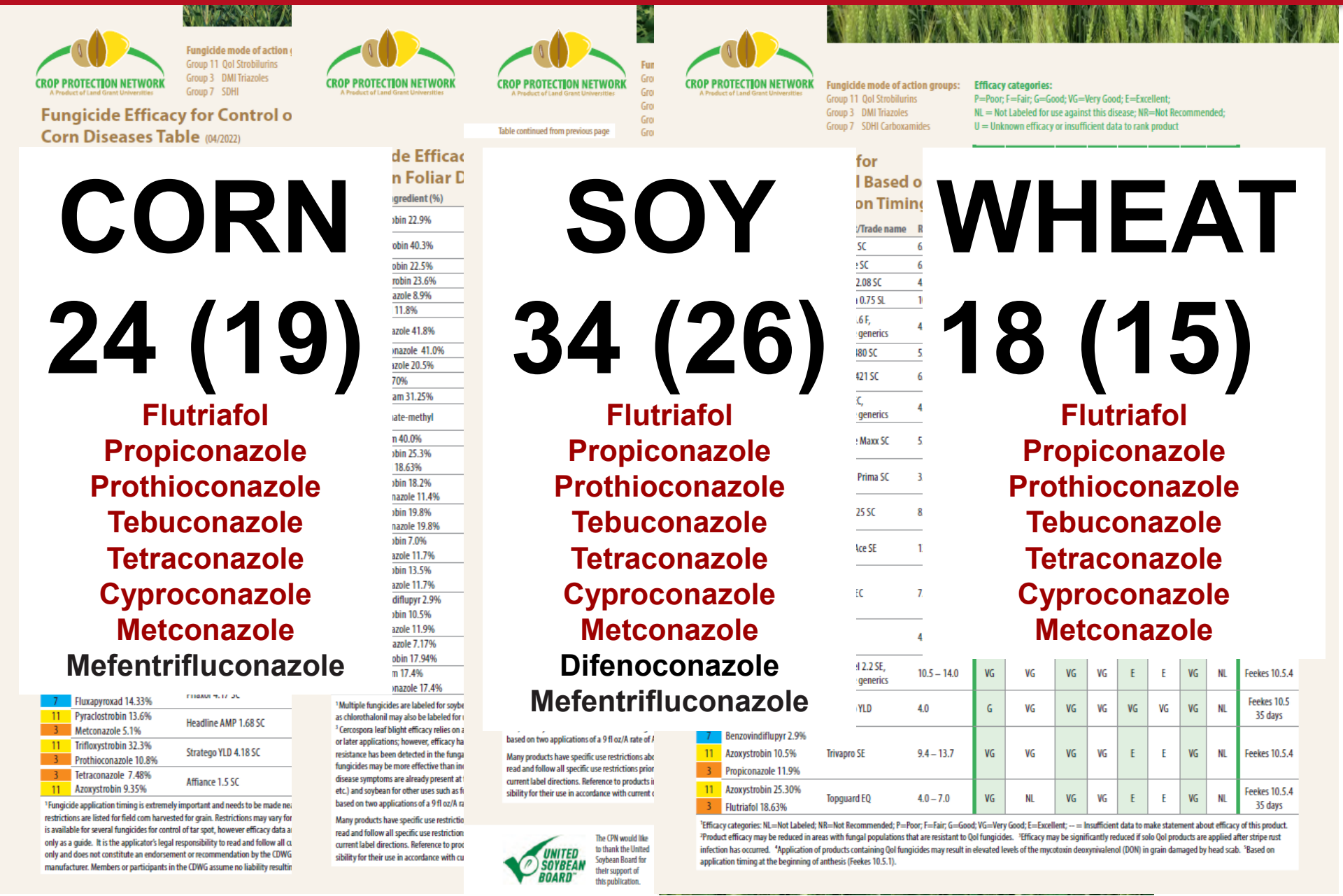

Cercospora leaf blight

Shifts in Fungicide use Patterns in field Crops: Mid-2000s

- Claims of plant-health benefits in the absence, or at low levels, of disease - particularly the QoI
  - Supplemental label granted for plant health benefit
- Higher grain prices and modern hybrids of higher yield potential.
- Major disease outbreaks/threats - soybean rust
- Ethanol industry.
  - More corn acres and continuous corn
- Change in production practices - conservation tillage.

… but, still not as widely used in Field Crops as in other Crop Production Systems

- A single application often sufficient for effective disease control (if timed correctly)
- Value of the crop often does not allow multiple applications
- Label restrictions prevent multiple apps (pre-harvest intervals)



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Fungicide Efficacy for Control o
Corn Diseases Table (04/2022)

Table continued from previous page

CORN

24 (19)

Flutriafol
Propiconazole
Prothioconazole
Tebuconazole
Tetraconazole
Cyproconazole
Metconazole
Mefentrifluconazole

SOY

34 (26)

Flutriafol
Propiconazole
Prothioconazole
Tebuconazole
Tetraconazole
Cyproconazole
Metconazole
Difenoconazole
Mefentrifluconazole

WHEAT

18 (15)

Flutriafol
Propiconazole
Prothioconazole
Tebuconazole
Tetraconazole
Cyproconazole
Metconazole

7 11 3	Benzovindiflupyr 2.9% Azoxystrobin 10.5% Propiconazole 11.9%	Trivapro SE	9.4 – 13.7
11 3	Azoxystrobin 25.30% Flutriafol 18.63%	Topguard EQ	4.0 – 7.0

[1]Efficacy categories: NL=Not Labeled; NR=Not Recommended; P=Poor; F=Fair; G=Good; VG=Very Good; E=Excellent; -- = Insufficient data to make statement about efficacy of this product. [2]Product efficacy may be reduced in areas with fungal populations that are resistant to QoI fungicides. [3]Efficacy may be significantly reduced if solo QoI products are applied after stripe rust infection has occurred. [4]Application of products containing QoI fungicides may result in elevated levels of the mycotoxin deoxynivalenol (DON) in grain damaged by head scab. [5]Based on application timing at the beginning of anthesis (Feekes 10.5.1).

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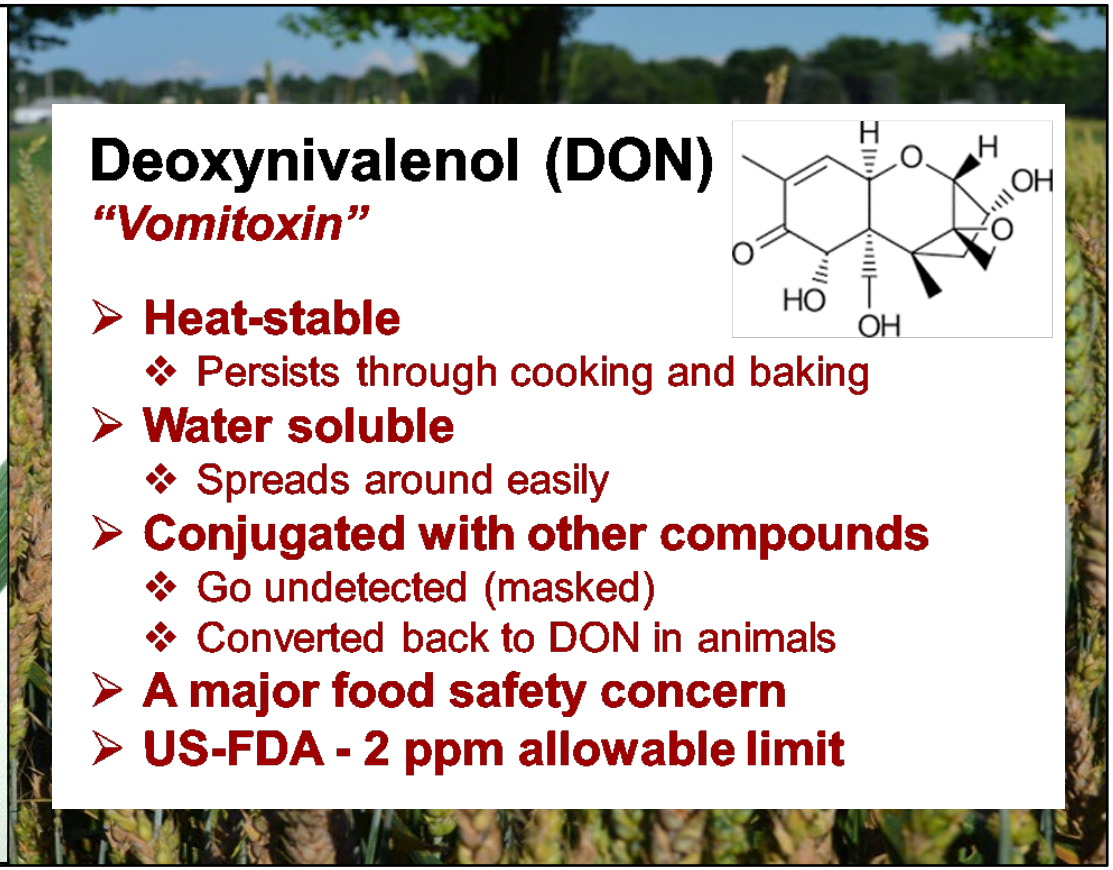
Why the AZOLES (FRAC 3)?

- Effective against some of the most economically important diseases
  - Spots and blotches as well as rusts
- Used in rotation or mixtures with QoI (FRAC 11) and SDHI (FRAC 7)
  - Increase spectrum of activity
  - Good fungicide resistance management strategy.
- **The only or best option for some diseases**
  - Gibberella ear rot and mycotoxins in corn
  - **Fusarium head blight and mycotoxins in small grain crops**

Fusarium head blight (head scab)

***Fusarium graminearum* (*Gibberella zeae*)**



Deoxynivalenol (DON)

"Vomitoxin"

- **Heat-stable**
  - Persists through cooking and baking
- **Water soluble**
  - Spreads around easily
- **Conjugated with other compounds**
  - Go undetected (masked)
  - Converted back to DON in animals
- **A major food safety concern**
- **US-FDA - 2 ppm allowable limit**

Management Guidelines

- **Guidelines**
  - **Genetic resistant**
    - ✓ No immunity
    - ✓ Not always the most high-yielding
  - **Tillage and Crop rotation**
    - ✓ Long-distance spore movement
  - **Fungicide application**
    - ✓ Azoles – industry standards for FHB control
      - Combinations of multiple Azole
      - Mixtures of SDHI and AZOLE
  - **FHB prediction center**
    - ✓ A guide for fungicide application
    - ✓ 80% accurate

AZOLES for FHB and DON Management

Tebuconazole

GENERICS

Prothioconazole

PROLINE®

Metconazole

Caramba®
Fungicide

Tebuconazole
Prothioconazole

PROSARO®

Metconazole	Group	3	Fungicide
Prothioconazole	Group	3	Fungicide

Sphaerex®
Fungicide

PROPICONAZOLE	GROUP	3	FUNGICIDE
PYDIFLUMETOFEN	GROUP	7	FUNGICIDE

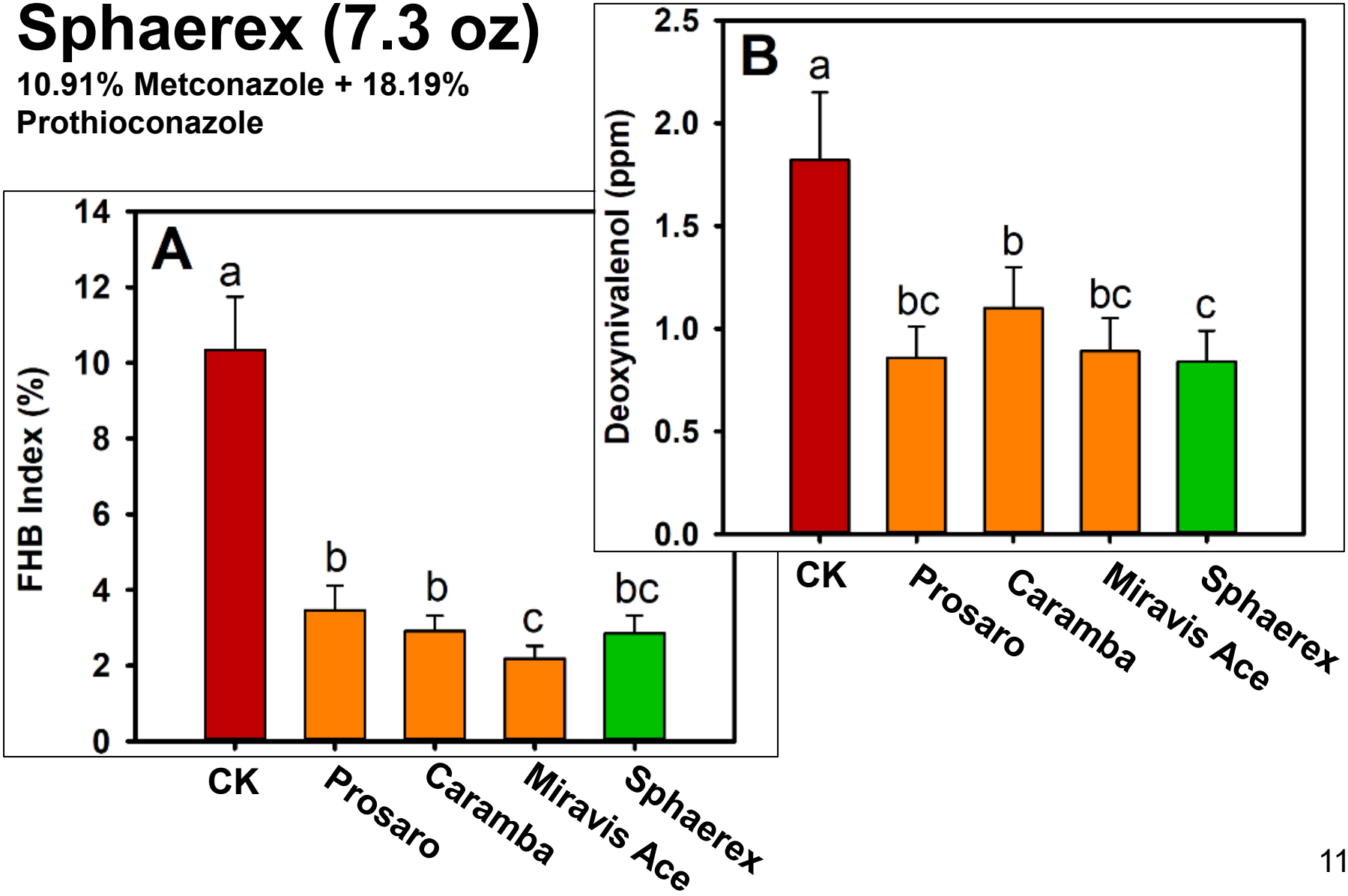
Miravis® Ace

PROTHIOCONAZOLE	GROUP	3	FUNGICIDE
TEBUCONAZOLE	GROUP	3	FUNGICIDE
FLUOPYRAM	GROUP	7	FUNGICIDE

PROSARO® PRO

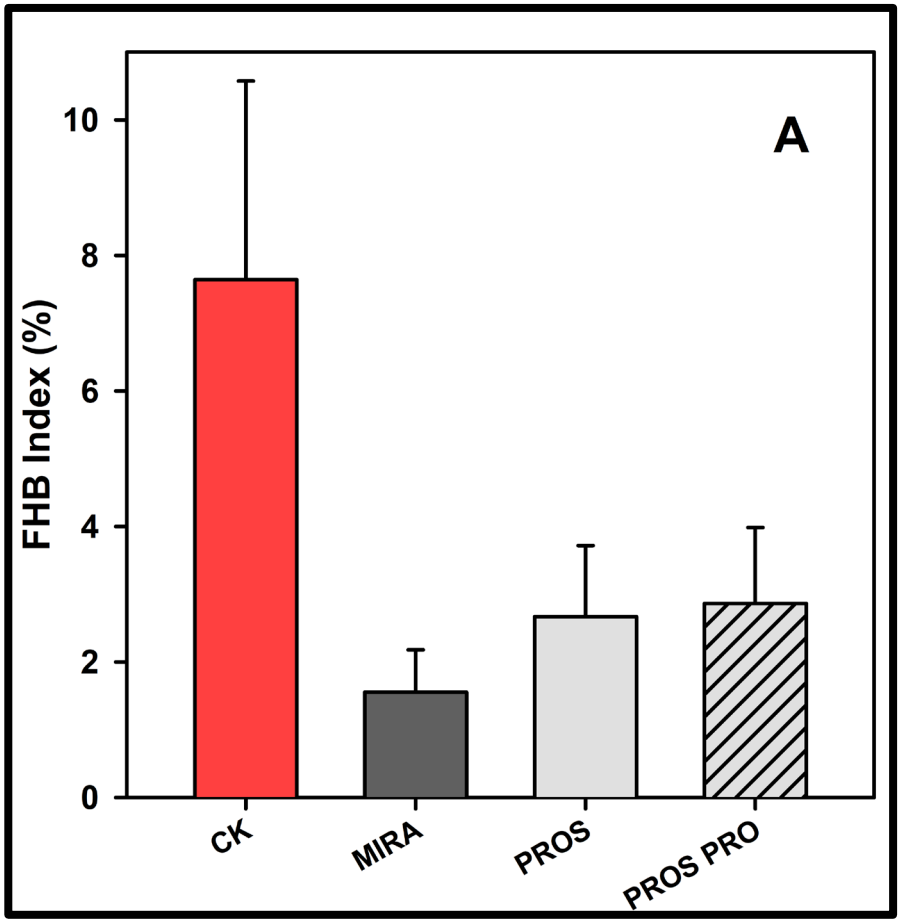
Sphaerex (7.3 oz)

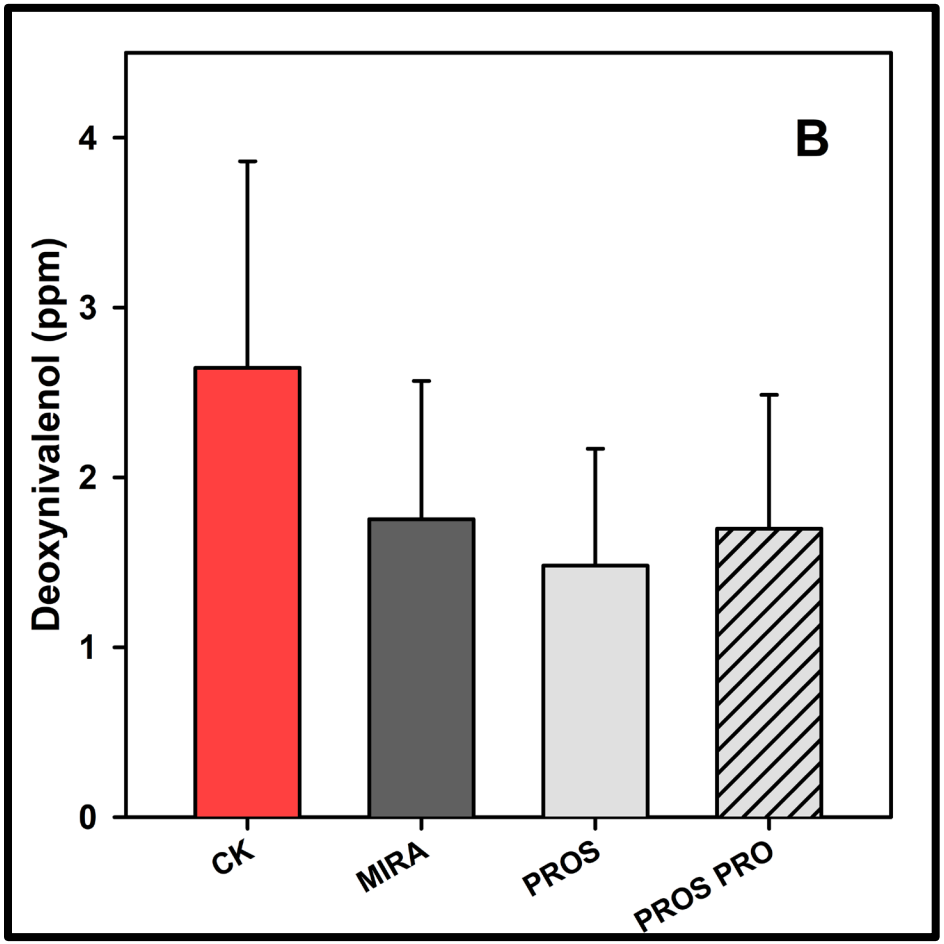
10.91% Metconazole + 18.19% Prothioconazole



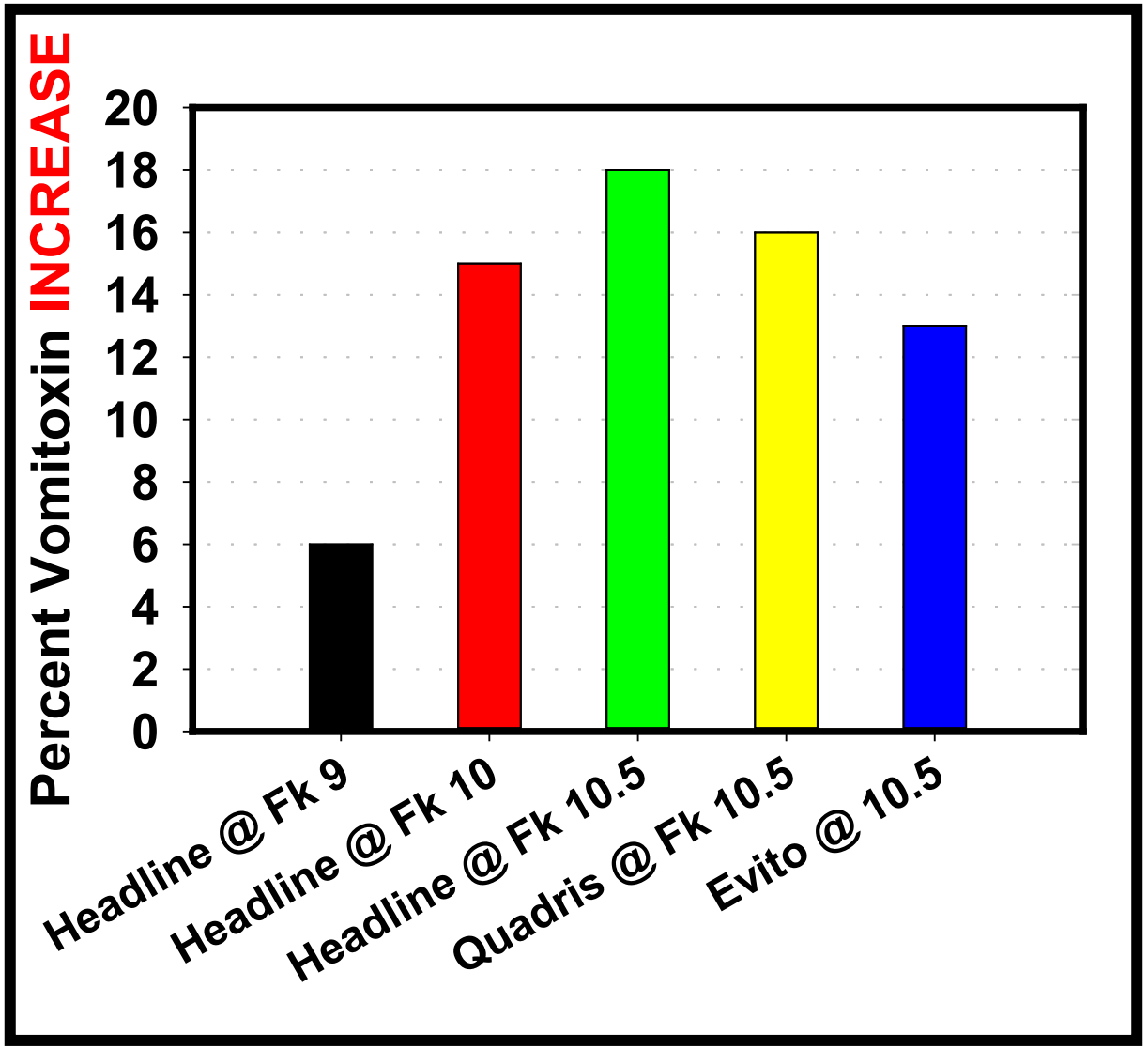
Prosaro Pro (10.3 oz)

8.7% Tebuconazole + 17.39% Prothioconazole + 8.7% Fluopyram





QoI MAY INCREASE DON



Summary

- **AZOLE - Critical for reducing FHB and Mycotoxins in Wheat, Barley and Corn**
  - **Maintaining grain yield and quality and reduce food safety concerns.**
    - **Benefit to the livestock industry**
    - **Benefit to the milling and baking industries**
    - **Benefit brewing industry**
    - **Benefit ethanol industry**

Acknowledgments

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