# Matching Fungicides with Apple Pest Management Priorities

Fruit Workers Meeting, Burlington, VT
October 19, 2010

Compiled by Dave Rosenberger
Department of Plant Pathology
Cornell University's Hudson Valley Lab
Highland, NY 12528

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## Welcome

### Welcome To FRAC

Fungicides have become an integral part of efficient food production. The loss of a fungicide to agriculture through resistance is a problem that affects us all.

FRAC works to prolong the effectiveness of fungicides liable to encounter resistance problems and to limit crop losses should resistance appear.

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## What's New

**2010-07-16 - The 2010 FRAC Mode of Action Poster© is online**

The **2010 FRAC Mode of Action Poster©** is now available as a PDF download on the FRAC publications webpage. Parallel to the updates made in the 2010 FRAC Code List several changes were also implemented in the 2010 poster. For example, the strobilurins pyraoxystrobin and pyrametostrobin were added to target site group C3. Penflufen was added to C2. Ametoctradin was added to a new group C8. Proquinazid was moved from unknown mode of action to E1. Dodine was moved from multi-site (M7) to unknown mode of action (U12).

**2010-07-12 - Banana Working Group: Meeting Report and Use Recommendations are now available**

The Banana Working Group met on March 11th, 2010 in Miami, FL. The monitoring results and fungicide use recommendations for 2010/2011 are now available online in English. The Spanish version of the minutes will follow soon.

**2010-05-19 - FRAC SDHI Working Group 2009 update is now online**

The 2009 monitoring data for the SDHI fungicides have been reviewed by the SDHI Working Group and are now

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**2010-05-18 - The List of Resistant Plant Pathogenic Organisms has been updated**

The January 2010 update for the list of resistant plant pathogens is now available online on the FRAC publications webpage. There are 13 new entries in the list. The new entries are flagged as blue citations in the reference column beginning on page 10 of the document.

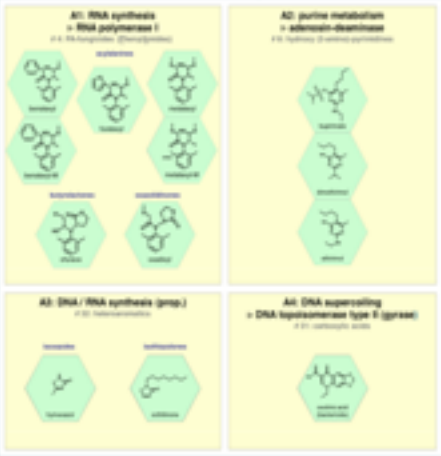
**2010-04-21 - FRAC List of Fungicide Common Names - NEW**

The FRAC Secretary has prepared a useful reference document entitled, **"FRAC List of Fungicide Common**

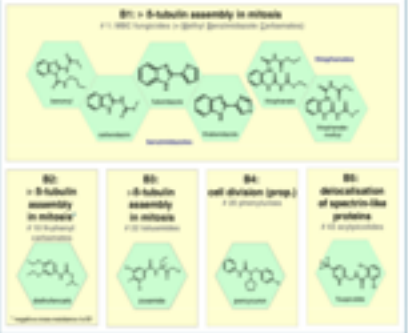
# Mode of Action of Fungicides

FRAC classification on mode of action 2009 (www.frac.info)

## A: Nucleic Acid Synthesis




## B: Mitosis and Cell Division




## C: Respiration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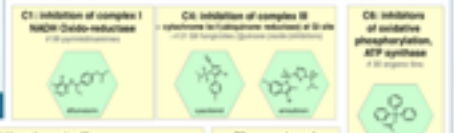
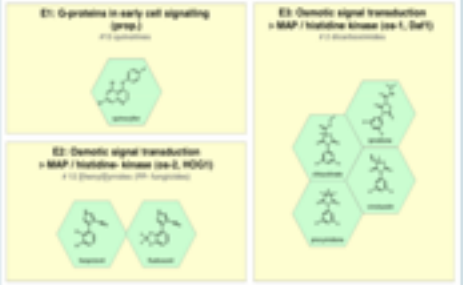
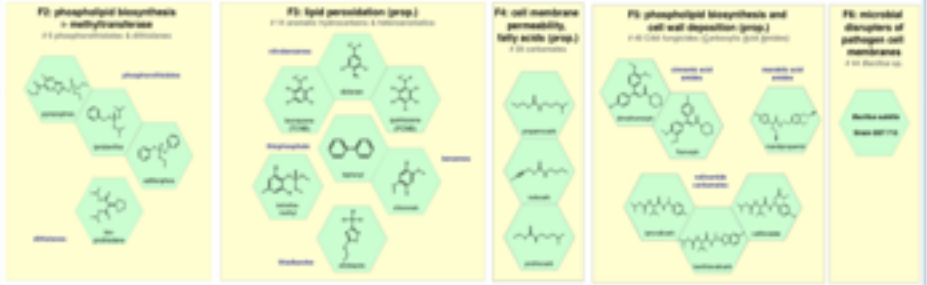



## D: Amino Acid and Protein Synthesis

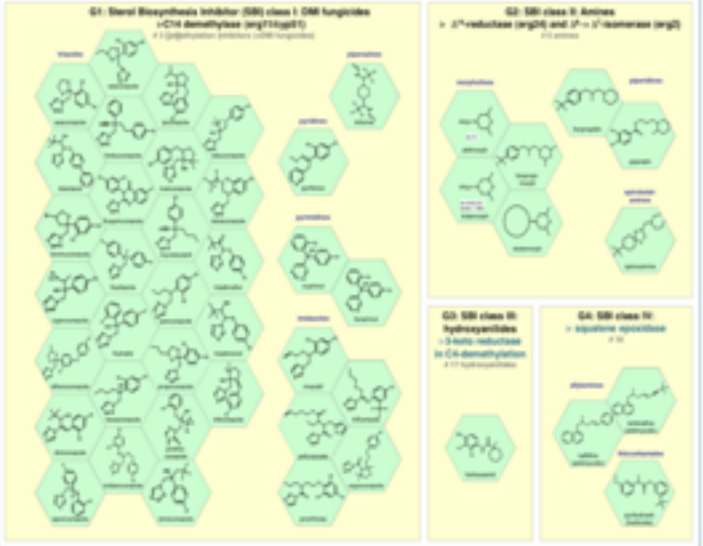

## E: Signal Transduction




## F: Lipid and Membrane Synthesis




## G: Sterol Biosynthesis in membranes




## H: Glucan Synthesis

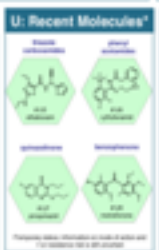

## I: Melanin Synthesis in Cell Wall


## P: Host Defence Inducer


## M: Multi Site Action


## Unknown Mode of Action

## U: Recent Molecules*



## NC : Not Classified

Legend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# Fungicide classes labeled for apples

Old contact fungicides:

Dodine
Benzimidazoles
SBIs or DMIs
QoIs or Strobilurins
SDHIs
Unclassified
Unkown

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# Fungicide classes labeled for apples

Old contact fungicides: mancozeb, Polyram, captan
copper, sulfur, lime-sulfur

Dodine

Benzimidazoles

SBIs or DMIs

QoIs or Strobilurins

SDHIs

Unclassified

Unkown

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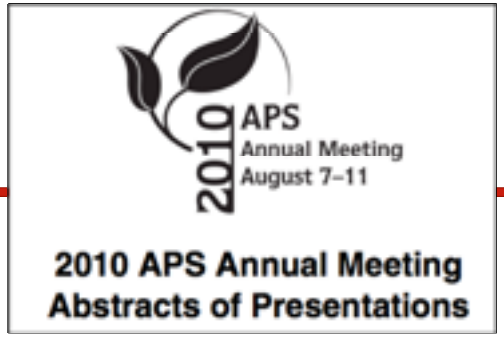
# A new perspective on copper




## Resistance to DMI fungicides in *Venturia inaequalis* from Pennsylvania

**E. E. PFEUFER (1), J. W. Travis (1), H. K. Ngugi (1)**

**(1) Penn State University, Biglerville, PA, U.S.A.** **Phytopathology 100:S100**

**Apple scab, caused by Venturia inaequalis, is the most economically important disease of apple in the eastern United States. Over the past 25 years, apple growers have relied on sterol demethylation inhibiting fungicides (DMIs) for scab control, but reduced efficacy has recently been noted. The aim of this study was to evaluate the sensitivity of V. inaequalis isolates from Pennsylvania to DMI fungicides. In 2009, leaves and immature fruit with scab symptoms were collected from 14 commercial orchards. Growers provided management history of the sampled plots. A total of 296 single-spore cultures were isolated from the tissues and maintained individually. Each isolate was tested for sensitivity to DMIs on 1/4-strength PDA plates amended with a range of concentrations of myclobutanil, fenbuconazole, or difenoconazole. Relative growth (RG) values were calculated and isolates with RG >75% on plates amended with 0.5 mg/ml were scored as resistant to the particular fungicide. About 14% of the isolates were cross-resistant to all three fungicides. Age of trees, size of orchard, number of DMI sprays in 2009, and lack of dormant copper sprays were positively correlated ($0.0001 < P < 0.05$) with the incidence of resistant isolates. Use of dormant copper sprays reduced the odds of an isolate being resistant to myclobutanil by about half (odds ratio = 0.446; 95% confidence interval = 0.239 to 0.832; $P = 0.011$). Management practices that reduce the risk of resistance to DMI fungicides in V. inaequalis were identified.**

# Sulfur/oil problems

Described in *Scaffolds Fruit Journal* 19(11):5-7, 1 June 2010.

- 11 May (1C):
  applied Esteem + 1% oil.
- 1.5 in. rain over next 14 days.
- 25 May: applied sulfur + mancozeb
  in early AM, temp in mid-70s F.
- Temp reached 87 °F later on 25
  May and 94 °F on 26 May.
- Leaf browning noted on 27 May.
- Injury was limited to trees that
  received oil on 11 May.

**Conclusion: Oil applied 14 days prior to sulfur contributed to burn when sulfur application was followed by heat.**

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# Lime-sulfur problems

- LLS at 2 qt/100 gal applied on 2 Jul to control summer diseases.
- Temperatures for 3 to 9 Jul were 88, 95, 96, 100, 99, and 89 °F.
- Injury on Cortland evident by 12 Jul.
- Using LLS during summer may contribute to black rot problems.

Table 2: Effects of fungicides and cultural controls on incidence of black rot and phytotoxicity on **Royal Court** fruit at the time of **harvest** on 9 Sep as determined by evaluating 75 fruit per tree.

| Fungicide and rate of formulated product per 100 gal[z] | % fruit with black rot on 9 Sep: cultural controls: none | cultural controls: mummies removed | grand means for effects of fungicides |
|---|---|---|---|
| Control ..... | 2.7 a[y] | 4.3 ab | 3.5 a[x] |
| Miller's Liquid Lime Sulfur 2 qt ..... | 21.0 b | 12.7 b | 16.9 b |
| Captan 80W 16 oz/Prophyt 21.3 fl oz . | 1.7 a | 1.3 a | 1.5 a |
| Captan 80W 10 oz/Prophyt 21.3 fl oz . | 3.0 a | 3.0 ab | 3.0 a |
| Grand means for effects of mummies . | 7.1 A | 5.3 A[x] | |

See 2010 HVL Plant Path report, pages 27-30

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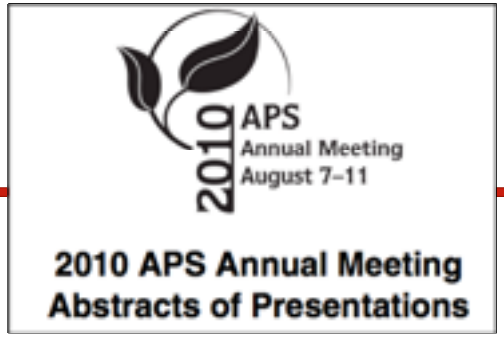
# Dodine possibilities?




**Status of dodine resistance and possibilities for renewed use against *Venturia inaequalis* populations in the Northeastern U.S.**

**K. COX (1), S. Villani (1), G. Jacon (2)**

**(1) Department of Plant Pathology and Plant-Microbe Biology, Cornell University, Geneva, NY, U.S.A.; (2) Groupe Agriphar, Ougree, BELGIUM** **Phytopathology 100:S27**

**The development of site-specific fungicide resistance in Venturia inaequalis populations in the Northeastern U.S. have left apple producers with few options for managing apple scab. Producers now rely on calendar-based applications of multi-site protectant fungicides to manage the disease. Decline in the frequency of dodine resistant isolates within a population was previously demonstrated for two orchards in the region. To investigate the prevalence of declining dodine resistance, we surveyed 93 commercial, 6 baseline, and 18 research apple orchards from 2007–2009 for sensitivity to dodine using microscopy-aided relative growth assays. Less than 27% of the orchards surveyed had V. inaequalis populations with practical resistance to dodine. Field trials were also conduced in an orchard formerly resistant to dodine, but with a current population displaying reduced sensitivity. Dodine programs were as effective or improved over standard programs of protectant and site-specific fungicides for managing apple scab. Following applications of dodine in the orchard, dodine sensitivity, expressed as population mean percent relative growth, increased from 36.0 ± 3.0% in 2008 to 51.4 ± 6.0% in 2009. Although, the majority of the orchard populations in the survey were composed of sensitive isolates or those with reduced sensitivity to dodine, it remains to be seen whether dodine resistant V. inaequalis populations will re- emerge following renewed use.**

Dodine-mancozeb combinations may be useful for sprays from GT to TC ???

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# DMI fungicides for apples

| Fungicide | In orchards with moderate DMI resistance: Powdery mildew activity | Apple scab activity | SBFS activity |
|---|---|---|---|
| Topguard (flutriafol) | (most) | (least) | (least) |
| Rally (myclobutanil) | ↑ | ↓ | ↓ |
| Procure (triflumazole) | ↑ | ↓ | ↓ |
| Vintage (fenarimol) | ↑ | ↓ | ↓ |
| Tebuzol (tebuconazole) | ↑ | ↓ | ↓ |
| Indar (fenbuconazole) | ↑ | ↓ | ↓ |
| Inspire (difenoconazole) | (least) | (most) | (most) |

## Factors affecting activity:

Levels of resistance/susceptibility in the target pathogen(s)
Intrinsic activity of the chemistry
Application rate
Water solubility (uptake into leaves/fruit)
Adjuvants (in the formulations or added when mixing)

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# DMI fungicides for apples

Effectiveness of fungicides for controlling SBFS at the Hudson Valley Lab, 2010

| Material and rate of formulated material per 100 gal [z] | % Mac fruit with flyspeck 3 Sep | % Mac fruit with flyspeck after incubation | % Macs with sooty blotch 3 Sep | % Macs with sooty blotch after incubation |
|---|---|---|---|---|
| Control | 53 d | 62. f | 47 e | 66 f |
| Dithane then Captan + Topsin M | 4 bc | 4 abcde | 5 bc | 14 abc |
| Flint 1 ab | 4 abcd | 16 d | 47 e | 30 cd |
| Rally | 8 c | 14 e | 15 d | 30 de |
| Indar + LI-700 | 6 c | 11 de | 7 cd | 12 bc |
| Tebuzol | 6 c | 8 cde | 3 abc | 13 abc |
| Inspire Super | 1 ab | 2 abc | <1 a | 2 a |

Applied at PK, BL, 1C, 2C and prehvst,
with Dithane applied to all plots at PF, Capt/Topsin during summer

*For details, see 2010 HVL Plant Path report, pages 20-26.*

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# SDHI fungicides for apples

| Fungicide | Generic name | Company | Planned combinations |
|---|---|---|---|
| Endura | boscalid | BASF | pyraclastrobin: Pristine |
| Fontelis | penthiopyrad | DuPont | ?? Stand-alone?? |
| Luna | fluopyram | Bayer | Flint |
| Xemium | fluxapyroxad | BASF | pyraclostrobin? |

Issues with SDHIs:

1. To date, tested exclusively in prepackage mixes, so activity of the SDHI is largely unknown.
2. Limited post-infection activity: perhaps 48 hr on scab.
3. Subject to resistance development.
4. Best mixing partners are QoI's?
   QoI resistance developing; limit of 4 sprays/season

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# Unexpected results with SDHI/QoI fungicides in 2010

Prebloom sprays affect necrotic leaf blotch in August?
Results from the Hudson Valley Lab, 2010

| Rates/100 gal of dilute spray; multiply by 3 for equivalent rates/A | Spray dates/growth stages 4/7 TC | 4/14 PK | 4/21 BL | 4/30 PF | 5/11 1C | % leaves with NLB[x] 24 Aug |
|---|---|---|---|---|---|---|
| Control | | | | | | 42 d[w] |
| Dithane Rainshield 75W 16 oz | | | x | x | x | |
| **Flint 50WDG 0.67 oz** | X | X | | | | 9 ab |
| Dithane Rainshield 75W 16 oz | | | x | x | x | |
| **Luna Sensation 500SC 1.67 fl oz** | X | X | | | | 4 a |
| Dithane 16 oz Scala 2 oz | X | X | X | | | |
| **Luna Sensation 500SC 1.67 fl oz** | | | | X | X | 19 bc |
| Dithane Rainshield 75W 16 oz | | x | x | x | x | |
| **Inspire Super 338SE 3.97 fl oz** | | X | X | | X | 5 a |
| Dithane 16 oz+ Vangard 1 oz | X | X | X | | | |
| **Inspire Super 338SE 3.97 fl oz** | | | | X | X | 11 ab |

CONCLUSION: Omitting Dithane at petal fall resulted in more leaf blotch.

# New fungicide with undefined mode of action:

Torino (cyflufenamid) from Gowan

- Active only as a mildewcide
- Could prove useful (depending on pricing):
  - > As a mixing partner for mancozeb
  - > For managing mildew populations with resistance to DMI and/or QoI fungicides.

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# Fungicide with unknown mode of action:

Phosphorous acid fungicides e.g., ProPhyt, AgriFos

- Boost activity of captan against SBFS.
- 2010 data suggests ProPhyt also improves activity of Ziram against SBFS.

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# Concerns about phosphorous acid fungicides:

**Author(s):** Malusa, E; Tosi, L
**Title:** Phosphorous acid residues in apples after foliar fertilization: Results of field trials
**Source:** FOOD ADDITIVES AND CONTAMINANTS, 22 (6): 541-548 JUN 2005

**Abstract:** The levels of phosphorous acid residues in apples after foliar fertilization with P fertilizers and after treatment with a phosphonate fungicide (Fosetyl-Al) were determined and compared. Two field trials and a glasshouse experiment, using different genotypes and plants of different age, were carried out and monitored over a three-year period. Phosphorous acid residues .... in some cases reached a level exceeding the maximum limit set by EU legislation. .... Plants treated with Fosetyl-Al contained phosphorous acid residues in their fruits and buds two years after the suspension of the treatment, suggesting a long-term persistence of the substance in plant storage organs. A second experiment, involving treatment of trees with seven foliar fertilizers of different composition, also induced accumulation of phosphorous acid residues in fruits. It is concluded that a wide array of foliar products containing phosphorous acid, even as a minor component, could mimic the residue effect of phosphonate fungicide treatments.

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**Conclusion:** Considering all of the options, matching apple fungicides with pest management priorities is an increasingly complex challenge!

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Old contact fungicides: mancozeb, Polyram, captan copper, sulfur, lime-sulfur

Dodine: Syllit

Benzimidazoles: Topsin M

SBIs or DMIs: Vintage, Rally, Procure, Indar, Inspire, Tebuzol, Topguard

QoIs or Strobilurins: Sovran, Flint, Cabrio

SDHIs: Endura, Fontelis, Luna, Xemium

Unclassified: Torino (cyflufenamid)

Unkown: Phosphorous acid products

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