DATA FROM 2009 FUNGICIDE TRIALS IN THE HUDSON VALLEY

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Final Report on Field Trials
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—NOT FOR PUBLICATION—
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Daily Max-Min Temperatures and Precipitation for 2009 ........................................................................ 5

New Fungicides for Controlling Early-Season Apple Diseases (M.9 test block) ..................................... 6

- Includes Rally, Indar, Tebuzol, Flint, Luna Sensation, LEM17+Flint, Pristine, and GWN-4617 (mildewcide) in a test against early-season diseases.

Apple Disease Control with Inspire Super, Rally, Indar, Tebuzol, and Luna Sensation .......................... 15

- Assessed effectiveness of Indar, Tebuzol, Inspire Super, and Luna Sensation against summer diseases and found interesting results from the latter two products.

Effect of Fungicides on Fruit Set and Fruit Size in Empire Apples .......................................................... 28

- Applied Penncozeb, Rally, and Tebuzol during and after bloom to determine if the DMI fungicides would adversely affected thinning sprays. The fungicides had no affect on crop load and fruit size.

Controlling Apple Summer Diseases with Captan, ProPhyt, and Pristine .................................................. 30

- Test designed to further evaluate benefits of and best uses for phosphite fungicides in summer spray programs, including effects of Captan rates on summer disease control.

Controlling Apple Summer Diseases with Fungicides Approved for Organic Production ........................ 34

- Kaligreen, Serenade Max, Oxidate, Clean Green Pro, and liquid lime-sulfur used alone or with copper all provided poor control of summer diseases of apples when applied nine times between 1 June and 18 September. Liquid lime-sulfur combined with Nordox (copper oxide) was the most effective.

Controlling Plum Black Knot with Bravo, Indar, Pristine, and Elite, 2007-2009 ...................................... 38

- Bravo and Indar provided comparable control of black knot, but Elite was ineffective.

Re-evaluation of Captan as a Postharvest Fungicide on Apples .............................................................. 39

- A postharvest trial provided initial evidence that Captan in postharvest drenches may work by reducing viability of Penicillium spores in recirculating drenches even though Captan alone is only modestly effective for protecting wounded fruit from infection.

Controlling Penicillium Blue Mold in Stored Apples with Scholar and Difenoconazole, 2008-09 ................ 41

- Difenoconazole provided good control of Penicillium blue mold and may prove useful as a mixing partner for Scholar as part of a resistance management strategy for postharvest fungicides.

New Approaches for Controlling Spread of Fire Blight During Summer, 2009 ................................. 47

- Despite a very low incidence of shoot blight in inoculated plots during 2009, plots that received insecticide treatments has significantly less shoot blight than those that did not.

Low-Volume Non-Recycling Drenches for Controlling Postharvest Diseases and Disorders of Apples ...... 52

- Non-recycling drenches provided a surprising degree of decay control, due at least in part to the fact that inoculum on apples is not redistributed to other fruit so long as drench solutions are not recycled.
Apple scab infection periods and wetting period for 2009

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<tr>
<th>Date</th>
<th>M.9 block</th>
<th>Scab ascospore counts</th>
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Apple scab infection periods and wetting period for 2009

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Apple scab infection periods and wetting period for 2009

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**COMBINED WETTING PERIOD STARTING**

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## 2009 MAXIMUM AND MINIMUM TEMPERATURES AND PRECIPITATION

Hudson Valley Laboratory, Highland, NY

All readings were taken at 0800 EST on the dates indicated

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Avg/Total: 47.3 28.3 2.53 59.8 41.0 1.89 69.4 49.2 4.52 74.6 58.6 8.45 79.3 60.3 4.71 81.5 63.1 4.50 72.0 52.3 1.23
Early-Season Apple Diseases (M.9 block)

APPLE (*Malus domestica* 'Jerseymac', 'Redcort', 'Golden Delicious')

Apple scab; *Venturia inaequalis*
Cedar apple rust; *Gymnosporangium juniperi-virginianae*
Quince rust; *Gymnosporangium clavipes*
Powdery mildew; *Podosphaera leucotricha*
Necrotic leaf spot; *Botryosphaeria obtusa* and *G. juniperi-virginianae*
Fruit rots; *Botryosphaeria* sp.
Flyspeck; *Zygophiala jamaicensis*
Sooty blotch; species complex

New Fungicides for Controlling Early-Season Apple Diseases, 2009.

Treatments were replicated four times in a randomized block design. Each plot contained three trees, one tree of each cultivar, on M.9 rootstocks. Half of the orchard was planted in 1986 and the other half was planted in 1995. Trees in this test block are spaced 32 ft between sprayed rows, 7.5 ft between trees within rows, and 15 ft between plots within rows. The space between sprayed rows contained either a buffer row of similar apple trees or a buffer row of stone fruit trees. Plots within rows were separated by cedar trees that provided inoculum for rust diseases and minimized drift between plots. Treatments were applied on dates shown in Table 1.

The prebloom period was relatively dry with only one significant scab infection period near tight cluster (20-22 Apr, 52 hr wetting, 47° F, 0.85 in. rain). Another major infection period occurred during bloom (3-9 May, 105 hr, 55° F, 1.76 in. rain). A very few primary scab lesions were noted on unsprayed trees in an adjoining block on 6 May. Abundant primary scab was evident on unsprayed trees by 15 May. There were 9 secondary scab infection periods during the latter half of May, 16 in Jun, 13 in Jul, 7 in Aug, and 4 in Sep. June and July were very wet with leaf wetting recorded for 50% of total time in June and 37% of total time in July. Inches of rainfall recorded for June and July were 8.45 and 4.71, respectively. Due to the cool weather, scab remained active throughout summer.

Observations and Conclusions:

Comments that apply to all data tables:
- Trt 2 is a standard program of contact fungicides.
- Trts 3-4-5-6 involved DMI fungicides.
- Trts 7-8-9-10 involved newer fungicides that either contain a QoI fungicide or were applied in a combination with Flint (trifloxystrobin), and these were compared to Flint applied alone (trt. 10). Luna Sensation is a package mix of trifloxystrobin and fluopyram. LEM-17 (penthiopyrad) was applied with a half-rate of Flint. Pristine is a package mix of pyraclostrobin and boscalid. The test fungicides were applied on the same dates in these four treatments.
- Trts 11-12 involved variations in timing of GWN-4617 (a mildewcide) that was alternated in trt 12 with GWN-4616 (a new formulation of fenarimol). In both trts 11 and 12, Penncozeb was applied at a rate of 2 lb/100 gal in sprays that extended beyond petal fall so as to ensure that scab and rust diseases would not compromise our abilities to rate leaves for mildew. Label restrictions limit Penncozeb to a maximum of 1 lb/100 gal of dilute spray for applications after petal fall, so this treatment could NOT be replicated in commercial orchards.
- Trt 13 received only Penncozeb and Captan with some sprays omitted during the early part of the season.

Table 1:
- The intervals between several of the sprays was extended farther than we would recommend for commercial applications. However, due to dry prebloom weather, we knew that we would not be able to detect differences among treatments if we did not extend the treatment intervals.
- Tebuzeol applied at pink and bloom (trt 6) had less frog-eye leaf spot than any of the other DMI treatments and was just as good as Pristine (trt 9).
- Trts 8-9 provided better leaf spot control than most of the DMI-Penncozeb combinations (trts 3-4-12).

Table 2: Early-season pressure for apple scab was relatively low, and all treatments except trt 13 where sprays were omitted provided good control of apple scab on cluster leaves and fruitlets as rated on 10 Jun.

Table 3:
- Apple scab disease pressure increased during and after bloom, so treatment effects are more visible on terminal leaves that developed beginning during late bloom.
10 Dec 2009
Rosenberger et al., Highland, NY
Early-Season Apple Diseases (M.9 block)

- Due to an application error, Tebuzol was applied at 3x rate on 13 and 22 May in trt 5 and on 22 May in trt 6. Thus, disease control recorded for trt 5 in samples collected on 2 Jun would have been affected by the 13 May high-rate application. However, scab usually appears on leaves only 12-14 days after infections occur, so scab ratings for trt 6 made on 2 Jun presumably were not affected by the application error because that error occurred only on 22 May in trt 6.

- For Jerseymac early-season scab (1st data column), trts 2-11-13 received only protectant scab fungicides and had more scab than other fungicide treatments.

- For Redcort early-season scab (2nd data column), trts 7-8-9-10 all provided better scab control than the standard DMI program involving Rally (trt 3). The same was true for trts 7-8-9 on Jerseymac leaves rated on 28 July.

Table 4:
- Trts 2 and 13 provided less control of fruit scab on Jerseymac and Redcort than any of the other treatments.
- If one disregards trt 13, all of the fungicides decreased the incidence of moldy core, but there were few differences among treatments. Some fruit rated as having moldy core showed only discoloration of the carpel walls whereas other had visible mycelia in the seed cavity. The former accounts for the difference between the two moldy core ratings shown in this table.

Table 5:
- Trts 2 and 13 provided less control of mildew than any of the other fungicide treatments.
- Mildew control was better in the 19 Jun ratings than in the 30 Jun ratings because the last application of test fungicides was made on 22 Jun for all except trts 6-11-12 and the Captan cover sprays applied during June would not be expected to control mildew.
- Trts 3-5-7 were the only trts that were consistently grouped with the best trt (i.e., always followed by an "a" in the letter separations for means) across all of the 6 columns of means shown in Table 5.

Table 6:
- Ratings are for cedar apple rust and hawthorn rust, two species that can both infect leaves and that cannot be differentiated early in the season. In this region, cedar apple rust is far more common that hawthorn rust.
- Cedar apple rust lesions on Jerseymac and Ginger Gold never enlarge very much due to host incompatibilities, but lesions were attributed to rust if we could detect any orange coloration in the centers of the lesions. Necrotic lesions with no orange coloration were called necrotic leaf spot and are tabulated in Table 6.
- All treatments except trt 13 provided good control of rust on cluster leaves.
- On bourse shoot leaves (i.e., leaves that developed during and after bloom), grand means for trts that included a rDMI fungicides on a regular basis (trts 3-4-5-6-12) had less rust than trts 7-8-9-10. The latter group matched the activity of the Penncozeb standard (trt 2), confirming that QoI fungicides have protectant activity against rust but lack the post-infection activity of DMI fungicides.

Table 7:
- Necrotic leaf spot (NLS) can result from either infections by Botryosphaeria obtusa (frog-eye leaf spot) or rust infections that fail to develop due to host resistance or post-infection activity of fungicides. In this trial, most of the NLS was attributable to failed rust infections.
- The grand mean for NLS on bourse leaves showed that all fungicides provided some degree of control, presumably by preventing rust spores from growing enough to kill leaf cells.
- All treatments except trt 13 provided excellent control of quince rust in a year when nearly 75% of Jerseymac fruit on control tree were affected by quince rust.

Table 8:
- All treatments except trt 13 provided excellent control of quince rust and cedar apple rust on fruit at harvest. The incidence of quince rust was lower at harvest than in earlier ratings on some treatments because many infected fruit drop from the tree during June.
- The percentage of fruit with severe fruit surface russetting was no better for trts 4-5-6-10 than in the unsprayed controls. Trt 8 had the least russet although it was not significantly different from several other treatments. However, trt 8 had much less russet than trt 10, thereby demonstrating that it is the LEM-17, not Flint in the LEM-17 plus Flint combination that suppresses fruit russet. This is the only data set in this experiment where any one of trts 7-8-9 were statistically superior to Flint applied alone (trt 10).
Table 9:
- Because most of the treatments reverted to uniform cover sprays (mostly with Captan) by the end of May, we did not expect to find many treatment differences in the incidence of sooty blotch and flyspeck (SBFS) at harvest.
- However, trts 11-12 both received Pencozeb sprays until mid-June, so these two treatments had less SBFS than other treatments.
- Pristine (trt 9) and Flint (trt 10) suppressed both flyspeck and sooty blotch on Redcort better than Captan alone (trt 2) or Indar/Captan combinations (trt 4).

Table 10:
- All trts except 4 and 13 suppressed black rot and white rot on Jerseymac fruit evaluated at harvest on 5 Aug, and all except trt 12 suppressed black/white rot on Redcort.
- Most treatments had similar levels of disease-free Jerseymac fruit except that trts 2 and 13 were less effective. Trts 11 and 12 had the highest levels of disease-free Redcort and Golden Delicious because the high rates of Pencozeb applied in these two treatments in mid-June suppressed SBFS development. Tebuzole in trts 5 and 6 was numerically better than Indar (trt4) for percentage of disease-free Golden Delicious, thanks to differences in activity on SBFS. However, Tebuzole in trt 6 was also applied on 17 Jun whereas Indar was not.

Summary of conclusions:
- All of the fungicides evaluated were reasonably effective considering the severe disease pressure that was fostered by rains during the latter half of May through June and July. None of the fungicides gave 100% control of fruit scab on Jerseymac evaluated at harvest, but the newer fungicides were all more effective than the contact fungicides applied in trt 2.
- Recent lab tests of scab populations in this orchard by Dr. Kerik Cox showed that DMIs and QoI fungicides should still be effective in this orchard, and results of our field test confirmed that they were effective.
- This trial produced no evidence that LEM-17 or Luna Sensation will control scab, rust diseases, mildew or SBFS any better than a full rate of Flint used alone.
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<td>Teburol 45DF (L= 2 oz; H= 6 oz)</td>
<td>X&lt;sup&gt;l&lt;/sup&gt;</td>
<td>X&lt;sup&gt;l&lt;/sup&gt;</td>
<td>X&lt;sup&gt;H&lt;/sup&gt;</td>
<td>X&lt;sup&gt;H&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captan 80WDG 10 oz</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Penncozeb 1 lb</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luna Sensation 300 SC (USF 2016)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Penncozeb 1 lb</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEM17 200SC 4.8 fl oz + Flint 50WDG 0.33 oz</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Penncozeb 1 lb</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pristine 38W 5 oz</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Penncozeb 1 lb</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flint 50WDG 0.67 oz</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Penncozeb 2 lb + GWN-4616 1.13 fl oz</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GWN-4617 1.13 fl oz + Przeb 2 lb + LI-700 8 fl oz</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Penncozeb 2 lb + GWN-4616 1.13 fl oz</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GWN-4617 1.13 fl oz + Przeb 2 lb + LI-700 8 fl oz</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GWN-4616 3.33 fl oz + Pricozbe 1 lb</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Penncozeb 1 lb</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> In addition to the sprays noted above, all plots including controls received aerial blast applications of Penncozeb 3 lb/A on 9 April; Captan-80 30 oz/A on 24 June, 6 & 22 July, 1 August; Captan-80 30 oz/A plus Tapsin M 3 oz/A on 6 August; and Captan-80 33 oz/A plus Tapsin M 14 oz/A on 25 August.

<sup>b</sup> Used only 4 fl oz LI-700 in the sprays applied at TC and PK, but 8 fl oz in applications at PF and 1C.

<sup>c</sup> Application error: used Teburol at 6 oz/100 gal in sprays applied at PF and 1C.

<sup>d</sup> C = Captan 80WDG 10 oz/100 gal was applied alone on these dates.

<sup>e</sup> Each tree was visually rated by 3 independent observers using a scale of 1 (= no frog-eye leafspot) to 5 (= severe frog-eye leafspot).

<sup>f</sup> Numbers within columns followed by the same small letter are not significantly different as determined using Fisher’s Protected LSD (P≤0.05).
## Table 2: Early scab ratings

<table>
<thead>
<tr>
<th>Fungicides and rates/100 gal</th>
<th>Cluster leaf scab on 2 Jun (15/tree)</th>
<th>Fruitlet scab on 2 Jun</th>
<th>Jersey-</th>
<th>Red-</th>
<th>Grand-</th>
<th>Jersey-</th>
<th>Red-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>mac</td>
<td>cort</td>
<td>means</td>
<td>mac</td>
<td>cort</td>
</tr>
<tr>
<td>1. Control</td>
<td></td>
<td></td>
<td>16.2 c</td>
<td>5.7 c</td>
<td>10.9</td>
<td>d</td>
<td>65.4</td>
</tr>
<tr>
<td>2. Penncozeb 1 lb // Captan</td>
<td></td>
<td></td>
<td>2.1 ab</td>
<td>0.0 a</td>
<td>1.0 ab</td>
<td>4.8 ab</td>
<td>1.0 ab</td>
</tr>
<tr>
<td>3. Rally 1.33 oz + Penncozeb</td>
<td></td>
<td></td>
<td>1.6 a</td>
<td>0.9 ab</td>
<td>1.3 ab</td>
<td>0.7 a</td>
<td>2.8 ab</td>
</tr>
<tr>
<td>4. Indar 2.67 fl oz + LI-700</td>
<td></td>
<td></td>
<td>0.3 a</td>
<td>0.0 a</td>
<td>0.1 a</td>
<td>3.7 ab</td>
<td>5.4 ab</td>
</tr>
<tr>
<td>5. Tebuzol 2 oz + Penncozeb</td>
<td></td>
<td></td>
<td>0.6 a</td>
<td>0.2 ab</td>
<td>0.4 a</td>
<td>0.5 a</td>
<td>1.9 ab</td>
</tr>
<tr>
<td>6. Penncozeb 1 lb // Tebuzol</td>
<td></td>
<td></td>
<td>0.9 a</td>
<td>0.6 ab</td>
<td>0.8 ab</td>
<td>1.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>7. Luna Sensation 500 SC</td>
<td></td>
<td></td>
<td>1.2 a</td>
<td>0.3 ab</td>
<td>0.7 ab</td>
<td>1.8 ab</td>
<td>1.4 ab</td>
</tr>
<tr>
<td>8. LEM17 4.8 fl oz + Flint</td>
<td></td>
<td></td>
<td>2.1 ab</td>
<td>0.0 a</td>
<td>1.0 ab</td>
<td>0.7 a</td>
<td>0.7 ab</td>
</tr>
<tr>
<td>9. Pristine 5 oz</td>
<td></td>
<td></td>
<td>1.7 ab</td>
<td>0.0 a</td>
<td>0.8 ab</td>
<td>2.3 ab</td>
<td>0.0 a</td>
</tr>
<tr>
<td>10. Flit 0.67 oz</td>
<td></td>
<td></td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>0.7 a</td>
<td>1.1 ab</td>
</tr>
<tr>
<td>11. Penncozeb 2 lb + GWN-4616</td>
<td></td>
<td></td>
<td>4.4 ab</td>
<td>1.2 ab</td>
<td>2.8 bc</td>
<td>5.5 bc</td>
<td>0.0 a</td>
</tr>
<tr>
<td>12. Penncozeb 2 lb + GWN-4616</td>
<td></td>
<td></td>
<td>4.4 ab</td>
<td>1.2 ab</td>
<td>2.8 bc</td>
<td>5.5 bc</td>
<td>0.0 a</td>
</tr>
<tr>
<td>13. Penncozeb 1 lb // Captan</td>
<td></td>
<td></td>
<td>4.2 b</td>
<td>2.6 bc</td>
<td>3.4 c</td>
<td>12.5 c</td>
<td>12.7 cd</td>
</tr>
</tbody>
</table>

*See application schedule and footnotes below Table 1.

## Table 3: Terminal leaf scab

<table>
<thead>
<tr>
<th>Fungicides and rates/100 gal</th>
<th>Early terminal leaf scab on 2 Jun (%)</th>
<th>Late season terminal leaf scab (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jersey-</td>
<td>Red-</td>
</tr>
<tr>
<td></td>
<td>mac</td>
<td>cort</td>
</tr>
<tr>
<td>1. Control</td>
<td>47.3 e</td>
<td>32.1 g</td>
</tr>
<tr>
<td>2. Penncozeb 1 lb // Captan</td>
<td>10.7 c</td>
<td>6.9 e</td>
</tr>
<tr>
<td>3. Rally 1.33 oz + Penncozeb</td>
<td>5.2 ab</td>
<td>6.4 de</td>
</tr>
<tr>
<td>4. Indar 2.67 fl oz + LI-700</td>
<td>4.9 ab</td>
<td>4.0 cd</td>
</tr>
<tr>
<td>5. Tebuzol 2 oz + Penncozeb</td>
<td>3.8 ab</td>
<td>2.1 abc</td>
</tr>
<tr>
<td>6. Penncozeb // Tebuzol</td>
<td>2.9 ab</td>
<td>2.2 abc</td>
</tr>
<tr>
<td></td>
<td>Capt. 10 oz//Tebuzol + Capt. 10 oz</td>
<td>3.1 ab</td>
</tr>
<tr>
<td></td>
<td>4.9 ab</td>
<td>0.7 a</td>
</tr>
<tr>
<td></td>
<td>3.6 ab</td>
<td>1.3 ab</td>
</tr>
<tr>
<td></td>
<td>2.3 a</td>
<td>2.7 bc</td>
</tr>
</tbody>
</table>

*See application schedule and footnotes below Table 1.
### Table 4: Fruit scab & moldy core at harvest

<table>
<thead>
<tr>
<th>Fungicides and rates/100 gal</th>
<th>Fruit scab at harvest (%)</th>
<th>Moldy core: Jerseymac 5 Aug</th>
<th>any sign of mold core</th>
<th>visible mycelia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jerseymac 5 Aug</td>
<td>Redcort 2 Sep</td>
<td>Golden D. 23 Sep</td>
<td></td>
</tr>
<tr>
<td>1. Control</td>
<td></td>
<td></td>
<td></td>
<td>32.1 c</td>
</tr>
<tr>
<td>2. Penncozeb 1 lb // Captan-80 10 oz</td>
<td>99.2 e</td>
<td>79.1 d</td>
<td>51.7 b</td>
<td></td>
</tr>
<tr>
<td>3. Rally 1.33 oz + Penncozeb 1 lb + Rally 1.33 oz + Captan-80 10 oz</td>
<td>18.9 c</td>
<td>10.0 b</td>
<td>0.4 a</td>
<td></td>
</tr>
<tr>
<td>4. Indar 2.67 fl oz + LI-700 + Penncozeb 1 lb Indar + LI-700 + Captan-80 10 oz</td>
<td>3.5 ab</td>
<td>1.2 a</td>
<td>0.0 a</td>
<td></td>
</tr>
<tr>
<td>5. Tebuzeol 2 oz + Penncozeb 1 lb Tebuzeol 6 oz + Captan-80 10 oz</td>
<td>6.4 b</td>
<td>1.2 a</td>
<td>0.4 a</td>
<td></td>
</tr>
<tr>
<td>6. Penncozeb // Tebuzeol 2 oz + P'zeb 1 lb Capt. 10 oz// Tebuzeol + Capt. 10 oz</td>
<td>2.9 ab</td>
<td>0.4 a</td>
<td>0.8 a</td>
<td>11.8 ab</td>
</tr>
<tr>
<td>7. Luna Sensation 500 SC 1.33 fl oz</td>
<td></td>
<td></td>
<td></td>
<td>5.0 ab</td>
</tr>
<tr>
<td>8. LEM17 4.8 fl oz + Flint 0.33 oz</td>
<td>1.2 a</td>
<td>0.4 a</td>
<td>2.1 a</td>
<td>15.7 ab</td>
</tr>
<tr>
<td>9. Pristine 5 oz</td>
<td>3.8 ab</td>
<td>0.4 a</td>
<td>0.8 a</td>
<td>11.2 a</td>
</tr>
<tr>
<td>10. Flint 0.67 oz</td>
<td>4.9 ab</td>
<td>0.4 a</td>
<td>1.7 a</td>
<td>14.1 ab</td>
</tr>
</tbody>
</table>

**See application schedule and footnotes below Table 1.**

### Table 5: Mildew assessments

<table>
<thead>
<tr>
<th>Fungicides and rates/100 gal</th>
<th>10 June</th>
<th>30 June (2nd rating)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jerseymac</td>
<td>Redcort</td>
</tr>
<tr>
<td>1. Control</td>
<td>30.1 e</td>
<td>23.2 d</td>
</tr>
<tr>
<td>2. Penncozeb 1 lb // Captan-80 10 oz</td>
<td>12.3 d</td>
<td>26.7 d</td>
</tr>
<tr>
<td>3. Rally 1.33 oz + Penncozeb 1 lb + Rally 1.33 oz + Captan-80 10 oz</td>
<td>1.4 abc</td>
<td>1.2 ab</td>
</tr>
<tr>
<td>4. Indar 2.67 fl oz + LI-700 + Penncozeb 1 lb Indar + LI-700 + Captan-80 10 oz</td>
<td>2.7 c</td>
<td>2.3 bc</td>
</tr>
<tr>
<td>5. Tebuzeol 2 oz + Penncozeb 1 lb Tebuzeol 6 oz + Captan-80 10 oz</td>
<td>1.7 abc</td>
<td>0.9 ab</td>
</tr>
<tr>
<td>6. Penncozeb 1 lb // Tebuzeol 2 oz + P'zeb 1 lb Capt. 10 oz// Tebuzeol 2 oz//6 oz + Capt. 10 oz</td>
<td>0.3 ab</td>
<td>1.9 abc</td>
</tr>
<tr>
<td>7. Luna Sensation 500 SC 1.33 fl oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. LEM17 4.8 fl oz + Flint 0.33 oz</td>
<td>2.2 bc</td>
<td>0.7 ab</td>
</tr>
<tr>
<td>9. Pristine 5 oz</td>
<td>4.1 c</td>
<td>3.5 bc</td>
</tr>
<tr>
<td>10. Flint 0.67 oz</td>
<td>1.3 abc</td>
<td>2.0 ab</td>
</tr>
</tbody>
</table>

**See application schedule and footnotes below Table 1.**
### Table 6: Foliar rust infections on 10 June

<table>
<thead>
<tr>
<th>Fungicides and rates/100 gal</th>
<th>Cluster leaves with rust (%)</th>
<th>Bourse/term'l leaves with rust (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jersey-</td>
<td>Red-</td>
</tr>
<tr>
<td></td>
<td>mac</td>
<td>cort</td>
</tr>
<tr>
<td>1. Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Penncozeb 1 lb // Captan-80 10 oz</td>
<td>12.3 b</td>
<td>25.5 d</td>
</tr>
<tr>
<td>3. Rally 1.33 oz + Penncozeb 1 lb + Rally 1.33 oz + Captan-80 10 oz</td>
<td>3.6 a</td>
<td>3.1 ab</td>
</tr>
<tr>
<td>4. Indar 2.67 fl oz + LI-700 + Penncozeb 1 lb</td>
<td>0.9 a</td>
<td>1.0 ab</td>
</tr>
<tr>
<td>5. Tebuozol 2 oz + Penncozeb 1 lb</td>
<td>0.7 a</td>
<td>0.6a</td>
</tr>
<tr>
<td>6. Penncozeb 1 lb // Tebuozol 2 oz + P'zeb 1 lb Capt. 10 oz // Tebuozol 2 oz//6 oz + Capt. 10 oz</td>
<td>1.3 a</td>
<td>6.1 a</td>
</tr>
<tr>
<td>7. Luna Sensation 500 SC 1.33 fl oz</td>
<td>1.6 a</td>
<td>5.2 abc</td>
</tr>
<tr>
<td>8. LEM17 4.8 fl oz + Flint 0.33 oz</td>
<td>0.8 a</td>
<td>2.1 ab</td>
</tr>
<tr>
<td>9. Pristine 5 oz</td>
<td>1.8 a</td>
<td>8.2 bc</td>
</tr>
<tr>
<td>10. Flint 0.67 oz</td>
<td>1.3 a</td>
<td>6.1 a</td>
</tr>
</tbody>
</table>

**See application schedule and footnotes below Table 1.**

### Table 7: Necrotic Leaf Spot and Quince Rust

<table>
<thead>
<tr>
<th>Fungicides and rates/100 gal</th>
<th>Bourse leaves with necrotic leaf spot</th>
<th>Fruitlets with quince rust</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jersey-</td>
<td>Red-</td>
</tr>
<tr>
<td></td>
<td>mac</td>
<td>cort</td>
</tr>
<tr>
<td>1. Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Penncozeb 1 lb // Captan-80 10 oz</td>
<td>31.9 d</td>
<td>24.4 b</td>
</tr>
<tr>
<td>3. Rally 1.33 oz + Penncozeb 1 lb + Rally 1.33 oz + Captan-80 10 oz</td>
<td>2.3 ab</td>
<td>8.8 a</td>
</tr>
<tr>
<td>4. Indar 2.67 fl oz + LI-700 + Penncozeb 1 lb</td>
<td>2.6 ab</td>
<td>13.1 ab</td>
</tr>
<tr>
<td>5. Tebuozol 6 oz + Captan-80 10 oz</td>
<td>3.8 ab</td>
<td>11.4 ab</td>
</tr>
<tr>
<td>6. Penncozeb 1 lb // Tebuozol 2 oz + P'zeb 1 lb Capt. 10 oz // Tebuozol 2 oz//6 oz + Capt. 10 oz</td>
<td>0.7 a</td>
<td>5.8 a</td>
</tr>
<tr>
<td>7. Luna Sensation 500 SC 1.33 fl oz</td>
<td>3.3 ab</td>
<td>4.8 a</td>
</tr>
<tr>
<td>8. LEM17 4.8 fl oz + Flint 0.33 oz</td>
<td>5.5 bc</td>
<td>10.7 ab</td>
</tr>
<tr>
<td>9. Pristine 5 oz</td>
<td>0.7 a</td>
<td>4.6 a</td>
</tr>
<tr>
<td>10. Flint 0.67 oz</td>
<td>1.6 ab</td>
<td>15.0 ab</td>
</tr>
</tbody>
</table>

**See application schedule and footnotes below Table 1.**
Table 8: Rust on fruit at harvest

<table>
<thead>
<tr>
<th>Fungicides and rates/100 gal</th>
<th>Quince rust</th>
<th>Golden D. with cedar apple rust</th>
<th>Russet: Golden D. fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jerseymac 5 Aug</td>
<td>Redcort 2 Sep</td>
<td>Golden D. 21 Sep</td>
</tr>
<tr>
<td>1. Control</td>
<td>50.5 c</td>
<td>15.8 c</td>
<td>57.2 b</td>
</tr>
<tr>
<td>2. Penncozeb 1 lb // Captan-80 10 oz</td>
<td>1.9 ab</td>
<td>1.3 ab</td>
<td>0.4 a</td>
</tr>
<tr>
<td>3. Rally 1.33 oz + Penncozeb 1 lb + Rally 1.33 oz + Captan-80 10 oz</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>4. Indar 2.67 fl oz + LI-700 + Penncozeb 1 lb Indar 2.67 fl oz + LI-700 + Captan-80 10 oz ...</td>
<td>0.4 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>5. Tebuzol 2 oz + Penncozeb 1 lb Tebuzol 6 oz + Captan-80 10 oz</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>6. Penncozeb 1 lb // Tebuzol 2 oz + P'zeb 1 lb Capt. 10 oz// Tebuzol 2 oz//6 oz + Capt. 10 oz</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>7. Luna Sensation 500 SC 1.33 fl oz</td>
<td>1.2 ab</td>
<td>0.8 ab</td>
<td>1.7 a</td>
</tr>
<tr>
<td>8. LEM17 4.8 fl oz + Flint 0.33 oz</td>
<td>0.8 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>9. Pristine 5 oz</td>
<td>1.5 a</td>
<td>0.8 ab</td>
<td>0.4 a</td>
</tr>
<tr>
<td>10. Flint 0.67 oz</td>
<td>1.5 a</td>
<td>0.8 ab</td>
<td>0.4 a</td>
</tr>
<tr>
<td>11. Penncozeb 2 lb + GWN-4616 1.13 fl oz GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-7000 ...</td>
<td>0.4 a</td>
<td>0.0 a</td>
<td>0.8 a</td>
</tr>
<tr>
<td>12. Penncozeb 2 lb + GWN-4616 1.13 fl oz GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-7000 GWN-4616 3.33 fl oz + Penncozeb 1 lb</td>
<td>0.4 a</td>
<td>0.0 a</td>
<td>0.8 a</td>
</tr>
<tr>
<td>13. Penncozeb 1 lb // Captan-80 10 oz</td>
<td>17.0 b</td>
<td>1.7 b</td>
<td>--</td>
</tr>
</tbody>
</table>

*See application schedule and footnotes below Table 1.*

Table 9: Summer disease on fruit at harvest

<table>
<thead>
<tr>
<th>Fungicides and rates/100 gal</th>
<th>Flyspeck (% fruit affected)</th>
<th>Sooty blotch (% fruit affected)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Redcort 2 Sep</td>
<td>Golden Delicious 23 Sep</td>
</tr>
<tr>
<td>1. Control</td>
<td>80.4 bc</td>
<td>46.1 b</td>
</tr>
<tr>
<td>2. Penncozeb 1 lb // Captan-80 10 oz</td>
<td>82.9 c</td>
<td>46.4 b</td>
</tr>
<tr>
<td>3. Rally 1.33 oz + Penncozeb 1 lb + Rally 1.33 oz + Captan-80 10 oz</td>
<td>80.0 bc</td>
<td>41.3 b</td>
</tr>
<tr>
<td>4. Indar 2.67 fl oz + LI-700 + Penncozeb 1 lb Indar 2.67 fl oz + LI-700 + Captan-80 10 oz ...</td>
<td>84.6 c</td>
<td>55.3 b</td>
</tr>
<tr>
<td>5. Tebuzol 2 oz + Penncozeb 1 lb Tebuzol 6 oz + Captan-80 10 oz</td>
<td>79.7 bc</td>
<td>37.7 b</td>
</tr>
<tr>
<td>6. Penncozeb 1 lb // Tebuzol 2 oz + P'zeb 1 lb Capt. 10 oz// Tebuzol 2 oz//6 oz + Capt. 10 oz</td>
<td>89.4 bc</td>
<td>37.2 b</td>
</tr>
<tr>
<td>7. Luna Sensation 500 SC 1.33 fl oz</td>
<td>80.4 bc</td>
<td>46.7 b</td>
</tr>
<tr>
<td>8. LEM17 4.8 fl oz + Flint 0.33 oz</td>
<td>80.6 bc</td>
<td>36.8 b</td>
</tr>
<tr>
<td>9. Pristine 5 oz</td>
<td>71.0 b</td>
<td>40.0 b</td>
</tr>
<tr>
<td>10. Flint 0.67 oz</td>
<td>70.2 b</td>
<td>42.6 b</td>
</tr>
</tbody>
</table>

*See application schedule and footnotes below Table 1.*
### Table 10: Harvest ratings

<table>
<thead>
<tr>
<th>Fungicides and rates/100 gal&lt;sup&gt;7&lt;/sup&gt;</th>
<th>Black/white rot at harvest</th>
<th>Disease-free fruit at harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jerseymac 5 Aug</td>
<td>Redcort 2 Sep</td>
</tr>
<tr>
<td>1. Control ..........................</td>
<td>8.6 c</td>
<td>28.3 d</td>
</tr>
<tr>
<td>2. Penncozeb 1 lb // Captan-80 10 oz</td>
<td>0.4 a</td>
<td>9.2 abc</td>
</tr>
<tr>
<td>3. Rally 1.33 oz + Penncozeb 1 lb +</td>
<td>Rally 1.33 oz + Captan-80 10 oz</td>
<td>0.0 a</td>
</tr>
<tr>
<td>4. Indar 2.67 fl oz + LI-700 + Penncozeb 1 lb</td>
<td>Indar 2.67 fl oz + LI-700 + Captan-80 10 oz</td>
<td>3.1 bc</td>
</tr>
<tr>
<td>5. Teburol 2 oz + Penncozeb 1 lb</td>
<td>Teburol 6 oz + Captan-80 10 oz</td>
<td>1.1 ab</td>
</tr>
<tr>
<td>6. Penncozeb 1 lb // Teburol 2 oz + P'zeb 1 lb</td>
<td>Capt. 10 oz// Teburol 2 oz//6 oz + Capt. 10 oz</td>
<td>0.4 a</td>
</tr>
<tr>
<td>7. Luna Sensation 500 SC 1.33 fl oz</td>
<td>1.1 ab</td>
<td>9.2 abc</td>
</tr>
<tr>
<td>8. LEM17 4.8 fl oz + Flint 0.33 oz</td>
<td>1.6 ab</td>
<td>11.9 abc</td>
</tr>
<tr>
<td>9. Pristine 5 oz</td>
<td>0.4 a</td>
<td>5.8 a</td>
</tr>
<tr>
<td>10. Flint 0.67 oz</td>
<td>1.2 ab</td>
<td>7.0 a</td>
</tr>
</tbody>
</table>

<sup>7</sup>See application schedule and footnotes below Table 1.

*Treatments are not significantly different, *P*=0.223.
Treatments were replicated four times in a randomized block design in a 11-yr-old orchard containing trees on MM.111 rootstocks with M.9 interstems. Trees in this test block are spaced 25 ft between rows, 10 ft between trees within rows, and 20 feet between plots within rows. Each plot consisted of one tree on which the lower scaffolds were McIntosh and the upper portion of the trees had been grafted to Ginger Gold. Plots within rows were separated by 10-ft-tall cedar trees that limited drift from one plot to another, and cedar hedges of a similar height were located on two sides of this triangular orchard. As a result, apple trees in this block were exposed to extremely high concentrations of inoculum for cedar apple rust and quince rust. All treatment sprays were applied with a tractor-powered high-pressure handgun at 250 psi and trees were sprayed to drip. Treatment dates are shown in Table 2.

The prebloom period was relatively dry with only one significant scab infection period near tight cluster (20-22 Apr, 52 hr wetting, 47°F, 0.85 in. rain). Another major infection period occurred during bloom (3-9 May, 105 hr, 55°F, 1.76 in. rain). A very few primary scab lesions were noted on unspayed trees in an adjoining block on 6 May. Abundant primary scab was evident on unsprayed trees by 15 May. There were 9 secondary scab infection periods during the latter half of May, 16 in Jun, 13 in Jul, 7 in Aug, and 4 in Sep. June and July were very wet with leaf wetting recorded for 50% of total time in June and 37% of total time in July. Inches of rainfall recorded for June and July were 8.45 and 4.71, respectively. Due to the cool weather, scab remained active throughout summer.

All trees in the block were inoculated with Botrytis cinerea on 6 May in the middle of a long wetting period to enhance the probability that apple fruit might develop calyx-end infections in the field or quiescent infections that would develop into postharvest decays. Inoculum was prepared using 94 petri plates of B. cinerea that had been growing on V-8 juice agar for 13 days. Agar, mycelia, and spores were removed from the plates, weighed (total wt = 2.705 kg), and homogenized with water in small batches in a blender. The resulting inoculum slurry was added to 100 gal of water in a high-pressure sprayer and all of the trees in the test block were sprayed until trees were wet but not dripping. Golden Delicious trees were just past full bloom at the time inoculum was applied whereas the McIntosh and Ginger Gold had lost about 90% of their petals by that time.

Disease development was monitored throughout the season as indicated by data collection times noted in the tables. A few fruit on control trees developed blossom-end infections (Fig. 1), but incidence of blossom-end rot was too low to allow collection of any meaningful data.

None of the treatments provided adequate control of rust diseases because of the tremendous rust inoculum present in this block, the continuously wet weather during June when cedar apple rust galls were still active, and the use of Captan rather than Dithane as the contact fungicide for sprays applied during June. Leaf yellowing attributable to severe rust infection was evident in many treatments by late June and presumably resulted from severe terminal leaf infections initiated prior to 8 June that were then suppressed by later fungicide applications. Yellowing on the upper and lower sides of leaves is shown in Figure 2.

Figure 1. Blossom end-rot and cedar apple rust in a Ginger Gold control tree on 1 July.
Figure 2. Golden Delicious leaves photographed 1 July 2009 showing severe cedar apple rust infection on the unsprayed control (top) compared to leaves with the rust-induced leaf yellowing that occurred where DMI fungicides arrested fungal development after infections were initiated. Yellowing was most evident on the upper sides of leaves (center) but was also visible when viewing undersides of leaves (bottom).
Leaves with severe yellowing did not become necrotic and generally persisted on the trees until at least mid-September, but they tended to deteriorate and drop from trees somewhat earlier than healthy leaves.

Results from this trial can be interpreted only by carefully comparing treatment timings, weather data, and ratings for the various diseases. Flyspeck development during summer is driven by hours of accumulated leaf wetness. Ascospores of the flyspeck pathogen are released from woodlots and hedgerows beginning at about petal fall (May 8 in this trial), but ascospore infections are usually prevented by scab fungicides that are applied until mid-June. The best evidence suggests that conidia of the flyspeck fungus begin blowing into orchards sometime shortly after trees have been exposed to 270 hr of accumulated wetting from petal fall (hr-AWPF). Conidial infections cause most of the damage that appears on fruit in sprayed orchards. After conidia are released and infect fruit, roughly 270 hr of additional wetting is required before infections on fruit become visible. That means (if the current model is correct) that flyspeck infections should begin appearing on unsprayed fruit beginning after 540 hr-AWPF. We have also determined based on past observations that most of the summer fungicides will protect fruit from sooty blotch and flyspeck (SBFS) for the shorter of either 21 days following an application or until 2 in. of rainfall have accumulated following an application. Captan is less effective and protects fruit for the shorter of 14 days or 1 in. of rainfall. Flyspeck infections that occur after fungicide residues are depleted between sprays apparently stop growing when fungicide coverage is renewed, but most (or at least many) infections remain viable and resume growth when fungicide residues are depleted again. In other words, fungicides can arrest fungal development and lengthen the incubation period for flyspeck, but fungicides applied after infections are established cannot eradicate these infections.

Leaf wetting and rainfall accumulations for the entire 2009 season and for intervals between sprays are shown in Table 1. Using the rules explained above, we also calculated accumulated hours of wetting that were not protected by fungicides, and

Table 1. Accumulations of rainfall and hours of wetting (as determined with a DeWitt string recorder) for the period from petal fall through harvest, with totals shown for the intervals between fungicide applications in the Pond Block, 2009, Hudson Valley Lab, Highland, NY.

<table>
<thead>
<tr>
<th>Spray dates and other significant dates for monitoring development of flyspeck</th>
<th>Accumulated hr of wetting from petal fall</th>
<th>Accumulated rainfall from petal fall</th>
<th>Hours of wetting</th>
<th>Rainfall (inches)</th>
<th>Hours of wetting that accumulated during periods lacking fungicide protection assuming that fungicide residues are depleted after accumulated rainfall of: 1 inch after Captan, otherwise 2 inches (e.g., trts 2-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-May</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 May: Petal Fall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-May</td>
<td>61.50</td>
<td>2.06</td>
<td>61.5</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>30-May</td>
<td>135.25</td>
<td>2.59</td>
<td>73.8</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>8-Jun</td>
<td>191.50</td>
<td>2.67</td>
<td>56.3</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>16-Jun</td>
<td>324.75</td>
<td>6.92</td>
<td>133.3</td>
<td>4.3</td>
<td>43.8</td>
</tr>
<tr>
<td>25-Jun</td>
<td>438.50</td>
<td>10.36</td>
<td>113.8</td>
<td>3.4</td>
<td>94.3</td>
</tr>
<tr>
<td>9-Jul</td>
<td>558.25</td>
<td>12.12</td>
<td>119.8</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>23-Jul</td>
<td>684.00</td>
<td>14.31</td>
<td>125.8</td>
<td>2.2</td>
<td>94.3</td>
</tr>
<tr>
<td>15-Aug</td>
<td>913.00</td>
<td>18.66</td>
<td>229.0</td>
<td>4.4</td>
<td>162.6</td>
</tr>
<tr>
<td>24-Aug: GG harvest</td>
<td>955.75</td>
<td>20.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28-Aug</td>
<td>1005.00</td>
<td>21.01</td>
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<tr>
<td>31-Aug</td>
<td>1013.00</td>
<td>21.01</td>
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</tr>
<tr>
<td>1-Sep</td>
<td>1026.00</td>
<td>21.01</td>
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</tr>
<tr>
<td>2-Sep</td>
<td>1038.00</td>
<td>21.01</td>
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</tr>
<tr>
<td>3-Sep</td>
<td>1051.00</td>
<td>21.01</td>
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<tr>
<td>4-Sep</td>
<td>1064.00</td>
<td>21.01</td>
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<tr>
<td>5-Sep</td>
<td>1067.00</td>
<td>21.01</td>
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</tr>
<tr>
<td>8 Sep: Mac harvest</td>
<td>1072.50</td>
<td>21.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-Sep</td>
<td>1103.50</td>
<td>21.55</td>
<td></td>
<td>253.3</td>
<td>253.3</td>
</tr>
<tr>
<td>17-Sep</td>
<td>1124.25</td>
<td>21.58</td>
<td>211.3</td>
<td>2.9</td>
<td>305.0</td>
</tr>
<tr>
<td>30 Sep: GD harvest</td>
<td>1143.50</td>
<td>22.15</td>
<td>19.25</td>
<td>0.57</td>
<td></td>
</tr>
</tbody>
</table>
that data is shown in the two columns on the right side Table 1. Given a full-season summer program of Topsin-M plus Captan (a trt not included in this trial), we would have expected flyspeck to appear when the accumulation in the second column from the right reached 270 hr. Where Captan was used in early-summer sprays (as for treatments 2-5, 11, 12), flyspeck should have appeared on fruit when the accumulation in the right-most column reached 270 hr.

Data from Table 1 shows that flyspeck actually appeared somewhat earlier than the model would have predicted. However, many of those early infections were relatively small and/or occurred only in the calyx cup or step cup of the fruit where they would not have caused fruit to be downgraded when packed. Comparisons of flyspeck and sooty blotch incidence with fruit out of grade (Table 11) show that only a quarter of infected fruit in most treatments had enough SBFS to cause downgrading. Since most growers are concerned about SBFS when it reaches the level where it causes downgrading, we conclude that the flyspeck model did a reasonable job of predicting when flyspeck began to appear at levels that would have caused economic damage.

The following pages provide additional comments on results shown in each table.

**Observations and Conclusions:**

Comments that apply to all data tables:

- Abbreviations used in the following notes: Mac = McIntosh; GG = Ginger Gold; GD = Golden Delicious; NLS = necrotic leaf spot; SBFS = sooty blotch and flyspeck; nd = no data available.
- Trts 3-4-5 were designed to evaluate Inspire Super at various timings just before or after bloom.
- Trts 2-5, 11, 12 all received identical sprays after 30 May. Thus differences among these treatments is attributable to effects of early-season sprays.
- Trts 6 through 12 received identical fungicide applications until the summer spray program was initiated on 6 Jun. Thus, early-season scab ratings made on 10 June should have produced similar results for trts 6-12.
- Trts 11 & 12 were identical until the preharvest sprays were applied. We rated them throughout the season and data for each of these two trts is shown in all tables. However, the preharvest sprays that are shown in Table 1 are not listed in data tables that involved preharvest evaluations. If trts 11 & 12 produced different results in preharvest evaluations, then those results should be considered artifacts rather than real treatment effects.
- Trts 6 through 10 were designed to evaluate Inspire Super and other products in summer sprays.
- Trts 7-10 had identical spray programs during summer except for the test products that are shown in bold print in Table 1 for each of those treatments. These treatments are placed within a box in each data table to allow for easy comparisons.
- Where 1-day preharvest sprays are indicated in Table 2, harvest samples for those plots were collected prior to making the 1-day preharvest sprays, the preharvest sprays were then applied, and a second harvest sample was collected from those same trees on the following day. The latter samples are being used to evaluate effects of preharvest sprays. All of the harvest data in Tables 3-13 was taken from fruit that were collected prior to the 1-day preharvest sprays.
- Data was analyzed using the SuperANOVA statistical software for Macintosh computers.

**Table 3:**

- Scab control on early terminal leaves for Mac and GG was weakest in treatments 2 and 3 where no DMI fungicides were used in sprays applied prior to 30 May.
- Scab control on GG fruit was slightly weaker for trt 3 where Captan alone was applied on 20 May than in trt 2 where all sprays through 30 May consisted of Dithane. Trt 4, where the 8 May spray consisted of Dithane plus Inspire Super, was intermediate between trts 2 and 3 in fruit scab control on GG.

**Table 4:**

- NLS in this block was caused primarily by cedar apple rust infections that failed to develop either due to host resistance (Mac) or applications of DMI fungicides after infections were initiated (GD).
- None of the treatments provided adequate control of rust diseases due to the tremendous rust inoculum present in this block, the continuously wet weather during June when cedar apple rust galls were still active, and the use of Captan rather than Dithane as the contact fungicide for sprays applied during June.
- Rust on terminal leaves for both GG and GD was greater for trt 2 than for trt 3 despite the fact that trt 2 received Dithane on 20 May whereas trt 3 received only Captan. Inspire Super applied on 30 May in trt 3 apparently provided some post-infection activity against rust infections initiated prior to this spray and/or better protection.
against rust infections that occurred following this spray. The fact that trt 3 had more NLS on GD than trt 2 suggests that differences in rust control between these two treatments was probably due to post-infection activity of Inspire Super because NLS often results when rust lesions are killed from post-infection sprays of DMI fungicides.

- Leaf yellowing was similarly severe on trts 5 through 12, but somewhat less severe on trts 1 through 4 because rust infections either developed into normal lesions (trt 1-2) or NLS (trt 3), or because sprays applied during May did a better job of suppressing rust (trt 4). Trts 5-12 relied on Captan either alone or with DMI sprays for the three applications during May and these did not adequately suppress rust. Leaf yellowing in trts 5-12 resulted when severe terminal leaf infections initiated prior to 8 June were then suppressed DMI fungicides applied on 8 June.

Table 5:

- Differences among treatments in percent leaves with no disease were relatively small for Macs but were larger for GG and GD where rust infections damaged more leaves. As explained in comments for Table 3, trts 2-3 showed reduced control of rust and therefore had lower percentages of disease-free trees.
- Mildew pressure in this block was very light and differences among treatments were not significant. However, trts 1,2,3, and 5 appeared to group together whereas other treatments provided better control.

Table 6:

- For both quince rust and cedar apple rust, we found less disease at harvest on 24 Aug than in the earlier rating on 19 June because some diseased fruit dropped from the trees during early summer.
- All fungicide treatments provided excellent control of quince rust.
- All treatments except trts 2-3 provided excellent control of cedar apple rust.
- Trts 11-12 were treated exactly the same until the preharvest spray was applied. Therefore, the slightly elevated incidence of cedar apple rust in trt 11 for GD rated at harvest is an artifact of the randomization pattern. It probably resulted from the chance selection of more trees in trt 11 that were immediately adjacent to cedar trees carrying high levels of inoculum.

Table 7:

- In control plots, we evaluated 20 fruit per tree for flyspeck (on-tree ratings) on 14 July and again on 22 July and found 0% and 7.5% of fruit with flyspeck on those respective dates (data not shown in the table). We passed 540 hr-AWPF on 7 Jul and had 606 hr-AWPF by 14 Jul and 685 hr-AWPF by 22 July. Thus, flyspeck appeared on fruit somewhat later than the 540 hr-AWPF that we projected as the expected date for flyspeck appearance based on our model.
- SBFS was present on most control fruit and on many fruit in weaker treatments by 24 Aug.
- Trts 2-11-12 which had only Dithane, Captan, or Rally until 25 Jun had unacceptable levels of flyspeck despite receiving four applications of Tospin M during summer. These three treatments averaged 30% of fruit with flyspeck on 1 Sep and 43% with flyspeck on 15 Sep. However, by 1 Sep and 15 Sep, these treatments had accumulated 272 and 362 hr respectively of accumulated wetting during periods of fungicide depletion (Table 1, last column on right). Thus, failure of these treatments is not unexpected.
- Trts 5-6 that included Inspire Super in summer sprays had low incidences of flyspeck.
- Indar (trt 8) and Tebuzol (trt 10) failed to provide adequate control of flyspeck, and this failure was already evident by 24 Aug on GG and by 1 Sep on GD. By 30 Sep, these treatments had more flyspeck than trts 2-11-12 programs that were the closest to a commercial standard for controlling SBFS in this trial.
- Luna Sensation (trt 9) provided good control of flyspeck through harvest on GG and through 1 Sep on GD, but it fared less well on incubated GG fruit and on GD at harvest. Nevertheless, it performed as well as trts 2-11-12.

Table 8:

- Indar (trt 8) and Tebuzol (trt 10) failed to control sooty blotch. With most fungicides, sooty blotch is easier to control than flyspeck, presumably because sooty blotch is suppressed longer than flyspeck by declining levels of fungicide residues as spray deposits are depleted between rains.
- The fact that only two treatments (trts 5-6) completely protected GG fruit against sooty blotch indicates the severity of this test. Weather conditions and spray intervals favored severe disease development.
- All of the fungicide treatments suppressed summer fruit rots as compared to the controls.

Table 9:

- Incidence of sooty blotch increased dramatically during postharvest incubation (compare SB data on Table 7 and 8).
• Incidence of SB on incubated fruit was greater than incidence of FS on incubated fruit for some treatments (compare data in Tables 6 & 8), including trts 6-7 where Inspire Super gave excellent control of FS.

Table 10:
• This table was compiled by totaling the numbers of fruit as indicated in footnote X. Fruit drops were collected from beneath each tree on 5 Aug and decays were identified based on symptoms, but we counted only fruit that had sized during summer and that had dropped from trees in the recent past. We repeated this process after harvest to assess fruit that dropped from trees between 5 and 24 August. Fruit remaining on the tree after we collected samples for harvest evaluations were counted and were assumed to have the same proportions and distribution of decays that occurred in our harvest samples. All of this data was compiled together to arrive at the totals shown in this table.
• Percentages for decays vary a bit from those shown in Tables 7 and 8 where means are based on harvest samples, but most discrepancies are small and the treatment rankings are similar. Thus, we conclude that we did not lose a disproportionate number of decayed fruit to preharvest drop and the harvest sample was therefore a reasonable measure of treatment effectiveness against summer fruit rot pathogens.
• Fruit numbers varied among trees due to variations in tree sizes and previous treatment history (i.e., trees with poor disease control last year had less fruit). There was no apparent effect of treatments on total fruit number. Fruit numbers in the control plots were very low because many diseased fruitlets dropped to the ground during June and were never counted.
• Incidence of decays in control fruit was very high due to the wet summer.
• Teburol (trt 10) had the smallest number of total fruit with decays, but a number of other treatments were statistically equivalent.

Table 11:
• The flyspeck incidence data in this table (3rd column from the right) is the same as shown in Table 7. It is shown again here to facilitate comparisons with the proportion of fruit that was out-of-grade. Trts 5 & 6 provided the highest counts of fruit with no visible disease, but several other treatments provided comparable results for percentages of fruit that would meet USDA Fancy grade because some of the other treatments had small SBFS infections that were not large enough to cause down-grading.
• Treatments that received Inspire Super or Luna Sensation had the highest percentages of fruit that would have met USDA Fancy Grade and they also had the least fruit out of grade for SBFS.
• Trts 3-4-6 all received Inspire Super on May 30 and had less fruit out of grade for SBFS than trt 5 which received only Captan on 30 May. Thus, the 30 May application was critical for final control of SBFS, perhaps because Inspire Super provided some post-infection activity for ascospore infections that might have been initiated shortly before 30 May.
• Though treatments did not separate statistically in this analysis, Luna Sensation and Teburol had less black/white rot at harvest than treatments that received Inspire Super or Indar.
• Trt 2, where Dithane was applied alone through May, had more black rot and white rot than trts 11-12 that had similar sprays after 30 May but received Rally plus Captan during May. Mancozeb and DMI fungicides are usually less effective against black/white rot than are captan and strobilurin fungicides.
• The mediocre control of black/white rot in most of the Inspire Super treatments might have occurred because Inspire Super provides only moderate control of black/white rots and it was applied alone (without Captan) at least once in most of these treatments.

Table 12:
• Weather conditions were conducive for severe fruit russetting which is usually induced during the 45 days after petal fall and is mostly caused by growth of Aureobasidium pullulans, an epiphytic yeast-like fungus that benefits from extended periods of wet weather.
• Most fungicide treatments suppressed fruit russetting on GD compared to the controls, but Inspire Super applied alone at critical periods in trt 5 provided no suppression and had russetting similar to the control fruit. Thus, all DMIs including Inspire Super should be applied in combinations with a contact fungicide after petal fall to avoid problems with russetting.

Table 13:
• Mac fruit were not rated at harvest because of logistical problems with getting fruit into storage for the postharvest assessment phase of this trial. Instead, Mac fruit were rated Nov. 9-10 after being held at 35° F from harvest on 8 Sep until rating on 9 Nov. Thus, some of the SBFS noted on Mac fruit may have developed during storage.
Table 2. Treatments and spray dates for the Pond Block fungicide trial in 2009.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1. Control</td>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>2. Dithane 75 DF 1 lb</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>+ Captan 80WDG 10 oz</td>
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<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>+ Tonsin M 70W 4 oz</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>11. Captan 80WDG 10 oz</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
</tr>
<tr>
<td>+ Tonsin M 70W 4 oz</td>
<td>Dth³</td>
<td>Rly³</td>
<td>Rly³</td>
<td>-</td>
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<td>-</td>
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</tr>
<tr>
<td>3. Inspire Super 338SE 3.97 fl oz</td>
<td>-</td>
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<tr>
<td>+ Captan 80WDG 10 oz</td>
<td>Dth³</td>
<td>Dth³</td>
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<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>+ Tonsin M 70W 4 oz</td>
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</tr>
<tr>
<td>4. Inspire Super 338SE 3.97 fl oz</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>+ Captan 80WDG 10 oz</td>
<td>Dth³</td>
<td>Dth³</td>
<td>X</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
</tr>
<tr>
<td>+ Tonsin M 70W 4 oz</td>
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</tr>
</tbody>
</table>

- All plots including controls received applications of Penncozeb 3 lb/A on 9 Apr and Dithane 3 lb/A on 18 Apr.
- The application on 9/17 was to Golden Delicious only (other cultivars had already been harvested).
- Dth = Dithane 75DF 1 lb/100 gal was applied on this date; Rly = Rally 40WSB 1.33 oz/100 gal was applied on this date.
- Indicates treatments where the last spray on 17 Sep also included ProPhyt 4.2L at 21.3 fl oz/100 gal.
- The preharvest spray was applied to McIntosh (trts 11 & 12) on 8 Sep and to Golden Delicious (trts 9,11,12) on 30 Sep.
For treatment details, see Table 1.

Fruit ratings are based on observing all leaves on 15 terminal shoots/tree.

For McIntosh and Ginger Gold (10 Jun) and 60 fruit/tree for Golden Delicious (or all available fruit if less than 60/tree).

Numbers within columns followed by the same small letter are not significantly different: Fisher's Protected LSD (P≤0.05).
<table>
<thead>
<tr>
<th>Table 5. Mildew ratings and early terminal leaves with no disease</th>
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</thead>
<tbody>
<tr>
<td>Fungicide and rate/100 gal</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1. Control</td>
</tr>
<tr>
<td>2. Dithane 1 lb// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>11. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>12. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>3. Dithane 1 lb// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>4. Insp. Super + Dith // Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>5. Dithane // Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>6. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>7. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>8. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>9. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>10. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
</tbody>
</table>

See footnotes below Table 1 at the bottom of the page.

<table>
<thead>
<tr>
<th>Table 6. Rust on Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fungicide and rate/100 gal</td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td>1. Control</td>
</tr>
<tr>
<td>2. Dithane 1 lb// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>11. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>12. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>3. Dithane 1 lb// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>4. Insp. Super + Dith // Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>5. Dithane // Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>6. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>7. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>8. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>9. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
<tr>
<td>10. Dth // R+C// Capt. 10 oz// C+T</td>
</tr>
</tbody>
</table>

Footnotes:
1. For treatment details, see Table 1.
2. Terminal leaf ratings are based on observing all leaves on 15 terminal shoots/tree.
3. Fruit ratings are based on observing 25 fruit/tree for 10 Jun data. Harvest ratings on 24 Aug and 30 Sep were based on 60 fruit/tree or all available fruit for trees with lower fruit counts.
4. Numbers within columns followed by the same small letter are not significantly different: Fisher's Protected LSD (P≤0.05).
5. Treatments do not differ significantly, P= 0.136. aNumbers within columns followed by the same small letter are not significantly different: Fisher's Protected LSD (P≤0.05).
6. Treatments do not differ significantly, P= 0.394.
Table 7. Development of flyspeck at various intervals during summer

<table>
<thead>
<tr>
<th>Fungicide and rate/100 gal</th>
<th>% fruit with flyspeck</th>
<th>24 Aug after incbtn</th>
<th>30 Sep at hvst</th>
<th>Ginger Gold</th>
<th>Golden Delicious</th>
<th>McIntosh fruit harvested 8 Sep &amp; rated 9 Nov.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>24 Aug</td>
<td>1 Sep</td>
<td>15 Sep</td>
<td>24 Aug</td>
<td>1 Sep</td>
</tr>
<tr>
<td>1. Control</td>
<td></td>
<td>96.9 g</td>
<td>nd</td>
<td>95 g</td>
<td>100 g</td>
<td>100.0 f</td>
</tr>
<tr>
<td>2. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td></td>
<td>23.3 de</td>
<td>19 abc</td>
<td>34 bcd</td>
<td>45.2 bc</td>
<td>56.7 de</td>
</tr>
<tr>
<td>11. Dith // R+C// Capt. 10 oz// C+T</td>
<td></td>
<td>14.2 cde</td>
<td>42 de</td>
<td>62 def</td>
<td>71.3 d</td>
<td>64.3 e</td>
</tr>
<tr>
<td>12. Dith // R+C// Capt. 10 oz// C+T</td>
<td></td>
<td>23.1 de</td>
<td>29 cde</td>
<td>34 cde</td>
<td>44.2 b</td>
<td>46.7 cd</td>
</tr>
<tr>
<td>3. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td>Inspire Super on 8 May</td>
<td></td>
<td>7.9 bcd</td>
<td>12.5 abc</td>
<td>3 ab</td>
<td>17 abc</td>
</tr>
<tr>
<td></td>
<td>Inspire Super on 30 Apr, 8 &amp; 30 May</td>
<td></td>
<td>5.4 abc</td>
<td>10.4 abc</td>
<td>4 ab</td>
<td>28 bcd</td>
</tr>
<tr>
<td></td>
<td>Inspire Super on 8 &amp; 20 May</td>
<td></td>
<td>15.1 cde</td>
<td>35.8 def</td>
<td>21 bcd</td>
<td>59 def</td>
</tr>
<tr>
<td>6. Dith // R+C// Capt. 10 oz// C+T</td>
<td>Inspire Super, 4 sprays</td>
<td></td>
<td>0.0 a</td>
<td>3.8 ab</td>
<td>0 a</td>
<td>2 a</td>
</tr>
</tbody>
</table>

*nd = no data collected. Other footnotes are shown at the bottom of the page.

Table 8. Ginger Gold at harvest 24 Aug

<table>
<thead>
<tr>
<th>Fungicide and rate/100 gal</th>
<th>% fruit with:</th>
<th>no visible disease</th>
<th>sooty blotch</th>
<th>black/wht blots</th>
<th>bitter rot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Control</td>
<td></td>
<td>0.0 g</td>
<td>100.0 e</td>
<td>95.3 d</td>
<td>7.3 b</td>
</tr>
<tr>
<td>2. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td></td>
<td>52.7 ef</td>
<td>22.1 bc</td>
<td>5.2 c</td>
<td>1.6 a</td>
</tr>
<tr>
<td>11. Dith // R+C// Capt. 10 oz// C+T</td>
<td></td>
<td>80.8 bcd</td>
<td>5.0 abc</td>
<td>4.2 bc</td>
<td>0.4 a</td>
</tr>
<tr>
<td>12. Dith // R+C// Capt. 10 oz// C+T</td>
<td></td>
<td>72.9 cde</td>
<td>11.7 bc</td>
<td>1.2 abc</td>
<td>0.0 a</td>
</tr>
<tr>
<td>3. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td>Inspire Super on 8 May</td>
<td></td>
<td>82.1 bcd</td>
<td>5.0 abc</td>
<td>2.1 abc</td>
</tr>
<tr>
<td>4. Insp. Super + Dith // Capt. 10 oz// C+T</td>
<td></td>
<td>92.6 ab</td>
<td>3.2 ab</td>
<td>1.5 abc</td>
<td>0.0 a</td>
</tr>
<tr>
<td>5. Dithane // Capt. 10 oz// C+T // Inspire Super on 8 &amp; 20 May</td>
<td></td>
<td>82.4 bcd</td>
<td>5.8 abc</td>
<td>0.4 abc</td>
<td>0.0 a</td>
</tr>
<tr>
<td>6. Dith // R+C// Capt. 10 oz// C+T</td>
<td>Inspire Super on 8, 25 Jun, 23 Jul, 15 Aug</td>
<td></td>
<td>97.5 a</td>
<td>0.0 a</td>
<td>0.4 ab</td>
</tr>
</tbody>
</table>

*For treatment details, see Table 1.
†Sequential on-tree ratings were based on observing 20 fruit/tree.
‡Harvest ratings were based on observing 60 fruit/tree (Ginger Gold and Golden Delicious), 80 fruit/tree (McIntosh), or all available fruit for trees with lower fruit counts.
§Ratings after fruit had been incubated at 72° F and 100% relative humidity for 14 days after harvest ratings.
‖Fruit were rated after storing at 35° F for 62 days, so some of the flyspeck noted on fruit may have appeared during storage.
*Numbers within columns followed by the same small letter are not significantly different: Fisher’s Protected LSD (P≤0.05).
Table 9. Ginger Gold after postharvest incubation for 14 days at 72° F and 100% relative humidity: % fruit affected:

<table>
<thead>
<tr>
<th>Fungicide and rate/100 gal</th>
<th>No visible disease</th>
<th>Scenescence breakdown</th>
<th>Sooty blotch</th>
<th>Black/wht rots</th>
<th>Bitter rot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td>22.8 d*</td>
<td>8.6*</td>
<td>72.0 d</td>
<td>10.8**</td>
<td>12.2***</td>
</tr>
<tr>
<td>11. Dth // R+C// Capt. 10 oz// C+T</td>
<td>49.1 bc</td>
<td>3.0</td>
<td>43.4 bc</td>
<td>3.5</td>
<td>0.0</td>
</tr>
<tr>
<td>12. Dth // R+C// Capt. 10 oz// C+T</td>
<td>37.3 c</td>
<td>4.3</td>
<td>56.2 cd</td>
<td>0.0</td>
<td>1.9</td>
</tr>
<tr>
<td>3. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspire Super on 8 May</td>
<td>49.6 abc</td>
<td>7.9</td>
<td>38.3 bc</td>
<td>4.8</td>
<td>2.6</td>
</tr>
<tr>
<td>4. Insp. Super + Dith // Capt. 10 oz// C+T</td>
<td>68.9 ab</td>
<td>6.2</td>
<td>23.0 ab</td>
<td>0.8</td>
<td>0.0</td>
</tr>
<tr>
<td>5. Dithane // Capt. 10 oz// C+T</td>
<td>40.2 bc</td>
<td>12.2</td>
<td>45.5 c</td>
<td>2.1</td>
<td>0.8</td>
</tr>
<tr>
<td>6. Dth // R+C// Capt. 10 oz// C+T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspire Super on 8, 25 Jun, 23 Jul, 15 Aug</td>
<td>77.1 ab</td>
<td>1.7</td>
<td>16.5 a</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>7. Dth // R+C// Capt. 10 oz// C+T</td>
<td>Inspire Super, 5-times, 8 Jun-17 Sep</td>
<td>86.1 a</td>
<td>1.6</td>
<td>11.2 a</td>
<td>0.5</td>
</tr>
<tr>
<td>8. Dth // R+C// Capt. 10 oz// C+T</td>
<td>Indar, 5-times, 8 Jun-17 Sep</td>
<td>36.5 c</td>
<td>6.9</td>
<td>49.9 c</td>
<td>2.6</td>
</tr>
<tr>
<td>9. Dth // R+C// Capt. 10 oz// C+T</td>
<td>Luna Sensation, 5-times, 8 Jun-17 Sep</td>
<td>40.3 bc</td>
<td>3.0</td>
<td>53.1 c</td>
<td>0.0</td>
</tr>
<tr>
<td>10. Dth // R+C// Capt. 10 oz// C+T</td>
<td>Teburol, 5-times, 8 Jun-17 Sep</td>
<td>16.3 d</td>
<td>1.8</td>
<td>73.3 d</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Treatments did not differ significantly: *P= 0.175, **P= 0.182, ***P= 0.206. For other footnotes, see bottom of page.

Table 10. Ginger Gold incidence of fruit decays after accounting for dropped fruit and total crop load on the trees

<table>
<thead>
<tr>
<th>Fungicide and rate/100 gal</th>
<th>Total no. of fruit/tree</th>
<th>% all decays at harvest</th>
<th>Botrytis at harvest</th>
<th>Black/wht rot after incubation</th>
<th>Bitter rot at harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>26.3*</td>
<td>94.8 d*</td>
<td>6.3 b</td>
<td>79.4 c</td>
<td>15.5 b</td>
</tr>
<tr>
<td>1. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td>105.0</td>
<td>6.9 c</td>
<td>0.1 a</td>
<td>5.6 b</td>
<td>13.0**</td>
</tr>
<tr>
<td>11. Dth // R+C// Capt. 10 oz// C+T</td>
<td>111.8</td>
<td>4.4 bc</td>
<td>0.0 a</td>
<td>3.6 ab</td>
<td>5.5</td>
</tr>
<tr>
<td>12. Dth // R+C// Capt. 10 oz// C+T</td>
<td>120.0</td>
<td>2.8 abc</td>
<td>0.2 a</td>
<td>2.1 ab</td>
<td>2.1</td>
</tr>
<tr>
<td>3. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspire Super on 8 May</td>
<td>115.8</td>
<td>3.4 abc</td>
<td>0.0 a</td>
<td>2.8 ab</td>
<td>5.9</td>
</tr>
<tr>
<td>4. Insp. Super + Dith // Capt. 10 oz// C+T</td>
<td>125.3</td>
<td>1.8 bc</td>
<td>0.0 a</td>
<td>1.8 ab</td>
<td>2.1</td>
</tr>
<tr>
<td>5. Dithane // Capt. 10 oz// C+T</td>
<td>55.3</td>
<td>3.9 bc</td>
<td>0.0 a</td>
<td>1.8 ab</td>
<td>3.5</td>
</tr>
<tr>
<td>6. Dth // R+C// Capt. 10 oz// C+T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspire Super on 8, 25 Jun, 23 Jul, 15 Aug</td>
<td>141.5</td>
<td>0.8 ab</td>
<td>0.0 a</td>
<td>0.7 ab</td>
<td>1.2</td>
</tr>
<tr>
<td>7. Dth // R+C// Capt. 10 oz// C+T</td>
<td>Inspire Super, 5-times, 8 Jun-17 Sep</td>
<td>94.3</td>
<td>3.8 abc</td>
<td>0.0 a</td>
<td>3.2 ab</td>
</tr>
<tr>
<td>8. Dth // R+C// Capt. 10 oz// C+T</td>
<td>Indar, 5-times, 8 Jun-17 Sep</td>
<td>109.8</td>
<td>0.9 bc</td>
<td>0.0 a</td>
<td>0.7 ab</td>
</tr>
<tr>
<td>9. Dth // R+C// Capt. 10 oz// C+T</td>
<td>Luna Sensation, 5-times, 8 Jun-17 Sep</td>
<td>125.0</td>
<td>1.2 ab</td>
<td>0.0 a</td>
<td>1.1 ab</td>
</tr>
<tr>
<td>10. Dth // R+C// Capt. 10 oz// C+T</td>
<td>Teburol, 5-times, 8 Jun-17 Sep</td>
<td>103.0</td>
<td>0.7 a</td>
<td>0.0 a</td>
<td>0.4 a</td>
</tr>
</tbody>
</table>

* no significant differences, P=0.101 ** no significant differences, P=0.133 *** no significant differences, P=0.50

For treatment details, see Table 1.

Numbers within columns followed by the same small letter are not significantly different: Fisher's Protected LSD (P≤0.05).
### Table 11. Golden Del. harvested 30 Sep

<table>
<thead>
<tr>
<th>Fungicide and rate/100 gal</th>
<th>% fruit:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>with no visible disease</td>
</tr>
<tr>
<td>1. Control ...............</td>
<td>0.0 f</td>
</tr>
<tr>
<td>2. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td>39.6 cd</td>
</tr>
<tr>
<td>11. Dth // R+C// Capt. 10 oz// C+T</td>
<td>17.1 e</td>
</tr>
<tr>
<td>12. Dth // R+C// Capt. 10 oz// C+T</td>
<td>40.0 cd</td>
</tr>
<tr>
<td>3. Dithane 1 lb. Capt. 10 oz// C+T Inspire Super on 8 May</td>
<td>52.1 bc</td>
</tr>
<tr>
<td>4. Insp. Super + Dith // Capt. 10 oz// C+T Inspire Super on 8 May 30 Apr, 8 &amp; 30 May</td>
<td>51.9 bc</td>
</tr>
<tr>
<td>5. Dithane // Capt. 10 oz// C+T Inspire Super on 8 &amp; 20 May</td>
<td>29.2 de</td>
</tr>
<tr>
<td>6. Dth // R+C// Capt. 10 oz// C+T Inspire Super on 8, 25 Jun, 23 Jul, 15 Aug</td>
<td>72.1 ab</td>
</tr>
</tbody>
</table>

**See footnotes below Table 1.**

### Table 12. Fruit russet at harvest

<table>
<thead>
<tr>
<th>Fungicide and rate/100 gal</th>
<th>Ginger Gold</th>
<th>McIntosh (%)</th>
<th>Golden Delicious</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(% with</td>
<td>raised lenticels</td>
<td>% with</td>
</tr>
<tr>
<td></td>
<td>russetting</td>
<td>≥3</td>
<td>Mean rating</td>
</tr>
<tr>
<td>1. Control ...............</td>
<td>nd a</td>
<td>nd</td>
<td>4.2</td>
</tr>
<tr>
<td>2. Dithane 1 lb// Capt. 10 oz// C+T</td>
<td>16.2 ab v</td>
<td>24.1 a</td>
<td>1.9 a</td>
</tr>
<tr>
<td>11. Dth // R+C// Capt. 10 oz// C+T</td>
<td>14.6 a</td>
<td>27.1 a</td>
<td>3.3 a</td>
</tr>
<tr>
<td>12. Dth // R+C// Capt. 10 oz// C+T</td>
<td>30.8 b</td>
<td>31.9 a</td>
<td>4.3 a</td>
</tr>
<tr>
<td>3. Dithane 1 lb. Capt. 10 oz// C+T Inspire Super on 8 May</td>
<td>22.5 ab</td>
<td>20.3 a</td>
<td>2.8 a</td>
</tr>
<tr>
<td>4. Insp. Super + Dith // Capt. 10 oz// C+T Inspire Super on 8 May 30 Apr, 8 &amp; 30 May</td>
<td>28.4 b</td>
<td>25.9 a</td>
<td>1.6 a</td>
</tr>
<tr>
<td>5. Dithane // Capt. 10 oz// C+T Inspire Super on 8 &amp; 20 May</td>
<td>70.3 c</td>
<td>38.3 a</td>
<td>5.6 a</td>
</tr>
<tr>
<td>6. Dth // R+C// Capt. 10 oz// C+T Inspire Super on 8, 25 Jun, 23 Jul, 15 Aug</td>
<td>29.7 b</td>
<td>25.9 a</td>
<td>1.3 a</td>
</tr>
<tr>
<td>7. Dth // R+C// Capt. 10 oz// C+T Inspire Super</td>
<td>25.9 ab</td>
<td>24.4 a</td>
<td>1.6 a</td>
</tr>
<tr>
<td>8. Dth // R+C// Capt. 10 oz// C+T Inspire Super on 8, 25 Jun, 23 Jul, 15 Aug</td>
<td>30.3 b</td>
<td>34.5 a</td>
<td>2.6 a</td>
</tr>
<tr>
<td>9. Dth // R+C// Capt. 10 oz// C+T Inspire Super on 8, 25 Jun, 23 Jul, 15 Aug</td>
<td>16.9 ab</td>
<td>22.8 a</td>
<td>1.9 a</td>
</tr>
<tr>
<td>10. Dth // R+C// Capt. 10 oz// C+T Inspire Super on 8, 25 Jun, 23 Jul, 15 Aug</td>
<td>22.1 ab</td>
<td>30.6 a</td>
<td>0.9 a</td>
</tr>
</tbody>
</table>

---

For treatment details, see Table 1.

Russetting on fruit was rated on a scale of 1-5 where 1 = no russet, 2 = roughened or enlarged lenticels, 3 = slight russetting extending between lenticels, 4 = moderate russetting, 5 = large patches of severe russetting.

Harvest ratings were based on observing 80 fruit/tree (McIntosh), 60 fruit/tree (Golden Delicious), or all available fruit for trees with lower fruit counts.

No data was available for controls due to severe fruit decay and small fruit numbers.

Numbers within columns followed by the same small letter are not significantly different: Fisher's Protected LSD ($P \leq 0.05$).
Table 13. McIntosh fruit harvested 8 Sep, held at 35°F until rated on 9-10 Nov

<table>
<thead>
<tr>
<th>Fungicide and rate/100 gal</th>
<th>% fruit&lt;sup&gt;y&lt;/sup&gt;</th>
<th>Out-of-grade from SBFS</th>
<th>with fly speck&lt;sup&gt;x&lt;/sup&gt;</th>
<th>with sooty blotch</th>
<th>with black/wht rots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no visible disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Control</td>
<td>0.0</td>
<td>h&lt;sup&gt;v&lt;/sup&gt;</td>
<td>e</td>
<td>f</td>
<td>f</td>
</tr>
<tr>
<td>2. Dithane 1 lb // Capt. 10 oz // C+T</td>
<td>40.0</td>
<td>def</td>
<td>9.5 abc</td>
<td>56.7 de</td>
<td>16.3 cd</td>
</tr>
<tr>
<td>11. Dth // R+C// Capt. 10 oz // C+T</td>
<td>33.7</td>
<td>ef</td>
<td>15.1 bc</td>
<td>64.3 e</td>
<td>22.4 d</td>
</tr>
<tr>
<td>12. Dth // R+C// Capt. 10 oz // C+T</td>
<td>48.3</td>
<td>cde</td>
<td>5.7 ab</td>
<td>46.7 cd</td>
<td>15.1 bcd</td>
</tr>
<tr>
<td>3. Dithane 1 lb // Capt. 10 oz // C+T Inspire Super on 8 May</td>
<td>61.8 bc</td>
<td>3.8 a</td>
<td>32.1 bc</td>
<td>4.7 abc</td>
<td>0.7 a</td>
</tr>
<tr>
<td>4. Insp. Super + Dith // Capt. 10 oz // C+T Inspire Super on 30 Apr, 8 &amp; 30 May</td>
<td>76.9 ab</td>
<td>3.1 a</td>
<td>15.2 a</td>
<td>2.5 a</td>
<td>0.6 a</td>
</tr>
<tr>
<td>5. Dithane // Capt. 10 oz // C+T // Inspire Super on 8 &amp; 20 May</td>
<td>50.9 cd</td>
<td>8.0 ab</td>
<td>47.1 cd</td>
<td>3.6 ab</td>
<td>1.1 a</td>
</tr>
<tr>
<td>6. Dth // R+C// Capt. 10 oz // C+T Insp Super on 8, 25 Jun, 23 Jul, 15 Aug ..</td>
<td>74.4 ab</td>
<td>1.3 a</td>
<td>20.9 ab</td>
<td>5.3 abc</td>
<td>0.0 a</td>
</tr>
<tr>
<td>7. Dth // R+C// Capt. 10 oz // C+T Insp Super, 5-times, 8 Jun-17 Sep ....</td>
<td>82.8 a</td>
<td>0.6 a</td>
<td>13.4 a</td>
<td>2.2 a</td>
<td>0.9 a</td>
</tr>
<tr>
<td>8. Dth // R+C// Capt. 10 oz // C+T Indar, 5-times, 8 Jun-17 Sep ...</td>
<td>25.9 fg</td>
<td>20.4 cd</td>
<td>71.5 ef</td>
<td>39.0 e</td>
<td>nd</td>
</tr>
<tr>
<td>9. Dth // R+C// Capt. 10 oz // C+T Luna Sensation, 5-times, 8 Jun-17 Sep...</td>
<td>73.1 ab</td>
<td>1.3 a</td>
<td>22.0 ab</td>
<td>9.1 abc</td>
<td>0.0 a</td>
</tr>
<tr>
<td>10. Dth // R+C// Capt. 10 oz // C+T Teburol, 5-times, 8 Jun-17 Sep ..........</td>
<td>13.1 gh</td>
<td>31.3 d</td>
<td>85.6 fg</td>
<td>50.3 e</td>
<td>0.3 a</td>
</tr>
</tbody>
</table>

For treatment details, see Table 1.

<sup>x</sup> Data for flyspeck are the same as those shown on Table 7. They are repeated here to allow comparisons with the percentage of fruit that are out-of-grade due to SBFS.

<sup>y</sup> Harvest ratings were based on observing either 80 fruit/tree or all available fruit for trees with lower fruit counts.

<sup>z</sup> McIntosh fruit data for treatment 1 was taken immediately after harvest on 8 Sep whereas harvest evaluations for other treatments were completed 9-10 Nov. after fruit had been stored at 37°F for 62 days.

<sup>v</sup> Numbers within columns followed by the same small letter are not significantly different: Fisher's Protected LSD (P≤0.05).
APPLE (Malus xdomestica 'Empire')

Fruit set
Fruit size

D. A. Rosenberger, S.A. Hoying, F. W. Meyer,
A. L. Rugh, and L.R. DeWitt
Cornell's Hudson Valley Laboratory
PO Box 727, Highland, NY 12528

Effect of Fungicides on Fruit Set and Fruit Size in Empire Apples, 2009.

In a previous trial, Ginger Gold trees treated with tebuconazole formulated as Elite and thinned with Sevin XLR retained two to four times more fruit than trees treated with other fungicides (Rosenberger et al., 1999. F&N Tests 54:18-19). In this test, tebuconazole formulated at Tebuzol was compared with other fungicides under two fruit thinning regimens to determine if Tebuzol reduces the effectiveness of sprays applied to reduce crop load. The test trees were Empire on M.9 rootstock planted in 2006 but then relocated to a new orchard site in 2008. Trees were supported with conduit posts attached to a single high wire trellis system. The entire test orchard received a commercial fungicide program throughout the season except that DMI fungicides were excluded between bloom and second cover when these treatments were applied. The experimental design was a randomized complete block with treatments replicated five times in two-trees plots except that the last replicate consisted of single trees. All test treatments were applied using a high-pressure sprayer and a handgun to spray trees to drip. Fruit counts were made by observing fruit numbers on each tree on 22 June and the number of fruit per square cm of trunk cross-sectional area was determined used trunk diameters measured 30 cm above the soil line. Harvest data were collected by harvesting, counting, and weighing all fruit from each tree on 25 Sep.

Fungicides had no effect on crop load as evaluated on either 22 Jun or 25 Sep (Table 1), but a two-way analysis of three fungicide treatments under two different thinning regimes showed that the thinning regimes produced different levels of crop load adjustment (Tables 2&3). Treatment with Sevin XLR plus Maxcel resulted in lower fruit numbers per tree and larger fruit size than did comparable treatments with Sevin XLR plus Fruitone N. However, there was no difference among treatments in the total fruit weight that was harvested from each tree (right-hand column, Table 1).

Results of this trial suggest that neither Tebuzol nor Rally have any significant effect on fruit set, thinning, fruit size, or total production per tree in orchards where trees are thinned with either Sevin XLR plus Maxcel or with Sevin XLR plus Fruitone N.

Table 1. Effects of fungicides and thinning regimes on crop load and fruit size as determined using a simple ANOVA

<table>
<thead>
<tr>
<th>Fungicides, thinning regimes and rates of formulated products per 100 gal of dilute spray</th>
<th>Mean fruit per square cm of TCSA at May spray dates</th>
<th>Mean fruit per square cm of TCSA at harvest on 25 September</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sevin XLR 16 fl oz + Fruitone-N 3 oz</td>
<td>6 19 21 27</td>
<td>22 Jun 25 Sep</td>
</tr>
<tr>
<td>Control (no test fungicide)</td>
<td>7.69 abc*</td>
<td>7.58 a</td>
</tr>
<tr>
<td>Penncozeb 75DF 1 lb</td>
<td>X</td>
<td>38.1 abc</td>
</tr>
<tr>
<td>Rally 40W 2 oz</td>
<td>X</td>
<td>238.1 bc</td>
</tr>
<tr>
<td>Tebuzol 45DF 1.33 oz</td>
<td>X</td>
<td>9.0 a</td>
</tr>
<tr>
<td>Tebuzol 45DF 2.66 oz</td>
<td>X</td>
<td>4.9 a</td>
</tr>
<tr>
<td>Sevin XLR 16 fl oz + Maxcel 64 fl oz</td>
<td>6 19 21 27</td>
<td>22 Jun 25 Sep</td>
</tr>
<tr>
<td>Control (no test fungicide)</td>
<td>6.49 bcd</td>
<td>29.7 c</td>
</tr>
<tr>
<td>Rally 40W 2 oz</td>
<td>X</td>
<td>291.2 a</td>
</tr>
<tr>
<td>Tebuzol 45DF 2.66 oz</td>
<td>X</td>
<td>8.4 a</td>
</tr>
</tbody>
</table>

P-value for treatments ........................................ 0.002 0.001 0.003 <0.001 0.414

* Means within columns followed by the same small letter do not differ significantly (Fisher's Protected LSD, P≤0.05)
Table 2. Effects of fungicides and thinning regimes as determined using a two-way analysis of variance

<table>
<thead>
<tr>
<th>Material and rate of formulated product per 100 gal</th>
<th>Thinning regimen</th>
<th>Grand means for fungicide effects**</th>
<th>Thinning regimen</th>
<th>Grand means for fungicide effects**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (no test fungicide).................. 7.69</td>
<td>6.49</td>
<td>7.09 a</td>
<td>7.58 a*</td>
<td>5.74 a</td>
</tr>
<tr>
<td>Rally 40W 2 oz................................. 8.56*</td>
<td>6.23</td>
<td>7.09 a</td>
<td>8.69 a*</td>
<td>5.64 a</td>
</tr>
<tr>
<td>Tebuzol 45DF 2.66 oz......................... 7.54*</td>
<td>5.24</td>
<td>6.33 a</td>
<td>7.78 a*</td>
<td>5.40 a</td>
</tr>
<tr>
<td>Grand mean for thinning** 7.92 B</td>
<td>5.99 A</td>
<td>8.00 B</td>
<td>5.59 A</td>
<td></td>
</tr>
</tbody>
</table>

* Indicates comparisons where thinning regimes caused significant differences ($P \leq 0.05$) between simple means in adjacent columns.

** Grand means were derived from 2x3 factorial analyses comparing effects and interactions between thinning treatments and fungicides. Grand means within columns followed by small letters and grand means for common variables within rows that are followed by the same upper-case letter are not significantly different ($P \leq 0.05$).

$P$-values for 22 Jun counts: Fungicide = 0.209; Thinning = <0.001; Fungicide * Thinning interaction = 0.584.

$P$-values for 25 Sep counts: Fungicide = 0.622; Thinning = <0.001; Fungicide * Thinning interaction = 0.663.

Table 3. Effects of fungicides and fruit thinning regiments on mean fruit numbers per tree and mean fruit weight at harvest on 25 Sep 09

<table>
<thead>
<tr>
<th>Material and rate of formulated product per 100 gal</th>
<th>Mean number of fruit per tree at harvest</th>
<th>Mean fruit weight (g) at harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material and rate of formulated product per 100 gal</td>
<td>Thinning regimen</td>
<td>Grand means for fungicide effects**</td>
</tr>
<tr>
<td>Control ........................................ 38.10 a</td>
<td>29.70 a</td>
<td>33.90 a</td>
</tr>
<tr>
<td>Rally 40W 2 oz................................ 47.11 a*</td>
<td>33.80 a</td>
<td>40.11 a</td>
</tr>
<tr>
<td>Tebuzol 45DF 2.66 oz............................ 41.22 a*</td>
<td>31.20 a</td>
<td>35.95 a</td>
</tr>
<tr>
<td>Grand mean for thinning .................. 42.00 B</td>
<td>31.57 A</td>
<td>233.8 A</td>
</tr>
</tbody>
</table>

* Indicates comparisons where thinning regimes caused significant differences ($P \leq 0.05$) between simple means in adjacent columns.

** Grand means were derived from 2x3 factorial analyses comparing effects and interactions between thinning treatments and fungicides. Grand means within columns followed by small letters and grand means for common variables within rows that are followed by the same upper-case letter are not significantly different ($P \leq 0.05$).

$P$-values for number of fruit/tree: Fungicide = 0.183; Thinning = 0.001; Fungicide * Thinning interaction = 0.801.

$P$-values for mean fruit weight: Fungicide = 0.369; Thinning = <0.001; Fungicide * Thinning interaction = 0.847.
APPLE (Malus xdomestica 'Royal Court, 'Cameo')
  Apple scab; Venturia inaequalis
  Necrotic leaf spot; Botryosphaeria obtusa and G. juniperi-virginiana
  Fruit rots; Botryosphaeria sp.
  Flyspeck; Zygomycota jamaicensis
  Sooty blotch; species complex

Controlling Apple Summer Diseases with Captan, ProPhyt, and Pristine, 2009.

This test was designed to further evaluate the benefits of including ProPhyt in summer sprays. The specific objectives of treatments included in this test were to determine (i) if previous benefits noted when ProPhyt was added to low rates of captan (e.g., Captan-80 at 10 oz/100 gal) would also be apparent when Captan was used at higher rates; (ii) if adding ProPhyt to Pristine in late-season sprays would enhance disease control compared to using Pristine alone in those same sprays; (iii) whether the combination of ProPhyt plus Captan-80 at 20 oz/100 applied throughout summer would control summer diseases as well as a program where Pristine was included in late-season sprays.

The test orchard was planted in 2001 and contained Cameo trees on Bud.9 rootstocks and Royal Court trees on EMLA.111 rootstocks with M.9 interstems. Trees in this orchard were maintained during the early part of the season using standard fungicides. Fungicides and rates/A for treatments applied to the entire block prior to the start of this experiment included Pennczoeb 3 lb/A on 9 Apr; Rally 3.8 oz/A plus Dithane 2.3 lb/A on 18 Apr, 30 Apr, and 8 May; Rally 4.5 oz/A plus Dithane 3 lb/A on 20 May and 30 May; and Captan-80 3 lb/A plus Flint 2 oz/A on 16 June. Test treatments were applied as shown in Table 1. All treatments were replicated four times on each of the two test cultivars. All test treatments were applied with a tractor-driven high-pressure sprayer using a handgun at 270 psi to spray trees to drip. June and July were very wet with leaf wetting recorded for 50% of total time in June and 37% of total time in July. Inches of rainfall recorded for June and July were 8.45 and 4.71, respectively.

Flyspeck development during summer is driven by hours of accumulated leaf wetness. Ascospores of the flyspeck pathogen are released from woodlots and hedgerows beginning at about petal fall (May 8 in this trial), but scab fungicides that are applied until mid-June usually prevent ascospore infections. The best evidence suggests that conidia of the flyspeck fungus begin blowing into orchards sometime shortly after trees have been exposed to 270 hr of accumulated wetting from petal fall (hr-AWPF). Conidial infections cause most of the damage that appears on fruit in sprayed orchards. After conidia are released and infect fruit, roughly 270 hr of additional wetting is required before infections on fruit become visible. That means (if the current model is correct) that flyspeck infections should begin appearing on unsprayed fruit beginning after 540 hr-AWPF. We have also determined based on past observations that most of the summer fungicides will protect fruit from sooty blotch and flyspeck (SBFS) for the shorter of either 21 days following an application or until 2 in. of rainfall have accumulated following an application. Captan at low rates (e.g., Captan-80 at 10 oz/100 gal) is less effective and protects fruit for the shorter or 14 days or 1 in. of rainfall. Flyspeck infections that occur after fungicide residues are depleted between sprays apparently stop growing when fungicide coverage is renewed, but most (or at least many) infections remain viable and resume growth when fungicide residues are depleted again. In other words, fungicides can arrest fungal development and lengthen the incubation period for flyspeck, but fungicides applied after infections are established cannot eradicate these infections.

Leaf wetting and rainfall accumulations for the entire 2009 season and for intervals between sprays are shown in Table 2. Using the rules explained above, we also calculated accumulated hours of wetting that were not protected by fungicides, and that data is shown in the two columns on the right side Table 1. Given a full-season summer program of Topcin-M plus Captan (a trt not included in this trial), we would have expected flyspeck to appear when the accumulation in the second column from the right reached 270 hr. Where Captan was used in early-summer sprays (as for treatments 2-5, 11, 12), flyspeck should have appeared on fruit when the accumulation in the right-most column reached 270 hr.

Results are shown in tables 3-8. For Royal Court (RC), incubated fruit from the 31 Aug harvest and from harvest on 10 Sep had less flyspeck where ProPhyt was added to the Pristine sprays (trt 6 vs. trt 5). However, the best treatment with Pristine (trt 6) was no better than trt 3 where Captan-80 at 20 oz/100 gal was applied with ProPhyt in all test applications. Those same observations were also true for Cameo fruit except that in the final harvest evaluation on 15 Oct the incidence of flyspeck was similar for Pristine applied with or without ProPhyt (trt 5 vs. trt 6). Where Captan was applied alone throughout the summer (trt 2) or during mid-summer followed by Pristine (trt 4), percentages of fruit with flyspeck and percentages of
fruit out of grade were consistently higher in late season ratings for both cultivars than in trts 3, 5, and 6. No effects of treatments on summer fruit decays were detected for either cultivar (Tables 7 and 8).
Table 1. Capitan-ProPhyt treatments, rates, and spray dates for the 2009 trial at the Hudson Valley Lab.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control ..................................................</td>
<td>RD**</td>
<td>RD*</td>
<td>CF**</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2. Capitan 80 20 oz .......................................</td>
<td>RD</td>
<td>RD..</td>
<td>CF..</td>
<td>X..</td>
<td>X..</td>
<td>X..</td>
<td>X..</td>
<td>X..</td>
</tr>
<tr>
<td>4. Capitan 80 10 oz ......................................</td>
<td>RD</td>
<td>RD..</td>
<td>CF..</td>
<td>X..</td>
<td>X..</td>
<td>X...</td>
<td>X...</td>
<td>X...</td>
</tr>
<tr>
<td>Pristine 5 oz/100 .........................................</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pristine 37.5WDG 5 oz.. ..................................</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pristine 5 oz+ ProPhyt 21.3 fl oz ....................</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Prior to dates shown in the table, the following sprays were applied to the entire block: 9 Apr—Penncozeb 3 lb/A; 18 Apr, 30 Apr, and 8 May—Rally 3.8 oz/A and Dithane 2.3 lb/A;
**R/D = Rally/Dithane (4.5 oz/A + 3 lb/A) and CF = Capitan/Flint (3 lb/A + 2 oz/A), both applied to all plots with an airblast sprayer on dates indicated.
*** Applied to Cameo only on 9/17 because Royal Court were already harvested.

Table 2. Accumulations of rainfall and hours of wetting (as determined with a DeWitt string recorder) for the period from petal fall through harvest, with totals shown for the intervals between fungicide applications in the 2009 ProPhyt Trial at Hudson Valley Lab, Highland, NY.

<table>
<thead>
<tr>
<th>Spray dates and other significant dates for monitoring development of flyspeck</th>
<th>Accumulated hr of wetting from petal fall</th>
<th>Accumulated rainfall from petal fall</th>
<th>Cumm. hr wetting for control plots after early-season sprays expired</th>
<th>Accumulated leaf wetting and rainfall during spray intervals preceding data shown</th>
<th>Hours of wetting</th>
<th>Rainfall</th>
<th>21 days or &gt;2 inches rain</th>
<th>14 days or &gt;1 inch rain</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-May</td>
<td>62</td>
<td>2.06</td>
<td>62</td>
<td>2.06</td>
<td>62</td>
<td>2.06</td>
<td>21 days or &gt;2 inches rain</td>
<td>14 days or &gt;1 inch rain</td>
</tr>
<tr>
<td>30-May</td>
<td>135</td>
<td>2.59</td>
<td>74</td>
<td>0.53</td>
<td>74</td>
<td>0.53</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>16-Jun</td>
<td>335</td>
<td>6.92</td>
<td>200</td>
<td>4.33</td>
<td>200</td>
<td>4.33</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>25-Jun</td>
<td>439</td>
<td>10.36</td>
<td>94</td>
<td>3.44</td>
<td>94</td>
<td>3.44</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>8-Jul</td>
<td>591</td>
<td>12.40</td>
<td>246</td>
<td>2.04</td>
<td>246</td>
<td>2.04</td>
<td>295</td>
<td>295</td>
</tr>
<tr>
<td>22-Jul</td>
<td>684</td>
<td>14.31</td>
<td>339</td>
<td>1.91</td>
<td>339</td>
<td>1.91</td>
<td>308</td>
<td>308</td>
</tr>
<tr>
<td>8-Aug</td>
<td>807</td>
<td>16.43</td>
<td>462</td>
<td>2.12</td>
<td>462</td>
<td>2.12</td>
<td>432</td>
<td>432</td>
</tr>
<tr>
<td>24-Aug</td>
<td>956</td>
<td>20.28</td>
<td>611</td>
<td>3.85</td>
<td>611</td>
<td>3.85</td>
<td>543</td>
<td>543</td>
</tr>
<tr>
<td>10 Sep: Royal Court harvest</td>
<td>1073</td>
<td>21.01</td>
<td>728</td>
<td>0.73</td>
<td>728</td>
<td>0.73</td>
<td>548</td>
<td>548</td>
</tr>
<tr>
<td>17-Sep</td>
<td>1124</td>
<td>21.58</td>
<td>779</td>
<td>1.3</td>
<td>779</td>
<td>1.3</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>2 Oct: last weather data</td>
<td>1198</td>
<td>22.35</td>
<td>853</td>
<td>0.77</td>
<td>853</td>
<td>0.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Oct: Cameo harvest</td>
<td>1198</td>
<td>22.35</td>
<td>853</td>
<td>0.77</td>
<td>853</td>
<td>0.77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Royal Court flyspeck

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Royal Court fruit with flyspeck for various harvest dates</th>
<th>12 Aug</th>
<th>31 Aug</th>
<th>final harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>at hvst</td>
<td>after incubtn</td>
<td>at hvst</td>
</tr>
<tr>
<td>1. Control</td>
<td></td>
<td>76.7 c</td>
<td>96.7 d</td>
<td>100.0 c</td>
</tr>
<tr>
<td>2. Captan 80 oz</td>
<td></td>
<td>20.0 b</td>
<td>38.3 bc</td>
<td>73.3 b</td>
</tr>
<tr>
<td>3. Captan 80 oz + ProPhyt 21.3 fl oz</td>
<td>1.7 a</td>
<td>10.0 ab</td>
<td>21.7 a</td>
<td>35.1 b</td>
</tr>
<tr>
<td>4. Captan 80 10 oz (3X), then Pristine (2X)</td>
<td>15.0 ab</td>
<td>40.0 c</td>
<td>75.0 b</td>
<td>80.3 cd</td>
</tr>
<tr>
<td>5. Captan 80 10 oz + PrPhyt 21.3 fl oz (3X)</td>
<td>Pristine 37.5WDG (2X)</td>
<td>11.7 ab</td>
<td>16.7 abc</td>
<td>23.3 a</td>
</tr>
<tr>
<td>6. Captan 80 10 oz + PrPhyt 21.3 fl oz (3X)</td>
<td>Pristine 37.5WDG+ ProPhyt 21.3 fl oz (2X).</td>
<td>5.0 a</td>
<td>6.7 a</td>
<td>11.9 a</td>
</tr>
</tbody>
</table>

See footnotes at the bottom of the page.

Table 4: Royal Court Sooty Blotch

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Royal Court with sooty blotch by harvest date</th>
<th>12 Aug</th>
<th>31 Aug</th>
<th>Out of grade SBFS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>at hvst</td>
<td>after incubtn</td>
<td>at hvst</td>
</tr>
<tr>
<td>1. Control</td>
<td></td>
<td>23.3 b</td>
<td>86.7 b</td>
<td>98.3 c</td>
</tr>
<tr>
<td>2. Captan 80 oz</td>
<td></td>
<td>0.0 a</td>
<td>11.7 a</td>
<td>3.3 ab</td>
</tr>
<tr>
<td>3. Captan 80 oz + ProPhyt 21.3 fl oz</td>
<td>0.0 a</td>
<td>1.7 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>4. Captan 80 10 oz (3X), then Pristine (2X)</td>
<td>1.7 a</td>
<td>11.7 a</td>
<td>13.3 b</td>
<td>13.1 bc</td>
</tr>
<tr>
<td>5. Captan 80 10 oz + PrPhyt 21.3 fl oz (3X)</td>
<td>Pristine 37.5WDG (2X)</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>3.3 ab</td>
</tr>
<tr>
<td>6. Captan 80 10 oz + PrPhyt 21.3 fl oz (3X)</td>
<td>Pristine 37.5WDG+ ProPhyt 21.3 fl oz (2X).</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>3.3 ab</td>
</tr>
</tbody>
</table>

See footnotes at the bottom of the page.

Table 5: Cameo flyspeck

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Cameo fruit with flyspeck for various harvest dates</th>
<th>12 Aug</th>
<th>31 Aug</th>
<th>final harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>at hvst</td>
<td>after incubtn</td>
<td>at hvst</td>
</tr>
<tr>
<td>1. Control</td>
<td></td>
<td>100.0 c</td>
<td>100.0 d</td>
<td>100.0 d</td>
</tr>
<tr>
<td>2. Captan 80 oz</td>
<td></td>
<td>8.3 b</td>
<td>16.7 bc</td>
<td>28.3 bc</td>
</tr>
<tr>
<td>3. Captan 80 20 oz + ProPhyt 21.3 fl oz</td>
<td>3.3 ab</td>
<td>5.0 ab</td>
<td>6.7 a</td>
<td>9.5 a</td>
</tr>
<tr>
<td>4. Captan 80 10 oz (3X), then Pristine (3X)</td>
<td>8.3 b</td>
<td>20.0 c</td>
<td>45.0 c</td>
<td>57.0 b</td>
</tr>
<tr>
<td>5. Captan 80 10 oz + PrPhyt 21.3 fl oz (3X)</td>
<td>Pristine 37.5WDG (3X)</td>
<td>0.0 a</td>
<td>1.7 a</td>
<td>13.3 ab</td>
</tr>
<tr>
<td>6. Captan 80 10 oz + PrPhyt 21.3 fl oz (3X)</td>
<td>Pristine 37.5WDG+ ProPhyt 21.3 fl oz (3X).</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>5.0 a</td>
</tr>
</tbody>
</table>

For details of spray schedules, see Table 1.

Based on evaluation of 15 fruit/tree on 12 Aug and 31 Aug, and 60 fruit/tree at final harvest, which was 10 Sep for Royal Court and 14 Oct for Cameo. A additional evaluation of 15 fruit/tree was made for Cameo using fruit collected 14 July, but no flyspeck was found on control fruit even after fruit was incubated (data not shown in table).

Following initial evaluations, fruit were incubated at 70°F and 100% relative humidity for 14 days to allow incubating infections of SBFS and fruit decays to develop visible lesions.

Fruit were graded as they would be on a commercial packing line and fruit that would not meet USDA Fancy grade were considered "out-of-grade."

Means within columns followed by the same small letter are not significantly different as determined using Fisher's Protected LSD test P≤0.05.
Table 6: Cameo sooty blotch

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Cameo fruit with sooty blotch for various harvest dates</th>
<th>Out of grade for SBFS at harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 Aug</td>
<td>31 Aug</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>1. Control</td>
<td>75.0 b</td>
<td>100.0 c</td>
</tr>
<tr>
<td>2. Captan 80 20 oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Captan 80 20 oz + ProPhyt 21.3 fl oz</td>
<td>0.0 a</td>
<td>5.0 ab</td>
</tr>
<tr>
<td>4. Captan 80 10 oz (3X), then Pristine (3X)</td>
<td>3.3 a</td>
<td>11.7 b</td>
</tr>
<tr>
<td>5. Captan 80 10 oz + ProPhyt 21.3 fl oz (3X) Pristine 37.5WDG (3X)</td>
<td>1.7 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>6. Captan 80 10 oz + ProPhyt 21.3 fl oz (3X) Pristine 37.5WDG+ ProPhyt 21.3 fl oz (3X)</td>
<td>0.0 a</td>
<td>1.7 a</td>
</tr>
</tbody>
</table>

See footnotes at the bottom of the page.

Table 7: Royal Court fruit rots

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Royal Court fruit with black/white rot for various harvest dates</th>
<th>Grand mean for repeated measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 Aug</td>
<td>31 Aug</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>1. Control</td>
<td>8.3</td>
<td>13.3</td>
</tr>
<tr>
<td>2. Captan 80 20 oz</td>
<td>3.3</td>
<td>11.7</td>
</tr>
<tr>
<td>3. Captan 80 20 oz + ProPhyt 21.3 fl oz</td>
<td>0.0</td>
<td>3.3</td>
</tr>
<tr>
<td>4. Captan 80 10 oz (3X), then Pristine (2X)</td>
<td>8.3</td>
<td>8.3</td>
</tr>
<tr>
<td>5. Captan 80 10 oz + ProPhyt 21.3 fl oz (3X) Pristine 37.5WDG (2X)</td>
<td>1.7</td>
<td>10.0</td>
</tr>
<tr>
<td>6. Captan 80 10 oz + ProPhyt 21.3 fl oz (3X) Pristine 37.5WDG+ ProPhyt 21.3 fl oz (2X)</td>
<td>3.3</td>
<td>10.0</td>
</tr>
</tbody>
</table>

P-values ≤ 0.05

See footnotes at the bottom of the page.

Table 8: Cameo with fruit rots

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Cameo fruit with fruit decays for various harvest dates</th>
<th>Grand means for 5 observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 Aug</td>
<td>31 Aug</td>
</tr>
<tr>
<td>1. Control</td>
<td>1.7</td>
<td>11.5</td>
</tr>
<tr>
<td>2. Captan 80 20 oz</td>
<td>0.0</td>
<td>10.0</td>
</tr>
<tr>
<td>3. Captan 80 20 oz + ProPhyt 21.3 fl oz</td>
<td>6.7</td>
<td>8.3</td>
</tr>
<tr>
<td>4. Captan 80 10 oz (3X), then Pristine (3X)</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>5. Captan 80 10 oz + ProPhyt 21.3 fl oz (3X) Pristine 37.5WDG (3X)</td>
<td>5.0</td>
<td>11.7</td>
</tr>
<tr>
<td>6. Captan 80 10 oz + ProPhyt 21.3 fl oz (3X) Pristine 37.5WDG+ ProPhyt 21.3 fl oz (3X)</td>
<td>1.7</td>
<td>6.7</td>
</tr>
</tbody>
</table>

P-values ≤ 0.05

Footnotes:
1. For details of spray schedules, see Table 1.
2. Based on evaluation of 15 fruit/tree on 12 Aug and 31 Aug, and 60 fruit/tree at final harvest, which was 10 Sep for Royal Court and 14 Oct for Cameo. An additional evaluation of 15 fruit/tree was made for Cameo using fruit collected 14 July, but no fliespek was found on control fruit even after fruit was incubated (data not shown in table).
3. Following initial evaluations, fruit were incubated at 70° F and 100% relative humidity for 14 days to allow incubating infections of SBFS and fruit decays to develop visible lesions.
4. Fruit were graded as they would be on a commercial packing line and fruit that would not meet USDA Fancy grade were considered “out-of-grade.”
5. Means within columns followed by the same small letter are not significantly different as determined using Fisher's Protected LSD test (P≤0/05). Where there were no differences among treatments, the P-values for each analysis are shown at the bottom of the table.
APPLE (Malus xdomestica 'Royal Court,' 'Cameo')

Apple scab; Venturia inaequalis
Necrotic leaf spot; Botryosphaeria obtusa and G. juniperi-virginianae
Fruit rots; Botryosphaeria sp.
Flyspeck; Zygophila jamaicensis
Sooty blotch; species complex

D. A. Rosenberger, F. W. Meyer,
A. L. Rugh, and L.R. DeWitt
Cornell's Hudson Valley Laboratory
PO Box 727, Highland, NY 12528

Controlling Apple Summer Diseases with Fungicides Approved for Organic Production, 2009.

(Note: write-up for this trial and footnotes for most tables have not yet been completed. However, this trial was conducted in the same block used for the previously described ProPhyt trial, and most methods were identical to those described for the ProPhyt trial except for variations in spray dates and variations in some of the data collections.)

Table 1: Rates/100 gal of dilute spray applied with handgun

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>Sprays applied</th>
<th>5/20</th>
<th>6/1</th>
<th>6/16</th>
<th>6/25</th>
<th>7/7</th>
<th>7/22</th>
<th>8/8</th>
<th>8/24</th>
<th>9/3</th>
<th>9/14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1c**</td>
<td>2c</td>
<td>3c</td>
<td>4c</td>
<td>5c</td>
<td>6c</td>
<td>7c</td>
<td>8c</td>
<td>9c</td>
<td>10c***</td>
</tr>
<tr>
<td>1. Unsprayed control</td>
<td></td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>2. Kaligreen 1 lb</td>
<td></td>
<td>R/D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3. Kaligreen 1 lb plus JMS</td>
<td></td>
<td>R/D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Stylet oil 2 qt</td>
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<td></td>
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<td>4. Oxidate 1 gal</td>
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<td>R/D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>5. CleanGreen Pro 1.33 lb</td>
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<td>R/D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur</td>
<td></td>
<td>R/D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>7. Millers Liquid Lime Sulfur</td>
<td></td>
<td>R/D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>+ Agri Star® Basic Copper 53</td>
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<td>+ Spray Lime 14 oz</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Millers Liquid Lime Sulfur</td>
<td></td>
<td>R/D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>+ Nordox (copper oxide) 4.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>oz</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Prior to dates shown in the table, the following sprays were applied to the entire block: 9 Apr—Penncozeb 3 lb/A; 18 Apr, 30 Apr, and 8 May—Rally 3.8 oz/A and Dithane 2.3 lb/A;
** R/D = Rally/Dithane (4.5 oz/A + 3 lb/A) applied to all plots with an airblast sprayer.
*** Applied to Cameo only on 9/17.

Table 2. Leaf spot in July

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray applied with handgun;</th>
<th>Spray dates</th>
<th>Leaf spot rating on 10 July</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5/20 6/1 6/16 6/25 7/7 7/22 8/8 8/24 9/3 9/14</td>
<td>Royal Court Cameo Grand means: both cultivars</td>
</tr>
<tr>
<td>1. Unsprayed control</td>
<td></td>
<td>3.4 b* 1.4 ab 2.4 abc</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td></td>
<td>4.9 d* 1.9 c 3.4 e</td>
</tr>
<tr>
<td>3. Kaligreen+ Serenade + Stylet oil 2 qt</td>
<td></td>
<td>4.6 d* 1.6 bc 3.1 de</td>
</tr>
<tr>
<td>4. Oxidate 1 gal</td>
<td></td>
<td>4.1 c* 1.3 ab 2.7 cd</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb</td>
<td></td>
<td>3.6 b* 1.3 ab 2.5 bc</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td></td>
<td>3.6 b* 1.1 a 2.3 abc</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 6 oz + Lime</td>
<td></td>
<td>2.9 a* 1.0 a 2.0 abz</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz</td>
<td></td>
<td>2.9 a* 1.0 a 1.9 a</td>
</tr>
</tbody>
</table>

Leaf spot rating based on 4 observations per tree (2 observers each rating the east and west sides of each tree) on a scale of 1-5 where 1 = no leafspot and 5 = leafspot throughout the entire canopy.
Table 3: Royal Court flyspeck

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Royal Court fruit with flyspeck for various harvest dates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 Aug</td>
</tr>
<tr>
<td></td>
<td>at hvst</td>
</tr>
<tr>
<td>1. Unsprayed control........................</td>
<td>76.7</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td>85.0</td>
</tr>
<tr>
<td>3. Kaligreen+ Serenade + Stylet oil 2 qt</td>
<td>75.0</td>
</tr>
<tr>
<td>4. Oxidate 1 gal...........................</td>
<td>48.3</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb ..................</td>
<td>86.7</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td>18.3</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 oz + Lime</td>
<td>18.3</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz ..............</td>
<td>4.4</td>
</tr>
</tbody>
</table>

SB in trt 14 on 31 Aug may have been false positives based on dark copper residues on fruit or because incubated fruit were wet and had to be wiped prior to rating, thereby possibly removing some of the sooty blotch.

Table 4: Royal Court sooty blotch

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Royal Court fruit with sooty blotch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 August</td>
</tr>
<tr>
<td></td>
<td>at hvst</td>
</tr>
<tr>
<td>1. Unsprayed control........................</td>
<td>66.7</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td>26.7</td>
</tr>
<tr>
<td>3. Kaligreen+ Serenade + Stylet oil 2 qt</td>
<td>8.3</td>
</tr>
<tr>
<td>4. Oxidate 1 gal...........................</td>
<td>1.7</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb ..................</td>
<td>8.3</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td>3.3</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 oz + Lime</td>
<td>0.0</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz ..............</td>
<td>2.2</td>
</tr>
</tbody>
</table>

SB in trt 14 on 31 Aug may have been false positives based on dark copper residues on fruit or because incubated fruit were wet and had to be wiped prior to rating, thereby possibly removing some of the sooty blotch.

Table 5: Royal Court fruit rots

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Royal Court fruit with black/white rot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rated at harvest</td>
</tr>
<tr>
<td></td>
<td>12 Aug</td>
</tr>
<tr>
<td>1. Unsprayed control........................</td>
<td>1.7 a</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td>10.0 a</td>
</tr>
<tr>
<td>3. Kaligreen + Serenade + Stylet oil 2 qt</td>
<td>6.7 a</td>
</tr>
<tr>
<td>4. Oxidate 1 gal...........................</td>
<td>6.7 a</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb ..................</td>
<td>13.3 a</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td>10.0 a</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 oz + Lime</td>
<td>1.7 a</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz ..............</td>
<td>0.0 a</td>
</tr>
</tbody>
</table>

P-values ................................................. 0.140 0.721 0.553 0.158

Fruit were considered decayed if they had spots \( \geq 2 \) mm diam.
### Table 6: Royal Court scab

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Royal Court fruit with scab</th>
<th>12 Aug</th>
<th>31 Aug</th>
<th>10 Sep</th>
<th>Grand means: 3 dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Unsprayed control</td>
<td></td>
<td>28.3 a</td>
<td>25.0 a</td>
<td>26.5 a</td>
<td>26.5</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td></td>
<td>21.7 a</td>
<td>15.0 a</td>
<td>20.0 a</td>
<td>18.9</td>
</tr>
<tr>
<td>3. Kaligreen + Serenade + Stylet oil 2 qt</td>
<td></td>
<td>13.3 a</td>
<td>15.0 a</td>
<td>15.3 a</td>
<td>14.6</td>
</tr>
<tr>
<td>4. Oxidate 1 gal</td>
<td></td>
<td>8.3 a</td>
<td>25.5 a</td>
<td>15.6 a</td>
<td>16.5</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb</td>
<td></td>
<td>18.3 a</td>
<td>21.7 a</td>
<td>11.7 a</td>
<td>17.2</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td></td>
<td>8.3 a</td>
<td>9.8 a</td>
<td>9.5 a</td>
<td>9.2</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 6 oz + Lime</td>
<td></td>
<td>10.0 a</td>
<td>6.6 a</td>
<td>7.9 a</td>
<td>8.2</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz</td>
<td></td>
<td>11.1 a</td>
<td>2.2 a</td>
<td>6.6 a</td>
<td>7.1</td>
</tr>
</tbody>
</table>

P-values ..................................................0.191 0.131 0.484 0.263

---

### Table 7: Cameo flyspeck at harvest

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Cameo fruit with flyspeck for various harvest dates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14 Jul at hvst incubtd</td>
</tr>
<tr>
<td>1. Unsprayed control</td>
<td>1.7</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td>0.0</td>
</tr>
<tr>
<td>3. Kaligreen + Serenade + Stylet oil 2 qt</td>
<td>0.0</td>
</tr>
<tr>
<td>4. Oxidate 1 gal</td>
<td>0.0</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb</td>
<td>0.0</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td>0.0</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 6 oz + Lime</td>
<td>0.0</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz</td>
<td>0.0</td>
</tr>
</tbody>
</table>

---

### Table 8: Cameo sooty blotch

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Cameo fruit with sooty blotch for various harvest dates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 Aug at hvst after incubtn</td>
</tr>
<tr>
<td>1. Unsprayed control</td>
<td>95.0 e</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td>46.7 d</td>
</tr>
<tr>
<td>3. Kaligreen + Serenade + Stylet oil 2 qt</td>
<td>64.3 d</td>
</tr>
<tr>
<td>4. Oxidate 1 gal</td>
<td>11.7 bc</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb</td>
<td>21.1 bc</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td>20.4 c</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 6 oz + Lime</td>
<td>0.0 a</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz</td>
<td>4.8 ab</td>
</tr>
</tbody>
</table>
Table 9: Cameo fruit decays at harvest

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Cameo fruit with fruit decays for various harvest dates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>at harvest</td>
</tr>
<tr>
<td></td>
<td>12 Aug</td>
</tr>
<tr>
<td>1. Unsprayed control</td>
<td>5.0</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td>10.0</td>
</tr>
<tr>
<td>3. Kaligreen+ Serenade + Stylet oil 2 qt</td>
<td>...3.2</td>
</tr>
<tr>
<td>4. Oxidate 1 gal</td>
<td>...20.0</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb</td>
<td>...9.6</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td>...3.4</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 6 oz + Lime</td>
<td>6.7</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz</td>
<td>...1.7</td>
</tr>
</tbody>
</table>

P-values .................................................. 0.181 0.049 -- 0.311 0.192 0.034

*Most fruit with decays in late August had dropped from trees prior to harvest in October.

**Data in this column includes decayed fruit from the 12 Aug harvest rating because decays were not discarded after rating on 12 Aug. Fruit with decays at harvest on 31 Aug were discarded, so fruit noted after incubation for that date are additional decays.

Table 10: Cameo clean fruit

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>% Cameo fruit with no visible disease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>at harvest</td>
</tr>
<tr>
<td></td>
<td>12 Aug</td>
</tr>
<tr>
<td>1. Unsprayed control</td>
<td>0.0 d</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td>3.3 cd</td>
</tr>
<tr>
<td>3. Kaligreen+ Serenade + Stylet oil 2 qt</td>
<td>1.7 cd</td>
</tr>
<tr>
<td>4. Oxidate 1 gal</td>
<td>25.0 b</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb</td>
<td>4.9 c</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td>56.6 a</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 6 oz + Lime</td>
<td>56.7 a</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz</td>
<td>69.0 a</td>
</tr>
</tbody>
</table>

Table 11: Cameo SBFS severity ratings:

<table>
<thead>
<tr>
<th>Rates/100 gal of dilute spray</th>
<th>In grade: Fancy (%)</th>
<th>% Just slightly out-of-grade</th>
<th>% surface area affected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt;25%</td>
<td>25-50%</td>
</tr>
<tr>
<td>1. Unsprayed control</td>
<td>0.0 c</td>
<td>5.8</td>
<td>47.4</td>
</tr>
<tr>
<td>2. Kaligreen 1 lb plus JMS Stylet oil 2 qt</td>
<td>2.1 c</td>
<td>31.6 bc</td>
<td>49.2 d</td>
</tr>
<tr>
<td>3. Kaligreen+ Serenade + Stylet oil 2 qt</td>
<td>8.8 bc</td>
<td>28.7 bc</td>
<td>46.2 cd</td>
</tr>
<tr>
<td>4. Oxidate 1 gal</td>
<td>20.8 b</td>
<td>42.5</td>
<td>30.0 ab</td>
</tr>
<tr>
<td>5. CleanGreen Pro 1.33 lb</td>
<td>1.7 c</td>
<td>17.5 b</td>
<td>61.7 d</td>
</tr>
<tr>
<td>6. Millers Liquid Lime Sulfur (LLS) 1 qt</td>
<td>17.1 b</td>
<td>46.3 c</td>
<td>23.8 bc</td>
</tr>
<tr>
<td>7. LLS 1 qt + Basic Copper 53 6 oz + Lime</td>
<td>45.4 a</td>
<td>28.8 bc</td>
<td>8.3 ab</td>
</tr>
<tr>
<td>8. LLS 1 qt + Nordox 4.24 oz</td>
<td>64.7 a</td>
<td>18.7 b</td>
<td>2.5 a</td>
</tr>
</tbody>
</table>

Note: For each treatment, the sum of all columns = 100 except for rounding errors.

Objective: To determine efficacy of new SI and strobilurin fungicides for controlling black knot on plums.

Procedures:
- Trees were pruned 19 April 2007, and all black knots were cut out and saved to use as inoculum.
- Limbs were flagged on 10 trees so that treatments could be replicated on two limbs of Stanley plum and two limbs of Italian plum.
- Put inoculum into mesh bags over trees on Monday, April 23; removed on Tuesday, 12 June. Trees had very heavy crop load in 2007.
- First shower occurred Wed evening, 25 April 2007, but was probably too cold to allow infection. Trees were approaching white bud as of 25 April.
- Tested for inoculum release from knots held in a bag in our lath hose at the start of season on 2 May and found only moderate discharge of 3-4 spores per discharge spot in discharge tower. Checked for discharge again on 12 June when we removed knots from the orchard and found massive discharge with piles of spores on the slides. Thus, the knot used as inoculum contained and released abundant spores for infecting test trees.
- Sprays applied in 2007 on 26 Apr, 7, 18, 31 May.
- Trees received regular fungicide sprays during 2008 growing season.
- All knots were removed, measured, and weighed in March of 2009.

<table>
<thead>
<tr>
<th>Material and rate of formulated product per 100 gal of spray</th>
<th>Number of knots per treated limb</th>
<th>Total knot length (in) per treated limb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>41.0 b</td>
<td>96.8 b</td>
</tr>
<tr>
<td>Bravo Weather Stik 6F 20 fl oz</td>
<td>8.0 a</td>
<td>15.8 a</td>
</tr>
<tr>
<td>Indar 2F 2.0 fl oz</td>
<td>10.5 a</td>
<td>39.0 a</td>
</tr>
<tr>
<td>Pristine 38W 4.0 oz</td>
<td>15.0 a</td>
<td>39.7 ab</td>
</tr>
<tr>
<td>Elite 45W 2 oz</td>
<td>44.7 b</td>
<td>66.3 ab</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material and rate of formulated product per 100 gal of spray</th>
<th>Weight of knots (g) and subtending tissues per treated limb</th>
<th>% of total limb weight removed with black knots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>788.6</td>
<td>4.1</td>
</tr>
<tr>
<td>Bravo Weather Stik 6F 20 fl oz</td>
<td>99.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Indar 2F 2.0 fl oz</td>
<td>342.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Pristine 38W 4.0 oz</td>
<td>226.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Elite 45W 2 oz</td>
<td>264.6</td>
<td>1.5</td>
</tr>
<tr>
<td>P values</td>
<td>0.172</td>
<td>0.148</td>
</tr>
</tbody>
</table>
Re-evaluation of Captan as a postharvest fungicide on apples

Introduction: Captan is labeled for use as a postharvest fungicide on apples, but in controlled trials with wound-inoculated fruit it rarely provides more than 50% control blue mold decay caused by *Penicillium expansum*. Nevertheless, some packinghouse operators have noted that they have less problems with storage decays when they include Captan in their postharvest treatment. This experiment was conducted to determine if Captan might work by killing *Penicillium* spores in drench solutions, thereby reducing inoculum levels, even though it is not very effective for protecting wound-inoculated fruit.

Methods: Treatment solutions were prepared in 30-gal plastic garbage cans and included the following:

1. Clean water
2. Dirty water
3. Captan 80 25 oz/100 gal in clean water
4. Captan 80 25 oz/100 gal in dirty water

"Dirty water" was prepared to simulate conditions in recycling drench tanks where soil from bin runners and other organic debris accumulates over time. We suspected *Penicillium* spores would remain dormant in clean water and therefore might not be susceptible to the effects of Captan whereas nutrients contained in the "dirty water" might stimulate spore germination and increase the activity of Captan over time. The dirty water was prepared by adding a soil/peat/apple puree to the 15 gal of treatment solution in each tank. The amendment for each dirty water tank consisted of 10.6 oz of whole apple puree (made by grinding apples in a blender) plus 8.8 oz of dry peat moss plus 70.5 oz of soil at field moisture collected from beneath a tree row in an orchard that had received no residual herbicides during the growing season. The 70.5 oz of fresh soil was equivalent to 66.3 oz of air-dried soil. The clean and dirty water tanks were prepared and held over night to allow water temperatures to equilibrate to ambient temperature (about 60° F) before treatments were initiated.

The morning after the treatment solutions were prepared, the tanks were stirred vigorously using a separate small broom for each of the four replicate tanks that had been prepared for each treatment. The appropriate amount of Captan was then added along with enough *Penicillium* spores to produce a final inoculum concentration of 10⁶ spores/ml. For each replicate, 25 apples that had been freshly wounded on a single hemisphere were immersed in the treatment tanks immediately after the solutions had been prepared (0 time), and additional replicates of 25 fruit were similarly treated after 6, 12, 24, 48 and 72 hours. After treated fruit had been allowed to dry for several hours, they were placed on spring-cushion trays and stacked in storage boxes. All of the treated fruit were held at ambient temperature until the 72-hr fruit had been treated and packed. All fruit were then moved to cold air storage at 36° F and were observed for decay after 90 days. Immediately after fruit had been treated at each of the 6 treatment times, a sample of the treatment solutions was collected and returned to the lab for dilution planting to determine the number of viable spores remaining.

Results: Effectiveness of the captan treatments improved as the holding time in the treatment tanks increased (Fig. 1, upper graph). There was considerable variation in disease incidence for fruit treated with only clean or dirty water (Fig. 1, lower graph), and the reasons for this variability remain unclear. The apparent density of viable spores in the treatment tanks at various times also was extremely variable (Fig. 2). However, when grand means for the effects of the treatments across all treatment times were compared (Fig. 3), results showed that Captan was more effective for protecting fruit than we had found in previous experiments where spores were given minimal exposure to captan in solution. Averaged across all treatment times, Captan also produced a significant reduction in the number of viable spores in the treatment tanks (Fig. 4).

Conclusions: The primary value of Captan in postharvest drench solutions may be its effect on reducing spore viability before spores can get into fruit wounds. Storage operators who noted benefits from including Captan in postharvest drench solutions were probably seeing the benefits of inoculum reduction that Captan produced in the recycling drench solutions whereas, in controlled trials where spores had only a short contact time with Captan in solution, Captan proved relatively ineffective for protecting wounded fruit. Combining Captan with newer fungicides might be a good resistance management strategy because Captan in the recycling drench solutions should reduce the quantity of inoculum that is ultimately exposed to the newer fungicides that protect fruit from infection but presumably do not kill spores in solution.
Fig. 1. Disease control expressed as a comparison with the proportion of decayed fruit observed for fruit exposed to spores in clean water with no Captan immediately after mixing (0-time). Results are for wounded Empire apple fruit exposed to *P. expansum* spores in drench solutions at various intervals after the solutions had been prepared.
APPLE (**Malus xdomestica 'Empire'**)

Blue mold; *Penicillium expansum*

D. A. Rosenberger, F. W. Meyer, and A. L. Rugh
Cornell's Hudson Valley Laboratory
PO Box 727, Highland, NY 12528

**Controlling Penicillium blue mold in stored apples with Scholar and difenoconazole, 2008-09.**

**Introduction:** The objective of this trial was to evaluate difenoconazole, a potential new postharvest fungicide for apples, to determine if it would be adversely affected by soil and organic matter that collects in recycling postharvest drenches, and to evaluate the possibility of combining difenoconazole with fludioxonil (Scholar) as for resistance management. Difenoconazole is in the DMI group of fungicides. Registration of this product for postharvest treatments would add a new chemistry group to the list of postharvest fungicides available for apples and it therefore could be important in minimizing selection for fungicide resistance in *Penicillium expansum*.

**Methods:** Empire apples were harvested 29 to 30 Sep 08 from an orchard at the Hudson Valley Lab and were held in cold storage at 36°F until 29 Oct. Mean fruit firmness, as determined by testing 28 arbitrarily selected fruit on 30 Oct, was 16.6 lb. Treatment tanks (30-gal polyethylene garbage cans) were filled with 15 gal water on Monday morning, 27 Oct, the fungicides and "dirty water" soil/peat/apple amendments were added, and the tanks were stirred vigorously with small brooms. A separate broom was used for each tank to avoid cross-contamination of the tanks. Tanks were left at ambient temperature in an unheated shed until Thursday morning when apples were treated. However, the treatment tanks were stirred again with the small brooms at 1 PM and 4:30 PM on Tuesday and at 9 AM, 1 PM, and 4:30 PM on Wednesday to re-suspend any of the fungicide and soil/peat mixture that had settled to the bottom of the tanks. The soil/peat/apple amendment added to each tank to create dirty water consisted of 10.6 oz of whole apple puree (made by grinding apples in a blender) plus 8.8 oz of dry peat moss plus 70.5 oz of soil at field moisture collected from beneath a tree row in an orchard that had received no residual herbicides during the growing season. The 70.5 oz of fresh soil was equivalent to 66.3 oz of air-dried soil. Temperature of the solutions was recorded for four arbitrarily selected tanks on Tuesday and Wednesday, and mean solution temperatures for the respective days were 45.3°F and 43.2°F. The pH of treatment tanks was measured on Tuesday and ranged from a low of 6.65 for difenoconazole at 32 fl oz in dirty water to a high of 7.25 for Scholar plus difenoconazole at 21.3 fl oz in clean water. Mean pH across all fungicide treatments was 7.2 for clean water and 6.7 for dirty water.

Apples were removed from cold storage on Wednesday morning and were moved to the unheated shed where treatments were applied so that they could warm up to ambient temperature overnight. On Thursday morning, each apple was wounded on a single face using a large cork fitted with three finishing nails spaced about three-eighth in. apart in a triangular pattern to create three wounds one-eighth in. deep by one-sixteenth in. diameter. Apples were counted into baskets so as to generate four replications of 25 apples per treatment. The baskets of wounded fruit were immersed in an inoculum suspension for 30 sec, allowed to dry for 2 hr, and were then immersed and agitated in freshly stirred treatment solutions for 30 sec. The inoculum suspension was made by washing spores with distilled water containing 0.01% Tween 20 from 6-day-old plates of both a benzimidazole-resistant (P-301) and a benzimidazole-sensitive (P-99) isolate of *P. expansum*. Spore densities in the initial wash solutions were measured with a hemacytometer. The suspensions from the two isolates of *P. expansum* were mixed and diluted to create a final inoculum suspension of 20,000 spores/ml that contained a 1:1 mixture of spores from the two isolates. After the full-rate fungicide treatments were applied, the tanks were stirred again, the amount of treatment solution in each tank was reduced from 15 gal to 3 gal, and then tanks were refilled to 15 gal with clean water. This process resulted in an 80% reduction in both fungicide rates and levels of soil/peat contamination. The tanks with adjusted rates were stirred again with the small brooms at 1 PM and 4:30 PM on Tuesday and at 9 AM, 1 PM, and 4:30 PM on Wednesday to re-suspend any of the fungicide and soil/peat mixture that had settled to the bottom of the tanks. The soil/peat/apple amendment added to each tank to create dirty water consisted of 10.6 oz of whole apple puree (made by grinding apples in a blender) plus 8.8 oz of dry peat moss plus 70.5 oz of soil at field moisture collected from beneath a tree row in an orchard that had received no residual herbicides during the growing season. The 70.5 oz of fresh soil was equivalent to 66.3 oz of air-dried soil. Temperature of the solutions was recorded for four arbitrarily selected tanks on Tuesday and Wednesday, and mean solution temperatures for the respective days were 45.3°F and 43.2°F. The pH of treatment tanks was measured on Tuesday and ranged from a low of 6.65 for difenoconazole at 32 fl oz in dirty water to a high of 7.25 for Scholar plus difenoconazole at 21.3 fl oz in clean water. Mean pH across all fungicide treatments was 7.2 for clean water and 6.7 for dirty water.

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This experiment was designed so that results could be analyzed using a 3-way analysis of six fungicide treatments (including the control fruit) X two fungicide rates X two water quality parameters. All analyses were completed using the SuperAnova statistical software package from Abacus Concepts. In addition to analyzing data showing percentages of fruit
infected, results for fungicide treatments were also expressed as percent disease control. To determine percent disease control, the incidence of decay for fungicide treatments within each replicate was compared to the incidence of decay in the same replicate for the clean water or dirty water controls.

Results: When compared across both fungicide rates and both water quality parameters, all of the treatments suppressed blue mold as compared to the untreated controls, but there were no differences among fungicides (Table 1). In all cases, the low rate of fungicides in clean water performed just as well as the high rate in either clean or dirty water, but that was not consistently true for the low rate in dirty water (Table 1). When rate effects were compared across both water quality treatments, the grand mean for all treatments showed the high rate was significantly better than the low rate (Table 2, lower right part of the table), but there was a significant fungicide X rate interaction because the incidence of decay for the control treatment was lower in dirty than in clean water whereas the reverse was true for fungicide treatments. It is possible that microbes in the soil and/or peat that was used in the dirty water tanks provided a low level of biocontrol, thereby lowering disease incidence for fruit exposed to dirty water with no fungicide. However, it appears that the dirty water also reduced effectiveness of the fungicides where fungicides were used at the low rate. This becomes especially evident when treatments are expressed as percent disease control (Tables 3 and 4). Water quality had no effect on percent disease control when fungicides were tested at full rates but percent disease control was significantly lower in dirty water when fungicide were tested at the low rate (Table 3). The grand means for clean water versus dirty water across all fungicides and across both rates showed a significant effect of water quality (Table 4, grand means for water quality at the bottom of the table), but there was also a significant rate X water quality interaction as noted in the footnotes for Table 4. Results from data collected after the shelf-life test followed the same general patterns (Tables 5-8).

Conclusions: Both Scholar and difenoconazole were very effective for controlling P. expansum when used at full rates. Despite the severity of this test with high inoculum levels, a decay-sensitive cultivar, wounded fruit, and a post-storage shelf life test, all of the full-rate fungicide treatments still provided more than 90% disease control in both clean and dirty water (Table 7). However, when rates were reduced to 20% of recommended rates, some loss of fungicide activity was evident in dirty water.

The benefit of combinations of Scholar plus difenoconazole was also more evident for fruit treated in dirty water and at 20% of full rates than in any of the other comparisons. We conclude that a combination of Scholar plus difenoconazole will provide excellent disease control under normal use, and the combination should be beneficial for reducing selection for resistance to these chemistries.
Table 1. Percent Empire fruit with blue mold following 90 days at 36° F as determined in a factorial experiment with six fungicide treatments, two fungicide rates, and two water qualities.

<table>
<thead>
<tr>
<th>Fungicides and &quot;full rate&quot; of formulated product per 100 gal of drench solution</th>
<th>Simple means for percent fruit with blue mold:</th>
<th>Grand means for fungicides across all 4 columns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full rate of fungicides</td>
<td>20% of full rate of fungicides</td>
</tr>
<tr>
<td></td>
<td>clean water</td>
<td>dirty water</td>
</tr>
<tr>
<td>Control ........................................</td>
<td>62.8 f²</td>
<td>44.0 ef</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz ..........</td>
<td>1.0 ab</td>
<td>2.0 abc</td>
</tr>
<tr>
<td>Difenoconazole 300SC 21.3 fl oz ......</td>
<td>9.0 abcd</td>
<td>2.0 ab</td>
</tr>
<tr>
<td>Difenoconazole 300SC 32 fl oz ..........</td>
<td>6.0 abcd</td>
<td>2.0 ab</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz + Difenoconazole 300SC 21.3 fl oz ....</td>
<td>0.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz + Difenoconazole 300SC 32 fl oz ......</td>
<td>2.0 abc</td>
<td>3.0 abc</td>
</tr>
</tbody>
</table>

² See text for description of "dirty water."
³ Simple means (all of the 24 means shown in the first four data columns) that are followed by the same small letter do not differ significantly (P≤0.05) as determined by applying Fisher's Protected LSD to results from a 2x2x6 three-way analysis of data. Simple means are results from four replicates that each contained 25 fruit.

w Means within the column followed by the same letter are not significantly different as determined by applying Fisher's Protected LSD to results from a 2x2x6 three-way analysis of data. Grand means in this column are results from four treatments (2 water quality trts X 2 fungicide rates) and therefore are derived from observations of 16 replicates that each contained 25 fruit.

Table 2. Percent Empire fruit with blue mold following 90 days at 36° F as determined from a factorial experiment with six fungicide treatments, two fungicide rates, and two water qualities.

<table>
<thead>
<tr>
<th>Fungicides and &quot;full rate&quot; of formulated product per 100 gal of drench solution</th>
<th>Fruit with blue mold decay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grand means for fungicides across both fungicide rates</td>
</tr>
<tr>
<td></td>
<td>Clear water</td>
</tr>
<tr>
<td>Control ........................................</td>
<td>55.4 c²</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz ..........</td>
<td>3.0 ab</td>
</tr>
<tr>
<td>Difenoconazole 300SC 21.3 fl oz ......</td>
<td>8.0 b</td>
</tr>
<tr>
<td>Difenoconazole 300SC 32 fl oz ..........</td>
<td>3.5 ab</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz + Difenoconazole 300SC 21.3 fl oz ..........</td>
<td>1.5 a</td>
</tr>
<tr>
<td>Grand means for effects of water quality</td>
<td>12.9 A w</td>
</tr>
</tbody>
</table>

² See text for description of "dirty water."
³ Means within columns that are followed by the same small letter do not differ significantly (P≤0.05) as determined by applying Fisher's Protected LSD to results from a 2x2x6 three-way analysis of data. The grand means within columns show results from eight replicates that each contained 25 fruit.

w Means within this row followed by the same upper case letter are not significantly different as determined by applying Fisher's Protected LSD to results from a 2x2x6 three-way analysis of data. Grand means in this row show results from 48 replicates that each contained 25 fruit. P-values from the full analysis were as follows: Effects of fungicides: P <0.001; Effects of fungicide rate: P = 0.003; Effects of water quality: P = 0.548; Fungicide X rate interaction: P = 0.110; Fungicide X water quality interaction: P = 0.181; Fungicide rate X water quality interaction: P = 0.045; 3-way interactions (fungicide, rate, water quality): P= 0.481.
Table 3. Percent disease control provided by various treatments after inoculated Empire fruit had been stored at 36° F for 90 days with treatments applied in a factorial design with six fungicide treatments, two fungicide rates, and two water qualities.

<table>
<thead>
<tr>
<th>Fungicides and &quot;full rate&quot; of formulated product per 100 gal of drench solution</th>
<th>% disease control for blue mold as compared to control fruit</th>
<th>Grand mean for fungicides</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full rate of fungicides</td>
<td>20% rate of fungicides</td>
</tr>
<tr>
<td></td>
<td>clean water</td>
<td>dirty water</td>
</tr>
<tr>
<td>Scholar 230SC  10 fl oz .........................</td>
<td>98.8 ( ^a )</td>
<td>95.6</td>
</tr>
<tr>
<td>Difenoconazole 300SC  21.3 fl oz ............</td>
<td>85.9</td>
<td>95.1</td>
</tr>
<tr>
<td>Difenoconazole 300SC  32 fl oz ..............</td>
<td>90.0</td>
<td>95.6</td>
</tr>
<tr>
<td>Scholar 230SC  10 fl oz + Difenoconazole 300SC  21.3 fl oz ..</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Scholar 230SC  10 fl oz + Difenoconazole 300SC  32 fl oz ......</td>
<td>96.7</td>
<td>93.1</td>
</tr>
</tbody>
</table>

\( ^a \) See text for description of "dirty water."

Simple means (all of the 24 means shown in the first four data columns) did not differ significantly \( (P=0.106) \) as determined from a 2x2x5 three-way analysis of data. Simple means are results from four replicates that each contained 25 fruit.

Means within the column followed by the same letter are not significantly different as determined by applying Fisher's Protected LSD to results from a 2x2x5 three-way analysis of data. Grand means in this column are results from four treatments (2 water quality trts X 2 fungicide rates) and therefore are derived from observations of 16 replicates that each contained 25 fruit.

Table 4. Percent disease control provided by various treatments after inoculated Empire fruit had been stored at 36° F for 90 days with treatments applied in a factorial design with six fungicide treatments, two fungicide rates, and two water qualities.

<table>
<thead>
<tr>
<th>Fungicides and &quot;full rate&quot; of formulated product per 100 gal of drench solution</th>
<th>Percent disease control as compared to control fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grand means for fungicides across both fungicide rates</td>
</tr>
<tr>
<td></td>
<td>Clear water</td>
</tr>
<tr>
<td>Scholar 230SC  10 fl oz .........................</td>
<td>94.7</td>
</tr>
<tr>
<td>Difenoconazole 300SC  21.3 fl oz ................</td>
<td>84.2</td>
</tr>
<tr>
<td>Difenoconazole 300SC  32 fl oz ..................</td>
<td>94.2</td>
</tr>
<tr>
<td>Scholar 230SC  10 fl oz + Difenoconazole 300SC  21.3 fl oz ..........</td>
<td>94.9</td>
</tr>
<tr>
<td>Scholar 230SC  10 fl oz + Difenoconazole 300SC  32 fl oz ......</td>
<td>86.9</td>
</tr>
<tr>
<td>Grand means for water quality ........................</td>
<td>91.0 A</td>
</tr>
</tbody>
</table>

\( ^a \) See text for description of "dirty water."

Means within columns that are followed by the same small letter do not differ significantly \( (P\leq0.05) \) as determined by applying Fisher's Protected LSD to results from a 2x2x5 three-way analysis of data. The grand means within columns show results from eight replicates that each contained 25 fruit.

Means within this row followed by the same upper case letter are not significantly different as determined by applying Fisher's Protected LSD to results from a 2x2x5 three-way analysis of data. Grand means in this row show results from 40 replicates that each contained 25 fruit. \( P \)-values from the full analysis were as follows: Effects of fungicides: \( P = 0.855 \); Effects of fungicide rate: \( P = 0.001 \); Effects of water quality: \( P = 0.019 \); Fungicide X rate interaction: \( P = 0.991 \); Fungicide X water quality interaction: \( P = 0.864 \); Fungicide rate X water quality interaction: \( P = 0.012 \); 3-way interactions (fungicide, rate, water quality): \( P = 0.679 \).
### Table 5. Percent Empire fruit with blue mold following 90 days at 36° F plus 11 days at 60° F as determined from a factorial experiment with six fungicide treatments, two fungicide rates, and two water qualities.

| Fungicides and "full rate" of formulated product per 100 gal drench solution | Simple means for percent fruit with blue mold: \(^a\) | Grand means for fungicide treatment
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full rate of fungicides clean water</td>
<td>dirty water (^a)</td>
</tr>
<tr>
<td>Control</td>
<td>96.0 (f)</td>
<td>80.0 (e)</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz</td>
<td>4.0 ab</td>
<td>2.0 ab</td>
</tr>
<tr>
<td>Difenoconazole 300SC 21.3 fl oz</td>
<td>13.0 abcd</td>
<td>8.0 abcd</td>
</tr>
<tr>
<td>Difenoconazole 300SC 32 fl oz</td>
<td>8.0 abcd</td>
<td>4.0 abc</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difenoconazole 300SC 21.3 fl oz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difenoconazole 300SC 32 fl oz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) See text for description of "dirty water."

\(^a\) Simple means (all of the 24 means shown in the first four data columns) that are followed by the same small letter do not differ significantly \((P \leq 0.05)\) as determined by applying Fisher's Protected LSD to results from a 2x2x6 three-way analysis of data. Simple means are results from four replicates that each contained 25 fruit.

\(w\) Means within the column followed by the same letter are not significantly different as determined by applying Fisher's Protected LSD to results from a 2x2x6 three-way analysis of data. Grand means in this column are results from four treatments (2 water quality trts X 2 fungicide rates) and therefore are derived from observations of 16 replicates that each contained 25 fruit.

### Table 6. Percent Empire fruit with blue mold following 90 days at 36° F plus 11 days at 60° F as determined from a factorial experiment with six fungicide treatments, two fungicide rates, and two water qualities.

<table>
<thead>
<tr>
<th>Fungicides and &quot;full rate&quot; of formulated product per 100 gal of drench solution</th>
<th>Fruit with blue mold decay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grand means for fungicides across both water qualities</td>
</tr>
<tr>
<td></td>
<td>Clear water</td>
</tr>
<tr>
<td>Control</td>
<td>90.5</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz</td>
<td>8.5</td>
</tr>
<tr>
<td>Difenoconazole 300SC 21.3 fl oz</td>
<td>16.0</td>
</tr>
<tr>
<td>Difenoconazole 300SC 32 fl oz</td>
<td>8.0</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz +</td>
<td></td>
</tr>
<tr>
<td>Difenoconazole 300SC 21.3 fl oz</td>
<td>6.5</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz +</td>
<td></td>
</tr>
<tr>
<td>Difenoconazole 300SC 32 fl oz</td>
<td>8.0</td>
</tr>
</tbody>
</table>

\(^a\) See text for description of "dirty water."

\(^a\) Means within columns that are followed by the same small letter do not differ significantly \((P \leq 0.05)\) as determined by applying Fisher's Protected LSD to results from a 2x2x6 three-way analysis of data. The grand mean in this row is results from eight replicates that each contained 25 fruit.

\(w\) Means within this row followed by the same upper case letter are not significantly different as determined by applying Fisher's Protected LSD to results from a 2x2x6 three-way analysis of data. Grand means in this row show results from eight replicates that each contained 25 fruit. \(P\)-values from the full analysis were as follows: Effects of fungicides: \(P < 0.001\); Effects of fungicide rate: \(P = 0.001\); Effects of water quality: \(P = 0.527\); Fungicide X rate interaction: \(P = 0.116\); Fungicide X water quality interaction: \(P = 0.288\); Fungicide rate X water quality interaction: \(P = 0.039\); 3-way interactions (fungicide, rate, water quality): \(P = 0.724\).
Table 7. Percent disease control provided by various treatments after inoculated Empire fruit had been stored at 36° F for 90 days plus 11 days at 60° F with treatments applied in a factorial design with five fungicide treatments, two fungicide rates, and two water qualities.

<table>
<thead>
<tr>
<th>Fungicides and &quot;full rate&quot; of formulated product per 100 gal of drench solution</th>
<th>% disease control for blue mold as compared to control fruit</th>
<th>Grand mean for fungicides w</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full rate of fungicides clean water</td>
<td>dirty water 20% rate of fungicides clean water</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz ....................</td>
<td>96.0 ab</td>
<td>96.8 ab</td>
</tr>
<tr>
<td>Difenoconazole 300SC 21.3 fl oz ..........</td>
<td>85.5 abcd</td>
<td>90.2 abcd</td>
</tr>
<tr>
<td>Difenoconazole 300SC 32 fl oz ..........</td>
<td>91.1 abc</td>
<td>95.3 ab</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz + Difenoconazole 300SC 21.3 fl oz ....</td>
<td>97.6 ab</td>
<td>96.3 ab</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz + Difenoconazole 300SC 32 fl oz ....</td>
<td>97.8 a</td>
<td>93.5 ab</td>
</tr>
</tbody>
</table>

See text for description of "dirty water."

Means within columns that are followed by the same small letter do not differ significantly (P≤0.05) as determined by applying Fisher's Protected LSD to a 2x2x5 three-way analysis of data. Simple means are results from four replicates that each contained 25 fruit.

Means within the column followed by the same letter are not significantly different as determined by applying Fisher's Protected LSD to results from a 2x2x5 three-way analysis of data. Grand means in this column are results from four treatments (2 water quality trts X 2 fungicide rates) and therefore are derived from observations of 16 replicates that each contained 25 fruit.

Table 8. Percent disease control provided by various treatments after inoculated Empire fruit had been stored at 36° F for 90 days plus 11 days at 60° F with treatments applied in a factorial design with six fungicide treatments, two fungicide rates, and two water qualities.

<table>
<thead>
<tr>
<th>Fungicides and &quot;full rate&quot; of formulated product per 100 gal of drench solution</th>
<th>Percent disease control as compared to control fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grand means for fungicides across both fungicide rates</td>
</tr>
<tr>
<td></td>
<td>Clear water</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz ....................</td>
<td>89.0</td>
</tr>
<tr>
<td>Difenoconazole 300SC 21.3 fl oz ..........</td>
<td>78.1</td>
</tr>
<tr>
<td>Difenoconazole 300SC 32 fl oz ..........</td>
<td>88.4</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz + Difenoconazole 300SC 21.3 fl oz ..........</td>
<td>89.5</td>
</tr>
<tr>
<td>Scholar 230SC 10 fl oz + Difenoconazole 300SC 32 fl oz ..........</td>
<td>88.1</td>
</tr>
<tr>
<td>Grand means for water ........................................................................</td>
<td>86.6 B</td>
</tr>
</tbody>
</table>

See text for description of "dirty water."

Means within columns that are followed by the same small letter do not differ significantly (P≤0.05) as determined by applying Fisher's Protected LSD to results from a 2x2x5 three-way analysis of data. The grand means within columns show results from eight replicates that each contained 25 fruit.

Means within this row followed by the same upper case letter are not significantly different as determined by applying Fisher's Protected LSD to results from a 2x2x5 three-way analysis of data. Grand means in this row show results from 40 replicates that each contained 25 fruit.
New Approaches for Controlling Spread of Fire Blight During Summer
Progress Report for Work Completed in 2009,
2nd Year of the NY-ARDP-Funded Project
Report submitted 30 November 2009

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Objective: Evaluate Apogee, Provado, sulfur, copper, and several combinations of these products for their effectiveness in suppressing potato leafhopper populations and shoot blight during summer.

Abstract:
A meadow orchard of Lady Apple trees on MM.111 rootstock was inoculated with Erwinia amylovora on 19 June and again on 2 July to determine if pesticide treatments applied to replicated plots within the test orchard would affect the incidence of shoot blight that developed following inoculations. Treatments were replicated five times using 6-tree plots for each replication. Yellow sticky traps were maintained in each 6-tree plot throughout summer to monitor populations of potato leafhoppers (PLH), an insect that has been implicated in spread of fire blight during summer. Because of cool wet weather during June and July, PLH populations were much lower in 2009 than in 2008 (total captures of 836 versus 5,115 for the two years respectively). Incidence of shoot blight was also much lower in 2009 than in 2008, with a total of 2,707 strikes removed in 2008 compared to only 46 strikes removed during the entire 2009 season. In both 2008 and 2009, we failed to detect any effects of individual treatments on PLH populations or on the incidence of shoot blight that developed in the plots. In 2009, however, when three treatments that received insecticide treatments were grouped together and compared to three similar treatments that did not receive insecticides, the insecticide-treated group had 62% fewer strikes than the no-insecticide group and differences were statistically significant. Thus, our 2009 trial provided evidence that insects may contribute to shoot blight infections whereas we failed to detect any contribution of insects to the shoot blight incidence in 2008. Given the very low incidence of both PLH and shoot blight in 2009, the role of insects in blight epidemiology remains questionable and additional data is needed before we can draw any conclusions about the role of insects in spread of shoot blight during summer.

Methods:
A meadow orchard containing 240 Lady Apple trees on MM.111 rootstocks was established in an isolated corner of the property at the Hudson Valley Lab in 2007 specifically to study spread of fire blight during summer. Lady Apples were chosen as the test cultivar because of their vigorous upright growth habit and their known susceptibility to the shoot blight phase of fire blight. MM.111 rootstocks were used so as to avoid rootstock blight, enhance vegetative growth, and minimize flowering of the young trees. The meadow orchard was designed with 40 six-tree plots arranged in a triple-row, high-density grid with 45 inches between rows, a 3-ft in-row spacing within plots, and a 6-ft in-row spacing between plots. Trees were closely spaced to favor potato leafhopper (PLH) populations and promote slow drying and higher relative humidity typical of a mature tree canopy.

After trees were planted in 2007, shoots were thinned to five or six per tree. These shoots were headed back during dormant pruning in spring of 2008, in mid-summer of 2008, and in spring of 2009 with the objective of preventing any 2-yr old wood from extending more than 3.5 feet above ground, thereby keeping trees small enough to allow easy observation of all terminal shoots when scouting for early symptoms of shoot blight. The heavy pruning favored development of many vigorous shoots that continued growing until late in the season and favored blight development throughout the summer.
Yellow sticky traps were mounted on posts in the middle of each six-tree plot to monitor populations of PLH. Traps were changed at regular intervals and the number of PLH on each trap were counted to determine if treatments applied to the plots had any impact on PLH numbers.

In 2008, trees were inoculated with fire blight bacteria on 4 June and more than 50% of all the growing shoots in the test orchard developed fire blight within the next five weeks. The entire block was sprayed with insecticide in early July of 2008 so as to "re-zero" insect populations and allow a second late-summer trial that was initiated by inoculating trees a second time on 29 July. However, the second inoculation in 2008 proved less successful than the first and we found that PLH populations in late summer were considerably lower than earlier in the season. Therefore we opted to attempt only a single trial during summer of 2009.

Treatments used in 2008 were modified for the 2009 trial. We intended to include a promising new biocontrol (Taegro) that Aldwinckle had tested in his 2009 field trials for blossom blight control. However, for unknown reasons, the manufacturer opted to withdraw that product from all trials in 2009. We therefore substituted a treatment involving a combination of ProPhyt plus Serenade for the slots that had been reserved for Taegro. We also tested Apogee in 2009 in hopes that we would have at least one effective treatment because none of the treatments were effective in the 2008 trial. Details of treatments and spray timings used in 2009 are shown in Table 1.

In 2009, we inoculated all plots except the non-inoculated control plots on 19 June and again on 2 July. On 19 June, inoculum came from an isolate of fire blight that was recovered from blossom blight infections that appeared in other orchards at the Hudson Valley Lab shortly after bloom. Because we hoped to generate a lower rate of infection than occurred in 2008, we used an inoculum suspension that contained only $10^5$ colony-forming units (cfu) per ml whereas in 2008 we used inoculum adjusted to $10^8$ cfu/ml. However, when very little shoot blight appeared following the 19 June inoculations, we made a second inoculation on 2 July. For the 2 July inoculations we used the same strain of Ea that we used in 2008, we inoculated control plots on 19 June and again on 2 July. For the 2 July inoculations we used the same strain of Ea that we used in 2008, but we again applied only $10^5$ cfu/ml in hopes that we would initiate only a modest epidemic.

<table>
<thead>
<tr>
<th>Materials and rate per 100 gal</th>
<th>5/16</th>
<th>5/27</th>
<th>6/6</th>
<th>6/16</th>
<th>6/25</th>
<th>7/8</th>
<th>7/23</th>
<th>8/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Non-inoculated control</td>
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<td>2. Microthiol Disperss 2 lb (sulfur)</td>
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<td></td>
<td></td>
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<td>3. Inoculated control</td>
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<td></td>
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<tr>
<td>4. Apogee 2 oz</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>5. ProPhyt 21.3 fl oz + Serenade 1.33 lb</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Insecticide trts 3-4-5*</td>
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<td>6. Provado .5 fl oz + Asana 5 fl oz</td>
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<td>X</td>
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<td>7. Provado .5 fl oz + Asana 5 fl oz +</td>
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<td>Apogee 2 oz</td>
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<tr>
<td>8. Provado .5 fl oz/A + Asana 5 fl oz +</td>
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<tr>
<td>ProPhyt 21.3 fl oz + Serenade 1.33 lb</td>
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</tbody>
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Note that treatments 3-4-5 are identical to treatments 6-7-8 except that Provado and Asana were applied in the latter group.

**Results:**

Heavy rains during June and July of 2009 suppressed PLH populations in our test plots. In 2008, we trapped a total of 5,115 PLH in nine weeks of trapping despite spraying out the entire block with insecticide in early July to re-zero the plots for a second trial in late summer. By comparison, traps in the
same locations in 2009 captured only 836 PLH between 28 May and 3 Sep (Table 2), and the entire block was never sprayed with insecticide until the experiment was discontinued in mid-August. PLH populations peaked in July in 2009 whereas they peaked in June in 2008.

The incidence of shoot blight that developed following inoculations was also much lower in 2009 than in 2008. In 2008 we removed 2,526 blighted shoots from the test block between 9 June and 15 July and another 181 blighted shoots during the second trial that ran from July 24 to August 25. In 2009, we found and removed only 46 strikes during then entire summer. The low infection rates following inoculations in 2009 may have been attributable to the reduced inoculum concentrations that we applied this year as compared to last year. Alternatively, the cooler summer in 2009 may suppressed infection rates that we observed in 2009.

In 2008, we found no evidence that any of the treatments we applied to replicated plots affected the distribution of shoot blight in the plots. In 2009 we again failed to find any significant effect of individual treatments on shoot blight development. However, when the three insecticide-treated plots and the three comparable non-insecticide plots were grouped together, the insecticide-treated plots had fewer PLH and a lower incidence of shoot blight (Table 2), and differences for both of these variables were statistically significant ($P\leq0.05$). Distributions of blight detections and PLH captures during summer are shown in Figures 1 and 2.

Table 2. Totals for potato leafhopper captures and fire blight strikes in treatments evaluated for fire blight suppression at the Hudson Valley Lab in 2009.

<table>
<thead>
<tr>
<th>Materials and rate per 100 gal</th>
<th>Total PLH trapped during 2009(^a)</th>
<th>Total blight strikes removed in 2009(^b)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>individual treatments</td>
<td>grouped treatments</td>
</tr>
<tr>
<td>1. Non-inoculated control</td>
<td>..................................</td>
<td>132 a (^c)</td>
</tr>
<tr>
<td>2. Microthiol Disperss 2 lb (sulfur)</td>
<td>..................</td>
<td>97 bc</td>
</tr>
<tr>
<td>Non-insecticide trts 3-4-5</td>
<td>..................................</td>
<td>363 b</td>
</tr>
<tr>
<td>3. Inoculated control</td>
<td>..................................</td>
<td>123 ab</td>
</tr>
<tr>
<td>4. Apogee 2 oz</td>
<td>..................................</td>
<td>101 bc</td>
</tr>
</tbody>
</table>
| 5. ProPhyt 21.3 fl oz + Sera
  nade 1.33 lb                | .................................. | 139 a | .......................... | 12 |
| Insecticide trts 6-7-8        | .................................. | 244 a | .......................... | 11 a |
| 6. Provado .5 fl oz + Asana 5 fl oz | .................. | 79 c | .......................... | 4 |
| 7. Provado .5 fl oz + Asana 5 fl oz + Apogee 2 oz | .................. | 73 c | .......................... | 6 |
| 8. Provado .5 fl oz/A + Asana 5 fl oz + ProPhyt 21.3 fl oz + Sera
  nade 1.33 lb | .................. | 92 c | .......................... | 1 |

\(^a\) Each treatment was replicated 5 times, so individual treatment totals represent total captures on 5 yellow sticky traps during 2009 whereas totals for grouped treatments are from 15 traps.

\(^b\) Treatments were replicated 5 times in 6-tree plots, so individual treatment totals are from 30 trees and grouped treatment totals are from 90 trees.

\(^c\) Means within columns that are followed by the same letter are not significantly different according to Fisher's Protected LSD test ($P\leq0.05$).

\(^d\) Statistically significant differences exist only for analyses were $P$-values are $\leq0.05$. 

\(P\)-values from statistical analyses \(\leq0.003\) 0.0001 0.217 0.021
Figure 1. Distribution of fire blight shoot infections noted throughout summer of 2009 for 15 plots that received insecticide sprays (treatments 6-7-8) compared to 15 comparable plots that did not receive insecticides (treatments 3-4-5). Comparisons are based on the number of strikes per day because intervals between observations dates were of unequal duration. Strikes/day were calculated by dividing the total number of strikes removed on any observation date by the number of days that had elapsed since the last observation. Note that inoculum was applied to the test trees on 19 June and 2 July, so infections noted on 12 and 19 June must have originated from other sources and cannot be attributed to inoculations that were applied to test plots in 2009.

Although infection rates were low following our blight inoculations, several lines of evidence suggest that most infections that appeared in the plots resulted from inoculations and not from external sources. First, the non-inoculated control was the only treatment wherein no fire blight strikes occurred at any time during 2009. Second, fire blight incidence in the plots increased gradually after the 4 June inoculations and dramatically after the 2 July inoculations (Fig. 1).

We were surprised to find that insecticide treatment had a significant effect on blight incidence in 2009 when both PLH populations and blight incidence were very low whereas we were unable to detect any benefit from insecticide treatment in 2008 when PLH were abundant and blight incidence was very high. However, the June insecticide treatments in 2008 consisted only of low rates of Provado and those treatments failed to suppress PLH. In 2009, we used a combination of a pyrethroid (Asana) plus Provado and that treatment was effective for reducing PLH populations below those observed in non-insecticide plots. Thus, successful detection of insecticide effects in 2009 may be related to changes in the insecticide program between the two years. However, impacts of insecticide treatment on shoot blight development needs to be verified in a setting where shoot blight is more prevalent than it was in our plots in 2009. Furthermore, trees that receive no insecticides also harbor large aphid populations, so effects of insecticide treatment may not be directly attributable to PLH populations alone.

The fact that Apogee failed to suppress blight incidence was somewhat surprising since Apogee has proven effective in other research trials. Apogee-treated trees showed the reduced shoot growth expected from Apogee treatment, so we know that enough product was absorbed by the foliage to affect tree physiology. Perhaps Apogee affects would be more evident in a test where blight was more prevalent or in trees that were less vigorous and/or of a less susceptible cultivar.
The plots that received repeated applications of ProPhyt produced strap-shaped leaves on growing terminals. This phytotoxicity was evident by 5 July after ProPhyt had been applied four times. ProPhyt was applied just as often in 2008 without causing noticeable phytotoxicity, so we suspect that the phytotoxicity observed this year is related either to the cooler weather or water-saturated soil conditions that prevailed in 2009 and that may have prevented efflux of the phosphite through roots.

In both 2008 and 2009, trees treated with ProPhyt had the most fire blight strikes, although differences among treatments were not statistically significant in either year. Nevertheless, results over two years suggest that ProPhyt is unlikely to have any benefits for suppressing spread of fire blight during summer, and adding Serenade in 2009 did not result in improved activity. Thus, so far as we can tell, there are not any biological controls or "green" treatments that hold promise for suppressing spread of fire blight during summer. Further evaluations of Apogee, sulfur, and insecticide treatments are warranted, but data collected during past two years suggests that there will not be any simple solution for slowing spread of fire blight during summer.

Results from two years of work suggest that under conditions favorable for rapid spread of blight during summer (as occurred in 2008), the role of insect facilitators is probably minimal whereas under less favorable conditions for spread of blight (as occurred in 2009), insects may play at least a small role in facilitating spread of shoot blight.

![Figure 2. Distribution of PLH captures during summer of 2009 for 15 plots (treatments 6-7-8) that received insecticide sprays compared to 15 comparable plots (treatments 3-4-5) that did not receive insecticides. Comparisons are based on the number PLH captured per trap per day because exposure intervals for the traps were of unequal duration. PLH/trap/day was calculated by dividing the total number of PLH captured during any trapping interval by the number of traps (15 for each mean shown) and by the number of days in the trapping interval that ended on the dates shown. Note that inoculum was applied to the test trees on 19 June and 2 July, so the second inoculation occurred at the start of the major PLH population peak in 2009.](image)
Evaluation of Low-Volume Non-Recycling Drenches for Controlling Postharvest Diseases and Disorders of Apples

Progress Report for Work Completed in 2009
1st Year of the NY-ARDP-Funded Project
Report submitted 30 November 2009

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Objectives:
1. Compare effectiveness of postharvest apple disease control and scald control achieved with DPA/fungicide treatments applied via traditional recycling postharvest drenches or via non-recycling sprays applied over the tops of full apple bins.
2. Compare proportions of fruit surfaces covered when postharvest treatments are applied via traditional recycling postharvest drenches or via non-recycling sprays applied over the tops of full apple bins.

Abstract:
Diphenylamine (DPA) and postharvest fungicides were applied to apples using either a low-volume non-recycling drench (NRD) or a traditional high-volume recycling drench (RD). Effectiveness of the two application systems are being compared by evaluating decay control in wounded Cortland fruit and by observing fruit for storage scald and carbon dioxide injury after more than 60 days of cold storage. Each treatment was replicated four times by applying treatments to fruit in specially constructed minibins that were 15 inches square but equal in height to commercial harvest bins. Fruit treated with water (controls) via the RD developed blue mold decay at 69% of puncture wounds whereas water applied as an NRD treatment resulted in decay at only 24% of puncture wounds. However, Scholar/Captan/DPA and Penbotec/Captan/DPA mixtures applied via RD provided >99% control of decay whereas those same combinations applied via NRD provided only 86-92% control of decay. Where fungicides were applied via NRD, the incidence of decay was 3 to 5 times greater in fruit at the bottom of the bin than in fruit located near the tops of the bins. Although fungicide treatments applied via NRD were not as effective as RD treatments, the NRD treatments may be effective enough to provide acceptable decay control under commercial conditions where fruit would be exposed to lower levels of inoculum than those used for this trial and relatively few fruit would have wounds. NRD and RD treatments applied for scald control remain in cold storage for later evaluations. Treatments with a fluorescent dye will be applied to stored fruit later in winter after minibins used for the decay and scald control trials have been emptied and can be re-filled with fruit held in cold storage. The fluorescent dye NRD treatment will enable visual assessments of the proportion of fruit surfaces that are contacted by treatment solutions at various locations within the minibins.

Methods:
Experiments were designed to compare the effectiveness of postharvest treatments applied to apples in a low-volume non-recycling drench (NRD) with results from the same treatments applied using a conventional high-volume recycling drench (RD). Because NRDs involve only small quantities of solution, we were specifically concerned about whether enough treatment solution would reach apples in the bottom of bins to control decays on those fruit.

To avoid the difficulties inherent in using full bins of apples as experimental units, we designed and constructed 24 plywood mini-bins that were 15 inches square (interior measurements) by 36 inches high
so that we could work with "columns" of fruit equal in depth to those in full-size commercial storage bins. Each minibin held roughly 2.4 bushels of fruit and had an interior footprint area equal to 12% of that found in a MacroPlastic model 32FV bin. Data were collected from 50 fruit in the bottom of each mini-bin, 25 fruit from the mid-height part of the bin, and 25 fruit from the top of the bin. We used Cortland fruit as data fruit and Golden Delicious to fill the intervening spaces. The color difference between the two cultivars allowed us to quickly separate "data fruit" from filler fruit when experiments were being evaluated.

Peter Chairo donated hail-damaged fruit for use in these trials. The fruit were picked and transported to the Hudson Valley Lab on 21 Sep. Fruit were held at ambient temperature until they could be transferred into our mini-bins on 22 and 23 Sep. Maturity analyses performed on 22 Sep showed that Cortland fruit used for this trial had an average starch-iodine rating of 3.0 and mean pressure of 14.9 lb. However, seven of the 24 fruit in the random sample used for maturity evaluations had moldy core. When fruit with moldy core were excluded, the average starch-iodine rating for the remaining fruit was 2.2 and mean pressure was 14.7 lb. Cortland destined for CA storage are considered mature enough to harvest when they have a starch index of 2.5-3.5 and internal firmness greater than 15.0 lb (from Mike Fargione's Apple Maturity Report for 9-23-09). We specifically tried to get Cortland fruit harvested toward the beginning of the maturity window so as to increase the probability that untreated fruit would develop scald during storage.

For logistical reasons, we divided the research into three separate trials. Trial 1 was designed to compare the efficacy of two DPA-fungicide combinations applied either via RD or via NRD. Trial 2 was designed to assess effectiveness of those same treatments for controlling storage scald and carbon dioxide injury. Trial 3 was a dye experiment designed to assess fruit coverage achieved with RD and NRD.

**Trial 1:** The Cortland fruit used in the experiment were wounded three times on each of three sides by puncturing the skin a large cork fitted with three finishing nails that produced wounds that were 3 mm deep and 2 mm in diameter. Groups of 25 wounded fruit were held in plastic half-bushel "handle bags" until they could be placed in bins. After all fruit were wounded, 50 wounded fruit (2 bags) were placed in the bottom of each minibin and a layer of Golden Delicious was added to bring the fruit level to about 15 inches from the floor of the bin. A 3rd bag of wounded Cortland fruit was added at the mid-level in the bin, more Golden Delicious were added to bring the fruit level close to the 30-inch mark on the bin, and then a 4th bag of wounded Cortland fruit was added to top off the fruit column while keeping the top layer of fruit at about 30 inches from the floor (Fig. 1). The number of data fruit in the bottom of the bin was double that used for the top and middle levels of the bin because we anticipated that we might need more data points to sort out treatment differences at the bottom of bins where NRD treatments were expected to result in incomplete coverage of fruit surfaces. To minimize the amount of treatment solution that might be absorbed by dry bins, the plywood minibins were thoroughly hosed down with water several times over a 4-hr period before fruit were placed into them.

Inoculum was prepared by removing spores from 10-day old cultures of *Penicillium expansum* isolate 301, an isolate that is not controlled by benzimidazole-plus-DPA treatments. Hemacytometer counts revealed that the inoculum suspension contained 19.5x10^6 spores/ml. The inoculum suspension was poured into a plastic spray bottle. Before bags of wounded fruit were emptied into bins, the open bag was misted with one squirt (ca. 3.2 ml) of the spore suspension. One additional squirt was applied over top of each layer of Cortland apples after they had been transferred from the bags into the minibins. We used four bags of 25 wounded fruit per minibin (2 bottom, 1 center, 1 top) and had 3 layers (bottom, center, top) of data fruit within the bin. Thus, we applied seven inoculum squirts per bin for a total application of 22.4 ml of inoculum per bin or a total of 439.9 million spores per bin. We opted to apply the inoculum by misting fruit rather than dipping fruit into inoculum suspensions so as to more closely simulate exposure to airborne spores that might contaminate fruit during harvest and transport to storages under commercial conditions.

For recycling drenches (RD), we placed minibins in a fiberglass catch basin (a child's sandbox) that had a large drain hole cut into one corner and that was supported on cement blocks so that solutions
draining from the catch basin could be recaptured. Treatment solutions were mixed in a volume of 9 gal of water held in a 10-gal plastic garbage pail. The pail containing treatment solutions was placed beneath the catch basin drain. A sump pump in the garbage pail delivered 48 gal/min through a 1.75-in diameter flexible hose. Solution that ran through the minibins was rapidly recirculated back to the sump pump via the drain in the catch basin (Fig. 1). We directed flow from the hose over the top of the minibin for 30 seconds and then allowed the minibin to drain before removing it from the fiberglass catch basin. The same treatment solution was used for treating four replicate bins for each treatment. The pump and catch basin were rinsed with clean water between treatments.

For non-recycling drenches (NRD), we used products at the same concentrations as those used for the recycling drenches. A double-layer of window screen was placed over the top of each bin and 500 ml of clean treatment solution was applied to each bin by pouring it through the double layer of screening in such a way that all apples on the upper layer were evenly wetted by the treatment solutions. Solution that drained from the bottoms of the minibins was recaptured in the catch basin and was measured to determine how much of the 500 ml/bin was retained by the fruit and bin surfaces.

Treatments in Trial 1 were applied on 22 Sep as follows:

1. NRD: Water control
2. NRD: No Scald DPA 1500 ppm plus Scholar 230SC 10 fl oz/100 gal plus Captan 80 1.25 lb
3. NRD: No Scald DPA 1500 ppm plus Penbotec 16 fl oz/100 gal plus Captan 80 1.25 lb
4. RD: Water control
5. RD: No Scald DPA 1500 ppm plus Scholar 230SC 10 fl oz/100 gal plus Captan 80 1.25 lb
6. RD: No Scald DPA 1500 ppm plus Penbotec 16 fl oz/100 gal plus Captan 80 1.25 lb

Figure 1. Left: Filling minibins with alternating layers of Cortland "data fruit" and Golden Delicious filler fruit. Although bins were 36 inches deep, six inches of headspace was left at the top to minimize splashing of treatment solutions. The full-size field bin in the rear was elevated on cement blocks for easier access to fruit. Right: A high-volume recycling drench is applied to fruit in a filled minibin while an assistant tracks time for the 30-second drench treatment.
Treatments 4-5-6 were applied first. Roughly an hour after those treatments were applied, the fruit from these bins was removed so that the bins could be reused. The Cortland data fruit were placed on spring cushion trays that were labeled to indicate treatment, rep, and position (top, center, bottom) within the bin. The Golden Delicious filler fruit were discarded. After they were emptied, the bins were washed with a high pressure washer, refilled with apples used for treatments 1-2-3, and treated with NRD treatments as described above. Because we wanted to know if the orientation of wounds on fruit in the bin would affect the control achieved with NRD treatments, treatments 1-2-3 were left in the bin and moved to cold storage along with the fruit from treatments 4-5-6 that were boxed on spring cushion trays. All of the bins and boxes were placed into plastic bags prior to being moved into cold storage at 35° F by 4 pm on 22 Sep. We bagged the containers to maintain high humidity that would favor decays, to ensure that volatiles produced by the treatments would be retained within the treated fruit and would not be diluted by air movement through the boxes/bins, and to enhance the possibility that we might incur carbon dioxide injury. The latter is usually prevented by DPA treatment, so differential development of CO₂ injury could help to indicate effectiveness of the various treatments.

Fruit from treatments 4-6 were removed from cold storage on 12 Nov and were evaluated for decays. The number of wounds on each fruit was recorded. Fruit from treatments 1-3 were removed from cold storage on 16 Nov. Fruit were removed from the bins with careful attention to maintaining the exact orientation of the fruit within the bin so that we could assess the number of wounds and number of infections that occurred on the upward-facing one-quarter of the fruit, on the downward facing quarter of the fruit, and on the sides of the fruit that represented the center half of the fruit.

**Trial 2:** Three treatments were applied to fruit in minibins on 23 Sep to evaluate effects of treatments on development of storage scald and CO₂ injury. Minibins were filled as described for treatments 1-6 above except that none of the fruit were wounded and no inoculum was applied. Treatments were as follows:

1. NRD: Water control
2. NRD: No Scald DPA 1500 ppm plus Scholar 230SC 10 fl oz/100 gal plus Captan 80 1.25 lb
3. HVRD: No Scald DPA 1500 ppm plus Scholar 230SC 10 fl oz/100 gal plus Captan 80 1.25 lb

Each treatment was applied to four replicate minibins. Treated fruit were left in the minibins, and the bins were enclosed in large plastic bags and moved into the same cold room as the other fruit within an hour of the time that treatments were applied.

Fruit from Trial 2 will be removed from cold storage in February and will then be held at 65° F for 10 days to enhance development of storage scald. Fruit then will be evaluated and the percentage of surface area affected by storage scald and/or by CO₂ injury will be recorded for each fruit.

**Trial 3:** This experiment will be conducted in our greenhouse in early January. Fruit from cold storage will be placed into minibins as previously described, and fruit will be treated with a fluorescent dye solution either via RD or NRD. The percentage of the fruit surface area covered by the dye will be recorded for each fruit, and we will determine if fruit coverage for various positions in the bin can be correlated with disease control achieved when wounded fruit were inoculated in Trial 1.

**Results:**

**Trial 1:** Means for the main treatment effects are shown in Fig. 2. These means were calculated by averaging the mean incidence of decay for fruit at the bottom, middle, and top of the bin, thereby providing an equal weighting for each of the three fruit positions within bins even though there were twice as many data apples at the bottom of the bins as compared to the other two positions. Fruit in the RD water control (trt 4) developed decay at 68.7% of the wounds whereas fruit in the NRD water control (trt 1) developed decay at only 24.3% of the wounds. Thus, the recycling water picked up the spores that we had misted over the fruit and effectively inoculated other fruit in the bins whereas that occurred to a much lesser extent in the NRD treatment. The fruit inoculation effects of the recycling water in treatment 4 is further illustrated by the fact that the first bin treated with recycling water had only 52% of wounds
with decay whereas subsequent bins had 68, 78, and 76%, respectively. This sequence is logical if one considers that spore concentrations in the recycling drench water would have increased as each bin was treated in turn, but the effect of increasing inoculum concentration leveled off after several bins had been treated.

If results for other treatments are converted to percent control using trt 4 as the basis for the maximum infection rate, then just switching away from the RD to the NRD treatment system in the absence of any fungicide provided a 65% reduction in disease incidence (Fig. 2). When Scholar and Penbotec were applied as RD treatments, they provided greater than 99% control of blue mold, but they only provided 86% and 92% control, respectively, when applied as NRD treatments.

Where water alone was applied as an NRD treatment, disease incidence for fruit at the top, middle, and bottom of the bins was virtually identical (Fig. 3), indicating that inoculum was evenly distributed among fruit in the top, middle, and bottoms of the minibins. However, where Scholar was applied as an NRD treatment, decay incidence was nearly 5 times greater in the bottoms of the bins than in the tops of the bins (15.2% vs. 3.3%). For Penbotec NRD treatments, disease incidence averaged 7.6% for fruit at the tops of bins compared to 2.3% for fruit at the bottoms of bins. Thus, it appears that fruit in the bottoms of bins received less complete fungicide coverage than those in the tops of bins.

For the NRD treatments, the orientation of the wound on apple surfaces within bins appeared to have relatively little impact on the probability that wounds would become infected. Looking at the total numbers of wounds across all of the NRD treatments, we found that 2,792 wounds faced upward, 5,660 wounds faced toward the sides of the bin, and 2,349 wounds faced downward. Infection percentages for those same categories were 14.2, 14.2, and 11.5%, respectively. Thus, there was a slightly lower incidence of infection in wounds facing downward in the bins where NRD treatments were applied, but the effect of wound position was relatively small.

![Figure 2](image_url)

Figure 2. Incidence of blue mold (blue bars) caused by *Penicillium expansum* in fruit wounds as affected by water, Scholar, or Penbotec applied either as a high-volume recycling drench (D) or as a low-volume non-recycling drench (NRD).
Discussion:

Trials 2 & 3 have not yet been completed, so no data is available for those trials at this time.

Results from Trial 1 showed the advantages and disadvantages of RD and NRD postharvest treatment systems. In the RD water treatment, the recycling solution rapidly picked up spores from the fruit surface and redistributed them to a high proportion of wounds on the fruit surfaces in the same way that spores in commercial DPA applications are redistributed to fruit wounds in the absence of an effective fungicide. By switching to the NRD treatment system (i.e., applying water without recycling it), we reduced decay incidence by nearly 65% in the absence of any fungicide. This reduction in decay with NRD treatment alone might have been greater if we had applied less inoculum to the fruit as we were filling the bins. Previous work has shown that fruit coming from the field rarely carry more than 30,000 *P. expansum* spores per commercial-size bin (Rosenberger et al. 2006). However, we misted fruit with the equivalent of 3.7 billion spores per full-size bin. Badly contaminated bins can carry more than 2 billion spores on bin surfaces (Rosenberger et al. 2006), so spores can accumulate in very high numbers in recycling drenches. In this trial we purposely used very high levels of inoculum so as to ensure that we would be able to detect effects of different treatments.

Applying Scholar or Penbotec in NRD treatments further reduced disease incidence below that observed in the water NRD. However, fungicides applied via NRD were less effective than comparable RD treatments. (Although we included DPA and Captan in all of the Scholar and Penbotec treatments, Scholar and Penbotec provided most of the disease control and we therefore refer to the treatments using those fungicide names.) Disease control with Scholar was especially compromised for fruit in the bottoms of bins, presumably because coverage was less complete in the bottom than in the tops of bins. Additional statistical analyses are needed to determine if observed differences between Penbotec and
Scholar for disease control at the bottoms of bins are statistically significant, and the trial must be repeated before we can conclude that Penbotec is more effective.

Packinghouse operators who pioneered the NRD concept reported that they used only about 2.5 qt of postharvest solution per bin or the equivalent of 283 ml per minibin. We increased the amount of solution applied in our NRD treatments to 500 ml per minibin (equivalent to 4.4 qt per commercial bin) because earlier in the year Dr. Alex Cochran from Syngenta shared results from trials where they found that higher volumes of water were essential for controlling blue mold on pears treated with Scholar NRD treatments. However, when we recaptured and measured the solution that ran through our minibins following the application of 2000 ml to four bins, we found that we recaptured 1000 ml following Scholar NRD treatments and 910 ml following Penbotec NRD treatments. The fact that we recovered almost half of the 500 ml that we applied to each minibin indicates that previous observations on how much solution can be retained by each bin were pretty accurate. In future tests, NRD treatments should be applied at the equivalent of 2.5 qt per commercial bin or 283 ml per minibin because higher rates of application will result in excessive run-off where large numbers of bins are treated in the same location.

The reduced disease control that we noticed with fungicides applied via NRD as compared to RD applications may be insignificant if inoculum levels are kept low by using clean bins and sanitizing storage rooms at the end of each packing season. Factors in our methodology that favored disease development included having nine wounds/fruit, introduction of artificially high inoculum levels, and maintenance of 100% relative humidity following treatment by bagging the minibins while fruit inside the bins were still wet. Another factor that may have artificially raised disease levels in the Penbotec and Scholar NRD treatments is the fact that, whereas we used clean water for the water NRD treatment, we reused the Penbotec and Scholar solutions that we had used earlier for the RD treatments. Thus, in addition to the spore load introduced by misting fruit with a spore suspension, the Scholar and Penbotec NRD treatments were also exposed to the spore load in that accumulated as RD treatments were applied.

Conclusions:

• Simply switching from RD to NRD applications of water reduced decay by 65% (from 68% of wounds infected for RD application to 24% following NRD application). The fact that NRD applications do not accumulate and recirculate spores gives it a distinct advantage over RD applications.

• Both Scholar and Penbotec were more effective when applied in RD as compared to NRD treatments, although our initial analysis showed that for Penbotec the effect of application method was not significant.

• Penbotec and Scholar applied as NRD treatments reduced decay levels significantly compared to the NRD water control. Benefits of these fungicides might have been even greater if we had used lower levels of inoculum. Alternatively, it is also possible that fungicide treatments could be completely eliminated if DPA can be applied as an NRD treatment under low-inoculum conditions.

• This experiment should be repeated using several different levels of inoculum to determine if NRD fungicide treatments are more effective with reduced inoculum levels or if fungicides can be eliminated completely at low inoculum levels.

Results from the remaining parts of this experiment (Trials 2 & 3) may help us to better understand results from Trial 1. All of the remaining work will be completed by 31 March 2010, the official termination date for the grant that supported the first year of this project.

Literature cited: