Spray Coverage, Hedging and Pecan Scab – An Update on Research

Clive H. Bock¹

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Pecan scab (*Fusicladium effusum*)

- Lifecycle of *Fusicladium effusum*, cause of pecan scab

  - **Spring**: Epidemics build up on young leaves (conidia)
  - **Summer**: Polycyclic pathogen (rain and wind)
  - **Autumn**: Overwinters as stroma and conidia
  - **Winter**: Fungus becomes dormant as stroma and overwintering conidia (twigs and shucks)
  - **Autumn**: Epidemics build up on fruit (conidia)

3-week old culture of *F. effusum* on oatmeal agar
Spray coverage in mature trees

Three experiments (2012)

- Cv. Moneymaker ~25 m (~80 ft) tall
- Water sensitive cards (Syngenta) placed at different heights (up to 15 m) in the canopy of mature pecan trees
- Inner and outer canopy locations
- Sprayer: Durand-Wayland 3210A, 3.2 kph (2 mph), 935 L/ha [100 gpa]
- Replicated three times (3 trees). Repeated experiment twice.
- Analyzed using generalized linear mixed modeling
Fungicide coverage in pecan trees

Coverage declined with sample (tree) height in all three experiments

- Was statistically similar to 10.0-12.5 m (33 – 41 ft)
- At sample ≥12.5–15.0 m (41-50 ft) was most often significantly less compared to lower in canopy (indicated by red arrow)
- Coverage was numerically slightly higher in the inner canopy

Representative water sensitive cards

Tree height

0 m [0 ft] 5 m [16 ft] 7.5 m [25 ft] 10 m [33 ft] 12.5 m [41 ft] 15 m [50 ft]
Hedging effects on scab

- Fresh growth produced throughout the season on hedged trees is susceptible to scab (susceptible cultivars)
- This could be more difficult to control in the southeast
- Consequently, fruit on hedged trees may have more severe scab
- However, an advantage may be hedged orchards are more open (more air movement, therefore conditions less conducive to scab)
- Managing scab may be easier in shorter trees (better fungicide coverage)
Hedging experiment – site 1, Weston, GA

- Pawnee trees 14 m (46 ft) tall (planted 2000, 14 y old)
- Received the same fungicide treatments (12 airblast sprayer applications)
- But different tree hedging/tree removal management practice
- Hedged to 12-14 m [40-45 ft] (and ~4 m [~12 ft] from trunk)
- Sampled at 5, 8 and 11 m (15, 26 and 37 ft)

Fungicide treatments applied to Pawnee hedging experiment

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Fungicide</th>
<th>Rate/A</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9-Apr</td>
<td>Sovran (kresoxim-methyl), Fungiphyte (phosphorous acid), Nickel CBM (Ni)</td>
<td>22 oz, 2.5 gal, 1 gal</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>21-Apr</td>
<td>Sovran (kresoxim-methyl), Fungiphyte (phosphorous acid), Nickel CBM (Ni)</td>
<td>22 oz, 2.5 gal, 1 gal</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>8-May</td>
<td>Topsin-M (thiophanate-methyl), Toledo (tebuconazole), Nickel CBM (Ni)</td>
<td>5 qts, 54 oz, 5 qts</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>22-May</td>
<td>AgriTin (TPTH), Fungiphite (phosphorous acid)</td>
<td>120 oz, 2.5 gal</td>
<td>Ground</td>
</tr>
<tr>
<td>5</td>
<td>1-Jun</td>
<td>AgriTin (TPTH), Elast (dodine)</td>
<td>120 oz, 3 gal</td>
<td>Ground</td>
</tr>
<tr>
<td>6</td>
<td>12-Jun</td>
<td>QuadrisTop (difenoconazole + azoxystrobin), Fungiphite (phosphorous acid)</td>
<td>1 gal, 2.5 gal</td>
<td>Ground</td>
</tr>
<tr>
<td>7</td>
<td>23-Jun</td>
<td>AgriTin (TPTH)</td>
<td>120 oz</td>
<td>Ground</td>
</tr>
<tr>
<td>8</td>
<td>2-Jul</td>
<td>QuadrisTop (difenoconazole + azoxystrobin), Fungiphite (phosphorous acid)</td>
<td>1 gal, 2.5 gal</td>
<td>Ground</td>
</tr>
<tr>
<td>9</td>
<td>15-Jul</td>
<td>Elast (dodine)</td>
<td>4 gal</td>
<td>Ground</td>
</tr>
<tr>
<td>10</td>
<td>24-Jul</td>
<td>QuadrisTop (difenoconazole + azoxystrobin), Fungiphite (phosphorous acid)</td>
<td>1 gal, 2.5 gal</td>
<td>Ground</td>
</tr>
<tr>
<td>11</td>
<td>6-Aug</td>
<td>AgriTin (TPTH), Elast (dodine)</td>
<td>120 oz, 3 gal</td>
<td>Ground</td>
</tr>
<tr>
<td>12</td>
<td>21-Aug</td>
<td>AgriTin (TPTH), Fungiphite (phosphorous acid)</td>
<td>120 oz, 2.5 gal</td>
<td>Ground</td>
</tr>
</tbody>
</table>
Hedging experiment – site 1, Weston, GA

Hedging and thinning treatments

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No thinning or hedging (check)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2. Pattern thinned on diagonal</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3. Selectively tree thinned (Dr. Bill Goff’s method). Replanted with spaded trees of high scores</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>4. Dormant hedged on 2 sides, following year hedged on opposite 2 sides. Cuts 12 feet from trunk on each side. Cut tops on hedged sides when height exceeds row width 12 feet (started cutting tops in 2013). Repeat the pattern over 2-year periods</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>5. Hedge one side of the tree each year. Also cut tops on hedged sides when height exceeds row width 12 feet (started cutting tops in 2013)</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>6. Repeat 4, except only on expected “on year”</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>7. Hedge tops mid May. Repeat July every year. Hedge 2 sides July during “on year”. Opposite 2 sides next “on year”</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Hedging experiment – site 1, Weston, GA

Scab severity (% area) on foliage

July 2014

- A low severity on foliage on all treatments (mean severity <1.71% leaflet area diseased on infected leaflets; range 1.54-1.71%)
- More severe scab high in the canopy
- A significant height effect

Data analyzed using generalized linear mixed modeling. Letters indicate significant differences based on t-grouping (α =0.05). 95% Confidence Intervals are indicated.
Hedging experiment – site 1, Weston, GA

Scab severity (% area) on fruit

Sept 2014

Treatment effects

Severity per fruit (% area diseased)

Treatment F=25.43, P<0.0001

- Some difference among treatments (34.7% for the diagonally thinned, and 51.9% for the dormant hedged on two sides sequentially, control = 37.0%)
- Differences in treatment effects compared to 2013 data
- Scab was severe - more severe higher in the canopy
- A pronounced height effect (6x more severe at 11 m [37 ft])

Height effects

Severity (% area diseased)

Sample ht (m) 15, 26 and 37 ft

Treatment effects

Severity (% area scabbed)

2013 Treatment effects

% fruit area scabbed

1 2 3 4 5 6 7

Data analyzed using generalized linear mixed modeling. Letters indicate significant differences based on t-grouping (α =0.05). 95% Confidence Intervals are indicated.
Hedging experiment – site 1, Weston, GA
Height and the relationship between scab severity and fruit weight

Sept 2014

- There was no relationship between scab severity on fruit and fruit weight at 5m (15 ft) or 8m (26 ft) above ground (despite more severe disease at 8m [26 ft])
- At heights ≥11 m (≥37 ft) there is more severe disease on the fruit
- Despite this, there was only a very weak relationship between scab and fruit weight at heights ≥11 m (≥37 ft)
- Pawnee may be better able to tolerate scab damage with less impact on yield; timing of infection in relation to fruit maturity may affect this

Bock et al., (unpublished data)
Hedging experiment – site 2, Marshallville, GA

- Desirable trees 14 m (~46 ft) and hedged to 12-14 m (39-46 ft)
- Planted 1996, 18 y old
- Hedged alternate rows - one side March 2013, other side March 2014 (sampled trees hedged on West in 2013, East in 2014)
- All received the same fungicide treatments
- Sampled at 7, 7-10 and >10 m (<21, 21-33 and >33 ft)

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Fungicide</th>
<th>Rate/A</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8-Apr</td>
<td>Abound (azoxystrobin)</td>
<td>9 oz.</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>21-Apr</td>
<td>Propicure (propiconazole) + Phostrol (phosphorous acid)</td>
<td>8 oz. + 1 qt.</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>5-May</td>
<td>Fitness (propiconazole)</td>
<td>8 oz.</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>20-May</td>
<td>Absolute (tebuconazole + trifloxystrobin)</td>
<td>6 oz.</td>
<td>Ground</td>
</tr>
<tr>
<td>5</td>
<td>2-Jun</td>
<td>Absolute (tebuconazole + trifloxystrobin)</td>
<td>6 oz.</td>
<td>Ground</td>
</tr>
<tr>
<td>6</td>
<td>16-Jun</td>
<td>AgTin (TPTH) + Elast 400 (dodine)</td>
<td>6 oz. + 25 oz.</td>
<td>Ground</td>
</tr>
<tr>
<td>7</td>
<td>24-Jun</td>
<td>AgTin (TPTH) + Topsin M (thiophanate methyl)</td>
<td>6 oz. + 16 oz.</td>
<td>Air</td>
</tr>
<tr>
<td>8</td>
<td>1-Jul</td>
<td>Topsin M + SuperTin (TPTH)</td>
<td>16 oz. + 12 oz.</td>
<td>Ground</td>
</tr>
<tr>
<td>9</td>
<td>9-Jul</td>
<td>SuperTin (TPTH)</td>
<td>12 oz.</td>
<td>Air</td>
</tr>
<tr>
<td>10</td>
<td>14-Jul</td>
<td>SuperTin (TPTH)</td>
<td>12 oz.</td>
<td>Ground</td>
</tr>
<tr>
<td>11</td>
<td>29-Jul</td>
<td>Absolute (tebuconazole + trifloxystrobin)</td>
<td>6 oz.</td>
<td>Air</td>
</tr>
<tr>
<td>12</td>
<td>28-Jul</td>
<td>SuperTin (TPTH) + Topsin M (thiophanate methyl)</td>
<td>12 oz. + 16 oz.</td>
<td>Ground</td>
</tr>
<tr>
<td>13</td>
<td>11-Aug</td>
<td>Abound (azoxystrobin)</td>
<td>12 oz.</td>
<td>Ground</td>
</tr>
</tbody>
</table>
Hedging experiment – site 2, Marshallville, GA

Scab severity (% area) on foliage

July 2014

- Scab severity was very low on foliage (0.58% and 0.55% leaflet area diseased on infected leaflets on hedged and non-hedged trees, respectively)
- No effect of hedging on severity on foliage
- Nonetheless, a significant height effect
- One-third more severe (but still low severity) in the upper canopy (highest sample height)

Data analyzed using generalized linear mixed modeling. Letters indicate significant differences based on t-grouping (α =0.05). 95% Confidence Intervals are indicated.

Bock et al., (unpublished data)
Hedging experiment – site 2, Marshallville, GA

Scab severity (% area) on fruit

Sept 2014

Scab severity was moderately low on fruit (mean of 6.32% and 5.88% area diseased on hedged and non-hedged trees, respectively)

No significant different in scab severity between hedged versus non-hedged trees

However, significantly more severe scab at higher sample heights in the canopy (2x more severe at ≥10 m [≥33 ft])

Bock et al., (unpublished data)

Data analyzed using generalized linear mixed modeling. Letters indicate significant differences based on t-grouping (α =0.05). 95% Confidence Intervals are indicated.
Hedging experiment – site 2, Marshallville, GA

Height and the relationship between scab severity and fruit weight

- No discernible relationship between scab severity and fruit weight at <7 m (21 ft)
- A very weak relationship between scab severity and fruit weight at >7 m (21 ft)
- Overall, scab severity was only moderate in this orchard, so the weak relationship is not surprising - at heights >7 m (21 ft) there is more severe disease on the fruit
- The more severe disease at greater heights results in a loss of fruit weight, and likely impacts other aspects of kernel quality

Bock et al., (unpublished data)
Hedging experiment - site 3, Valdosta, GA

- Desirable trees 18 m (60 ft) Planted 1996, 18 y old
- Treatments: trees were 1) hedged both sides March 2013, 2) hedged one side 2013, other side 2014, and 3) not hedged
- Hedging to 12-14 m (39-46 ft)
- All received the same fungicide treatments (16 applications)
- Sampled at = <7, 7-10, 10-14 and >14 m (<20, 20-30, 30-46, >46 ft)

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<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9-Apr</td>
<td>Elast (dodine)</td>
<td>50 oz</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>21-Apr</td>
<td>Sovran (kresoxim-methyl) + Topsin (thiophanate-methyl)</td>
<td>3.2 oz, 20 oz</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>28-Apr</td>
<td>QuadrisTop (difenconazole + azoxystrobin)</td>
<td>14 oz</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>5-May</td>
<td>Sovran (kresoxim-methyl) + Topsin (thiophanate-methyl)</td>
<td>3.2 oz, 20 oz</td>
<td>Ground</td>
</tr>
<tr>
<td>5</td>
<td>13-May</td>
<td>SuperTin (TPTH) + Elast (dodine) + Prophyt (phosphorous acid)</td>
<td>9 oz, 38 oz, 1 qt</td>
<td>Ground</td>
</tr>
<tr>
<td>6</td>
<td>23-May</td>
<td>SuperTin (TPTH) + Elast (dodine)</td>
<td>9 oz, 38 oz</td>
<td>Ground</td>
</tr>
<tr>
<td>7</td>
<td>4-Jun</td>
<td>SuperTin (TPTH) + Elast (dodine) + Prophyt (phosphorous acid)</td>
<td>12.8 oz, 25 oz, 1 qt</td>
<td>Ground</td>
</tr>
<tr>
<td>8</td>
<td>10-Jun</td>
<td>SuperTin (TPTH) + Elast (dodine) + Prophyt (phosphorous acid)</td>
<td>9 oz, 38 oz, 1 qt</td>
<td>Ground</td>
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<td>21-Jun</td>
<td>SuperTin (TPTH) + Elast (dodine) + Prophyt (phosphorous acid)</td>
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<td>7-Jul</td>
<td>SuperTin (TPTH) + Elast (dodine) + Prophyt (phosphorous acid)</td>
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<td>Ground</td>
</tr>
<tr>
<td>13</td>
<td>29-Jul</td>
<td>SuperTin (TPTH) + Topsin (thiophanate-methyl) + Prophyt (phosphorous acid)</td>
<td>38 oz, 20 oz, 1 qt</td>
<td>Ground</td>
</tr>
<tr>
<td>14</td>
<td>11-Aug</td>
<td>SuperTin (TPTH) + Elast (dodine) + Prophyt (phosphorous acid)</td>
<td>9 oz, 38 oz, 1 qt</td>
<td>Ground</td>
</tr>
<tr>
<td>15</td>
<td>25-Aug</td>
<td>SuperTin (TPTH) + Prophyt (phosphorous acid)</td>
<td>12.8 oz, 1 qt</td>
<td>Ground</td>
</tr>
<tr>
<td>16</td>
<td>8-Sep</td>
<td>SuperTin (TPTH) + Prophyt (phosphorous acid)</td>
<td>12.8 oz, 1 qt</td>
<td>Ground</td>
</tr>
</tbody>
</table>
Hedging experiment – site 3, Valdosta, GA

Scab severity (% area) on foliage

July 2014

- Very low severity of foliar scab throughout canopy (0.06, 0.06 and 0.11% area of infected leaflets on the hedged, half-hedged and non-hedged treatments)
- Significantly more severe scab on non-hedged trees
- There was a highly significant effect of height. Significantly more severe scab at 10-14 m (33-46 ft) and particularly so >14 m (46 ft) sample height in the trees

Data analyzed using generalized linear mixed modeling. Letters indicate significant differences based on t-grouping (α=0.05). 95% Confidence Intervals are indicated. Due to non-estimable values using the full model, a reduced model was used to calculate 95% Confidence Intervals and means separations for Height and Hedging effects.

Bock et al., (unpublished data)
Fruit scab severity was low on hedged trees and moderate on non-hedged trees (0.6-0.7% area diseased and 6.0% area diseased, respectively)

- Significant effect of hedging (most severe disease on non-hedged trees)
- Significant height effect - more severe scab on fruit at 10-14 m (33-46 ft) and particularly >14 m (>46 ft) sample height in the trees
Hedging experiment – site 3, Valdosta, GA
Height and the relationship between scab severity and fruit weight
Sept 2014

- Excellent scab control up to 10 m (33 ft)
- At 10-14 m (33-46 ft) the quality of control is still good, but declining (no discernible relationship with fruit weight)
- At heights >14 m (46 ft) there was some severe disease and a robust relationship between scab severity and fruit weight

Bock et al., (unpublished data)
Summary

○ There is a continuous decline in spray coverage with distance from the sprayer

○ Ground based air blast sprayers provide statistically similar coverage up to 10-12.5 m (33–41 ft) in pecan trees

○ At heights >12.5 m (41 ft), coverage was most often poor (often < 1% of the card area)

○ Scab severity on foliage was consistently very low in all hedging experiments (on both hedged and non-hedged trees)

○ Neither fruit nor foliage on hedged trees had more disease compared to non-hedged trees (except at site 1 Pawnee in 2014)

○ If trees were taller than the hedging height of 12-14 m (39-46 ft), the hedged trees had significantly less severe scab compared to the non-hedged trees

○ In all experiments there was a consistent effect of height

○ In trees >14 m (>46 ft) there was an increasing advantage to hedging as more of the fruit are within reach of effective fungicide coverage
Acknowledgements

We thank the GA Commodity Commission for Pecans for financial support for some of the work.

Growers: Buck Paulk, Mike Jaros and Richard Merritt for access to their orchards, and for use of lift equipment, and Tom Stevenson for some of the images.

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Thank you, and any questions?