# Boxwood Blight

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Photo by Cristi Palmer

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# Boxwood blight — CT production nursery

SD

# Boxwood blight — CT commercial property

SD

# Boxwood blight — CT residential property

SD

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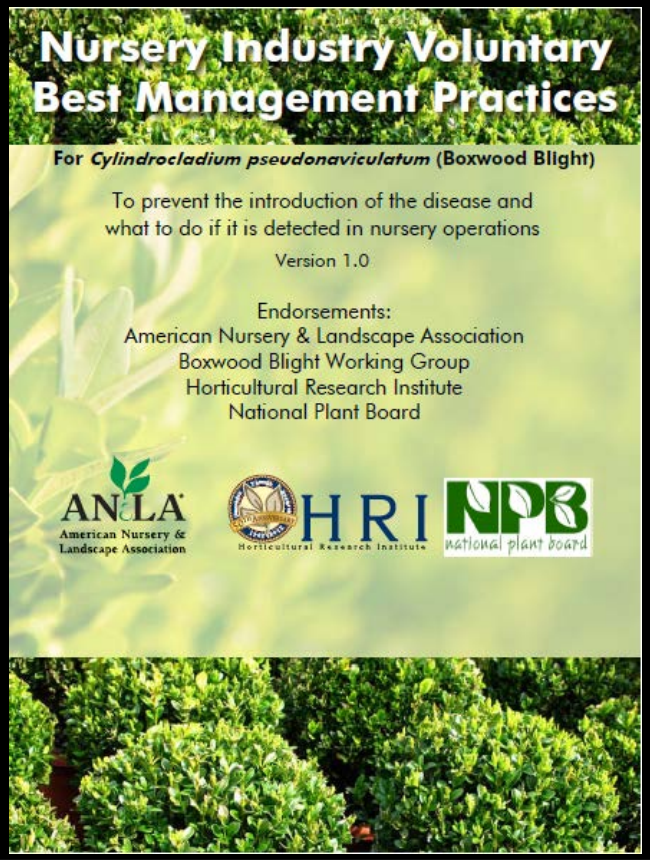
# Helping to Coordinate a Response

## BoxwoodBlight.org


## BMPs




## Funded Research

NORTH CAROLINA STATE UNIVERSITY FOUNDED MARCH 7, 1887

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION

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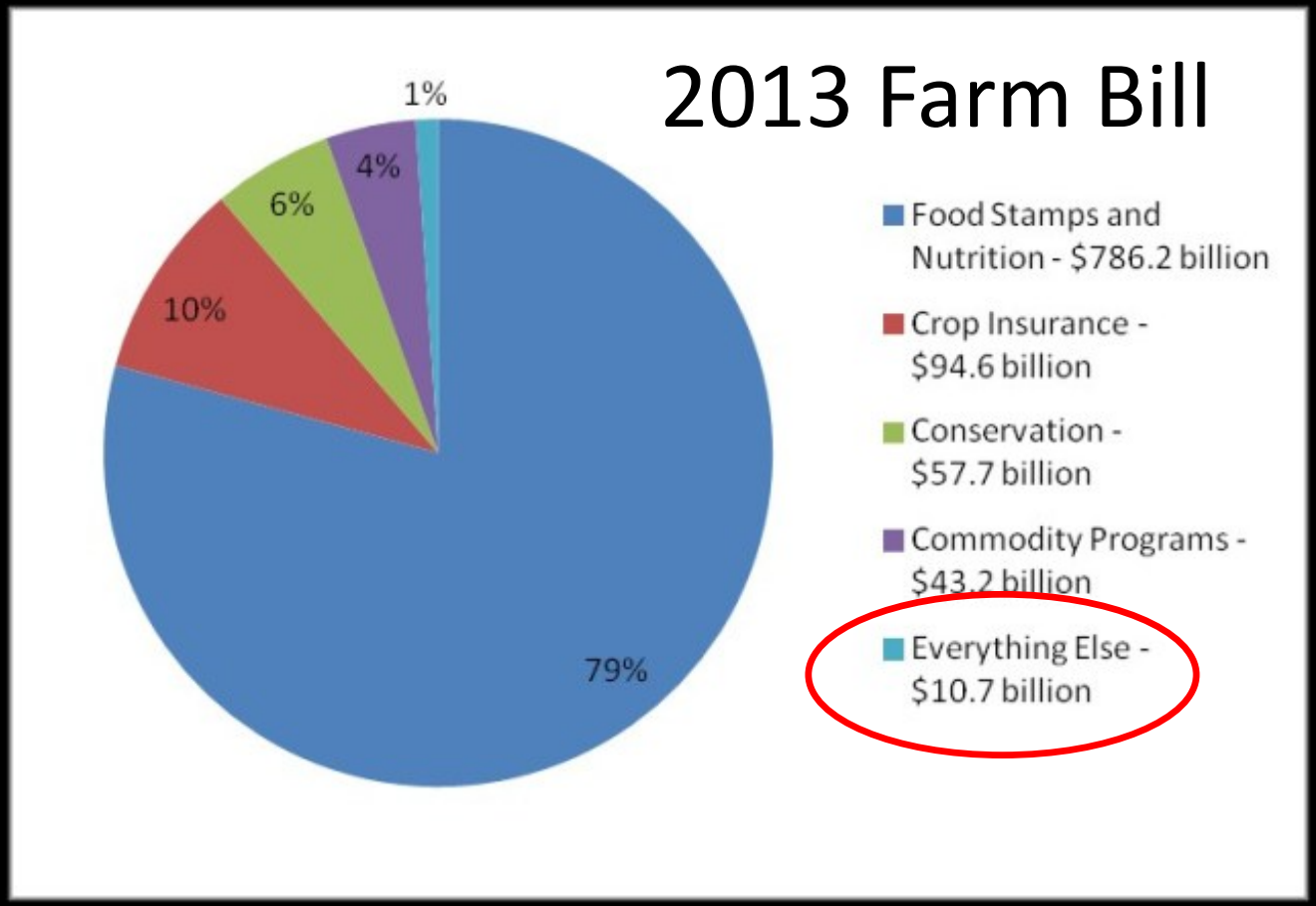


$1.8 Billion

- 10201 – Pest & Disease Management
- NCPN – National Clean Plant Network
- SCRI – Specialty Crop Research Initiative
- SCBG – Specialty Crop Block Grants

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- **Legislative advocacy**
- **Regulatory representation**
- **Research into tools and solutions**

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# Boxwood Blight

The following slides were compiled from presentations and information provided by Dr. Sharon Douglas, Dr. Jim LaMondia, Dr. Bob Marra, Dr. JoAnne Crouch, Dr. Nina Shishkoff, Dr. Kelly Ivors, Dr. Mike Benson, and Ms. Margery Daughtrey.

**Photo by Cristi Palmer**
Location: Williamsburg, VA
Date: 9/5/2014

# Boxwood Blight Disease in the U.S.

- Caused by the fungus *Calonectria pseudonaviculata*
  - also referred to as *Cylindrocladium pseudonaviculata* or *Cylindrocladium buxicola*
- First identified in October 2011
- Current known range in North America
  - NC, CT, MD, VA, RI, MA, OR, NY, PA, DE, and NJ, USA
  - Canada

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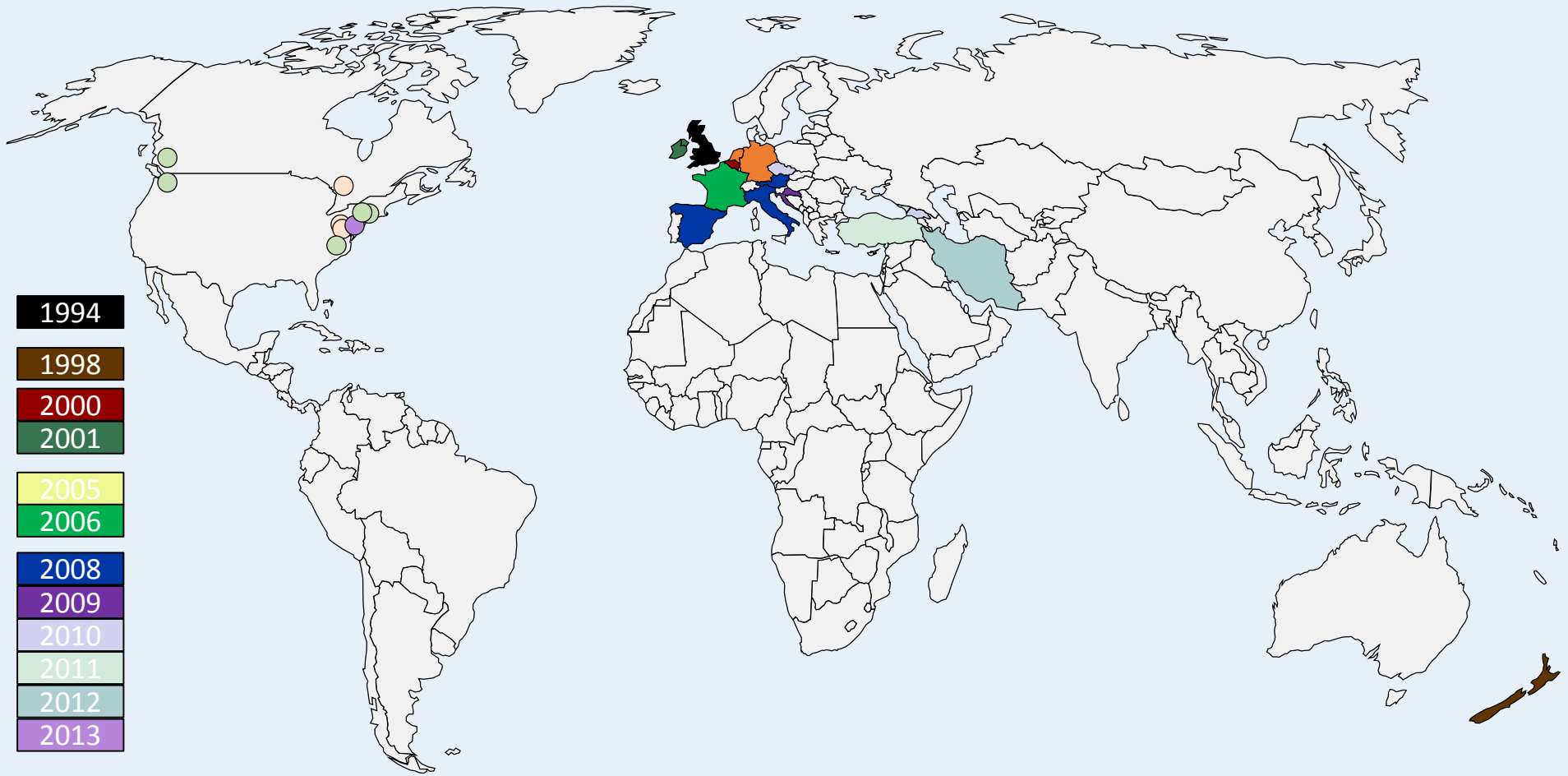
# Temporal Geographic Distribution




World map by www.freeworldmaps.net

# Boxwood Blight-Pathogen Biology

- Disease cycle completed in one week
- Temperature range: 41-86°F (optimum 77°F)
- Moisture necessary for infection
- Wound not necessary for infection

Photo by Greg Parra

# Boxwood Blight-Pathogen Biology (cont'd)

- How the pathogen spreads:
  - Infected plant material
  - Wind, wind-driven rain, and splashing irrigation water
  - Contaminated equipment, tools, vehicles, and shipping containers
  - Contaminated shoes and clothing
  - Potentially via animals

# Boxwood Blight-Pathogen Biology (cont'd)

- Isolated from symptomless plants
- Abundant spores (**conidia**) in a slimy matrix
- Survives in leaves and cankers of infected plants and in leaf debris (fallen, infected leaves)

Photos by Cristi Palmer

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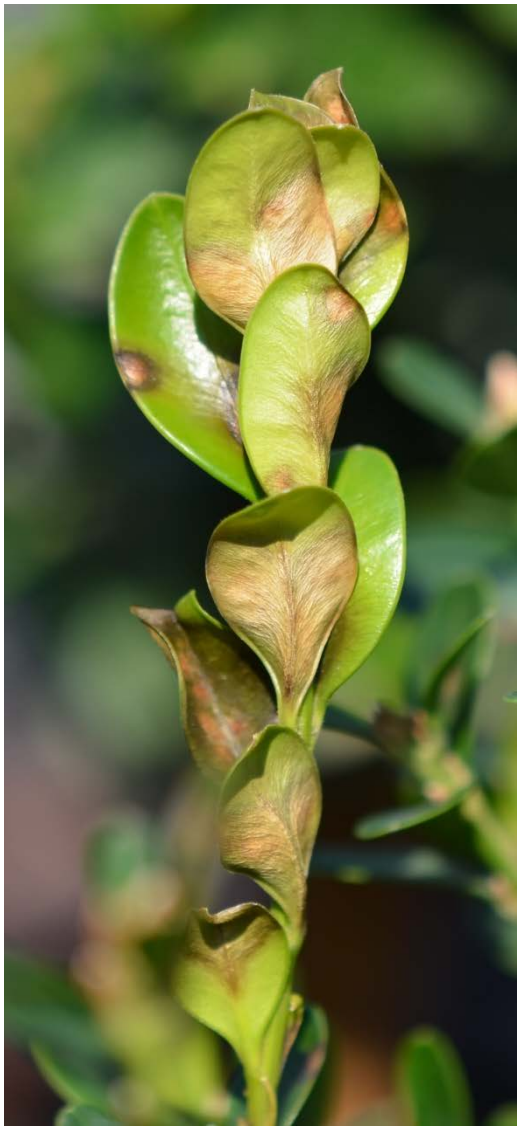
# Symptoms



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# Sporulation on undersurfaces of leaves

Photo by Sharon Douglas

# Spore-producing bodies on stem lesion

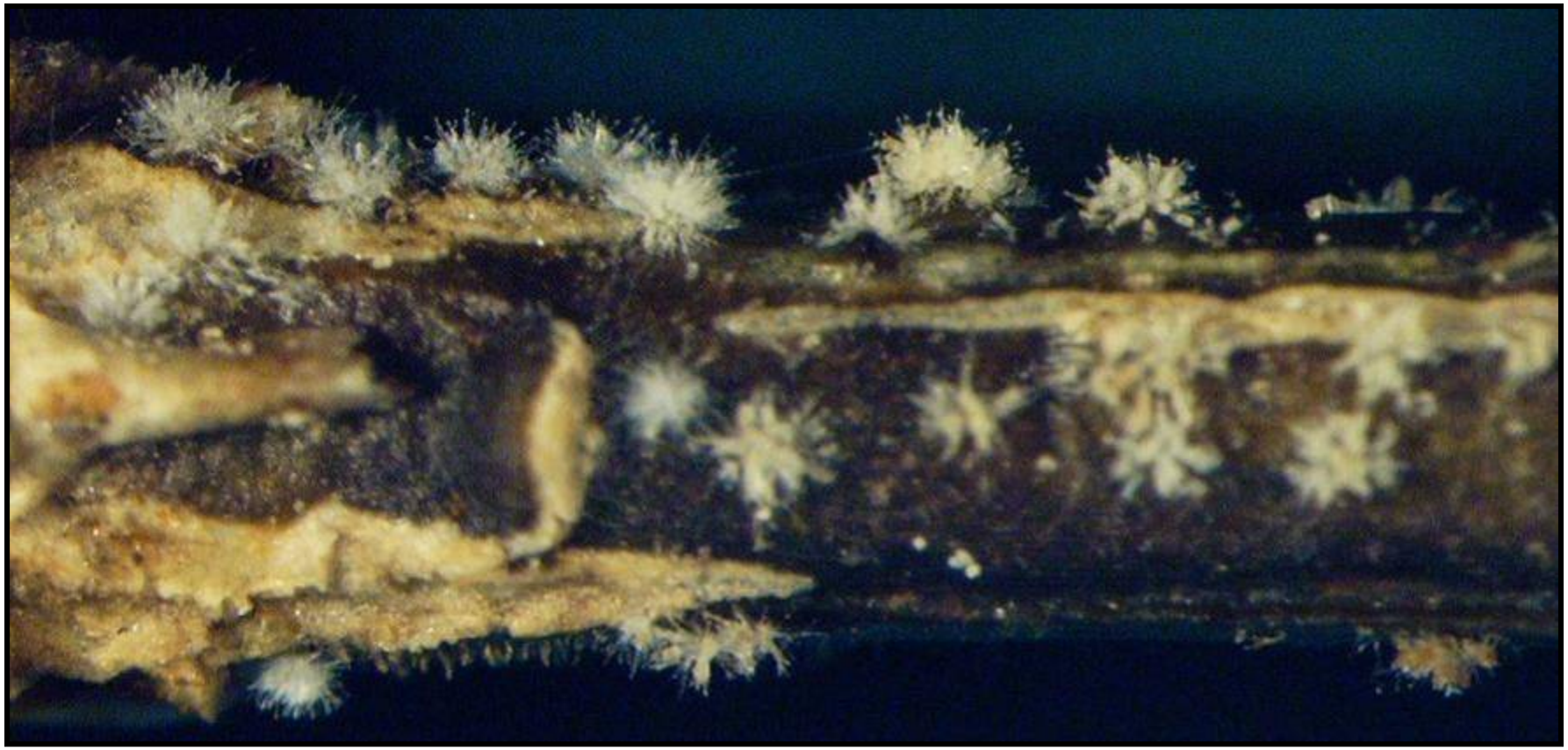
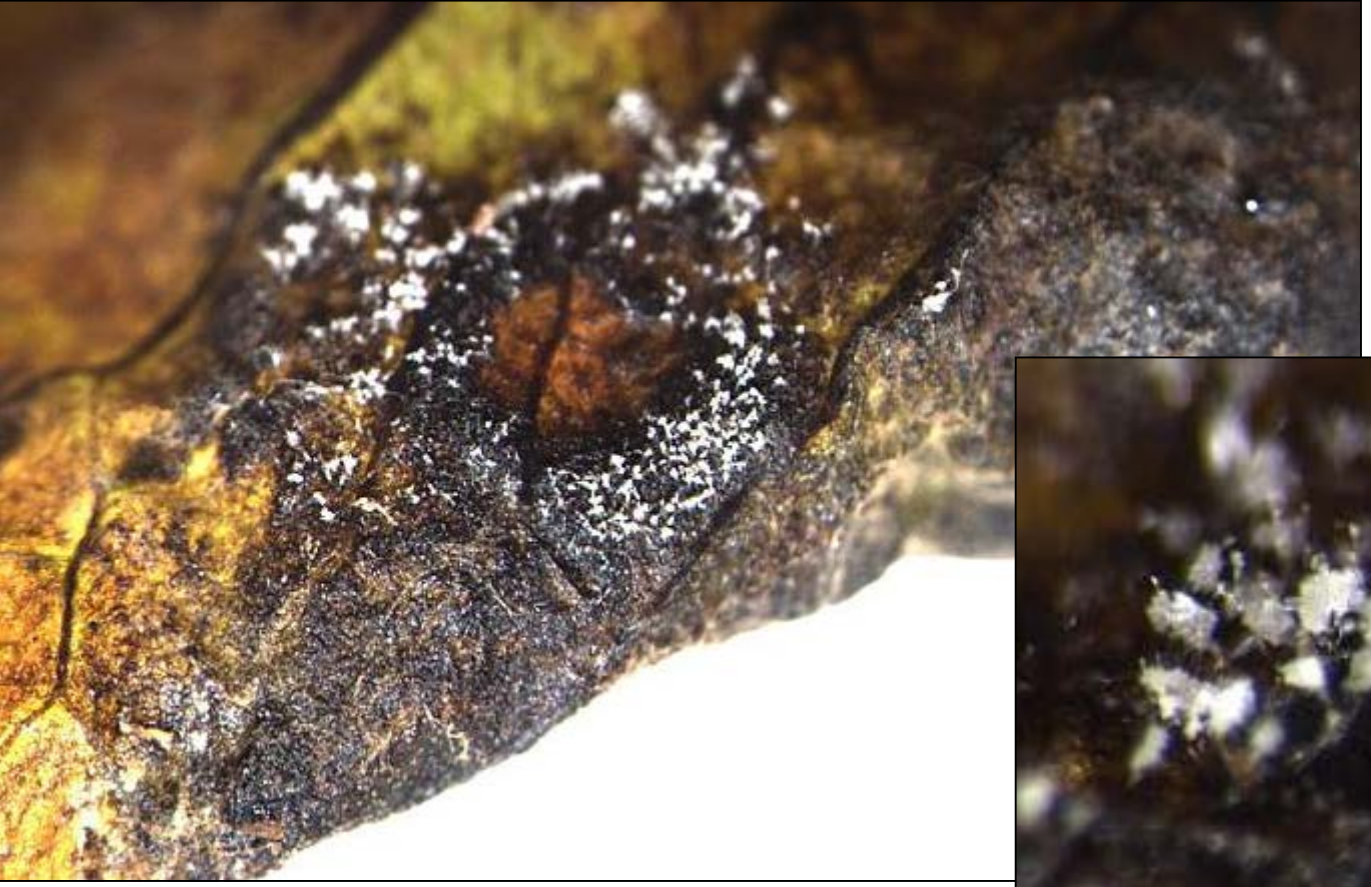
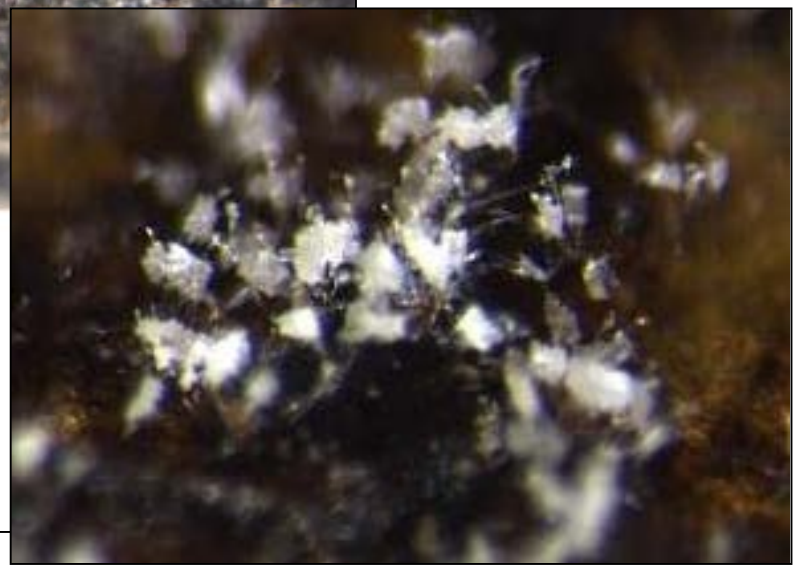


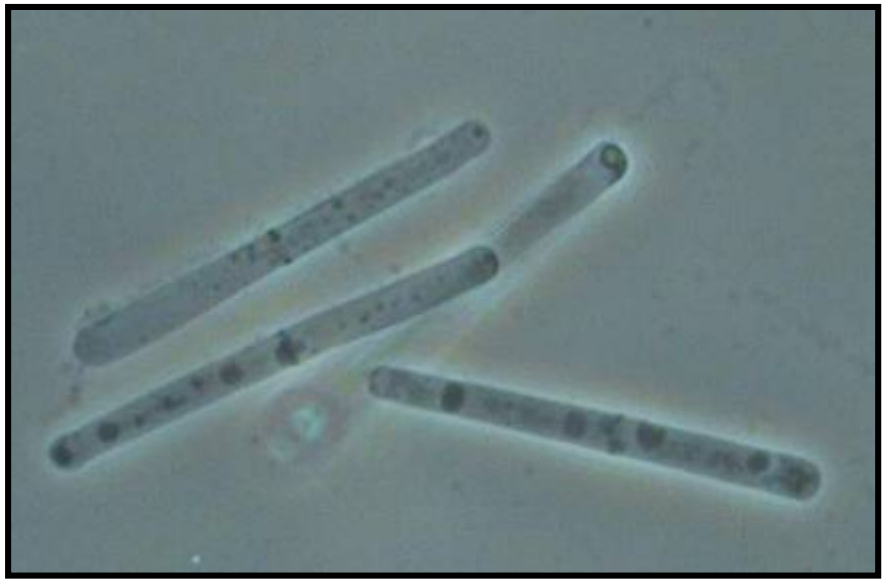
Photo by Sharon Douglas

# Sporulation on leaves





# Boxwood Blight Fungus



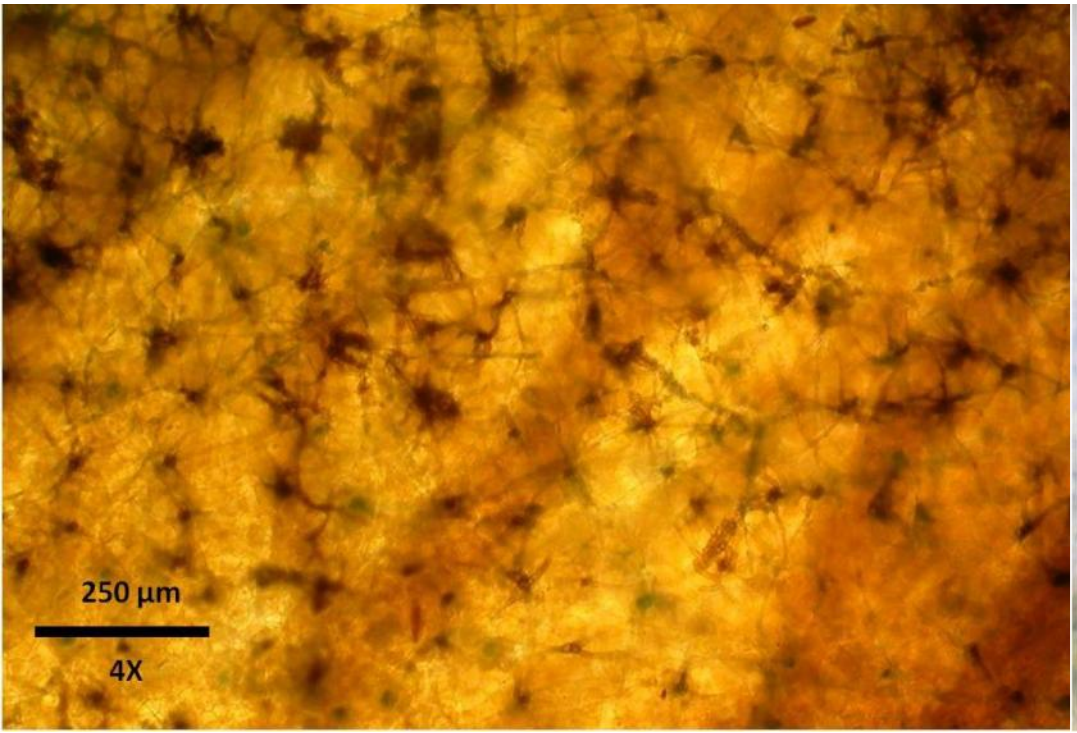
Individual spores

Photos by Sharon Douglas

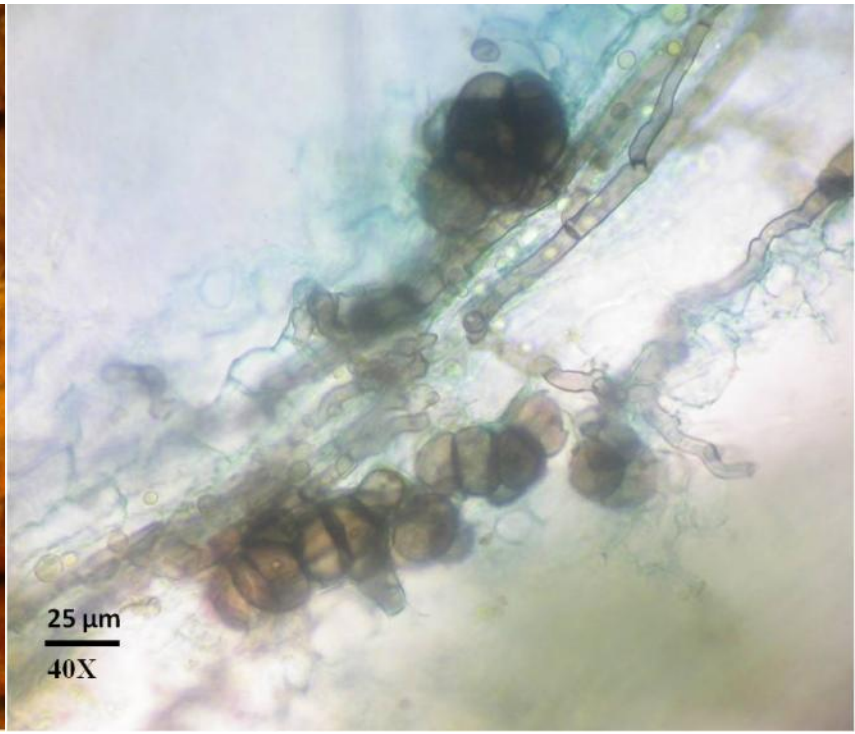
Cluster of spores in a slimy matrix

# Microsclerotia:  An adaptation for surviving and dispersing in soil

*Cylindrocladium* microsclerotia in stained and cleared leaf




Closer view of *Cylindrocladium* microsclerotia



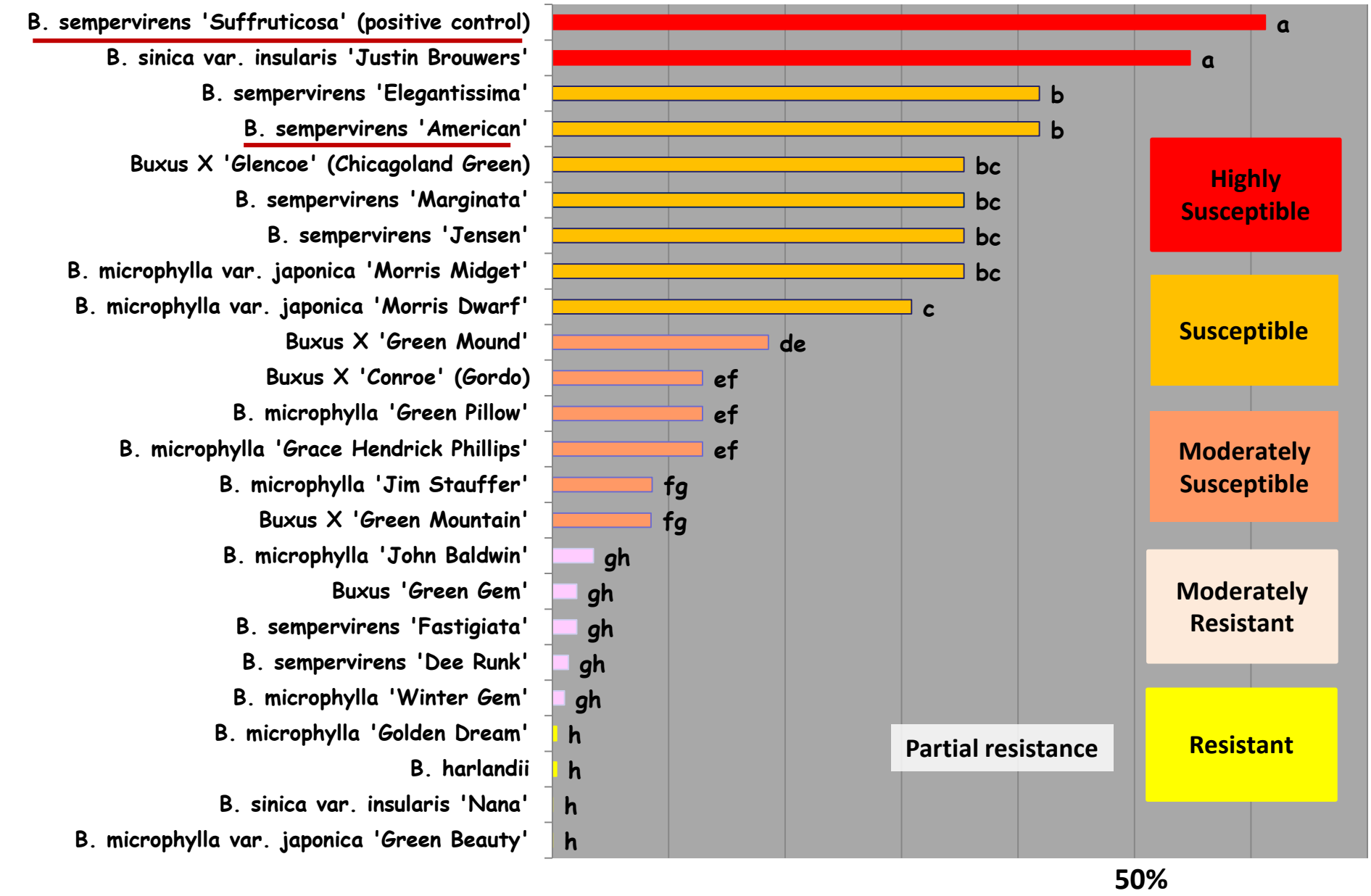
# Host Range of *C. ps.*

- Boxwood (*Buxus*)
- Japanese Spurge (*Pachysandra*)
- Sweet Box (*Sarcoccoca*)

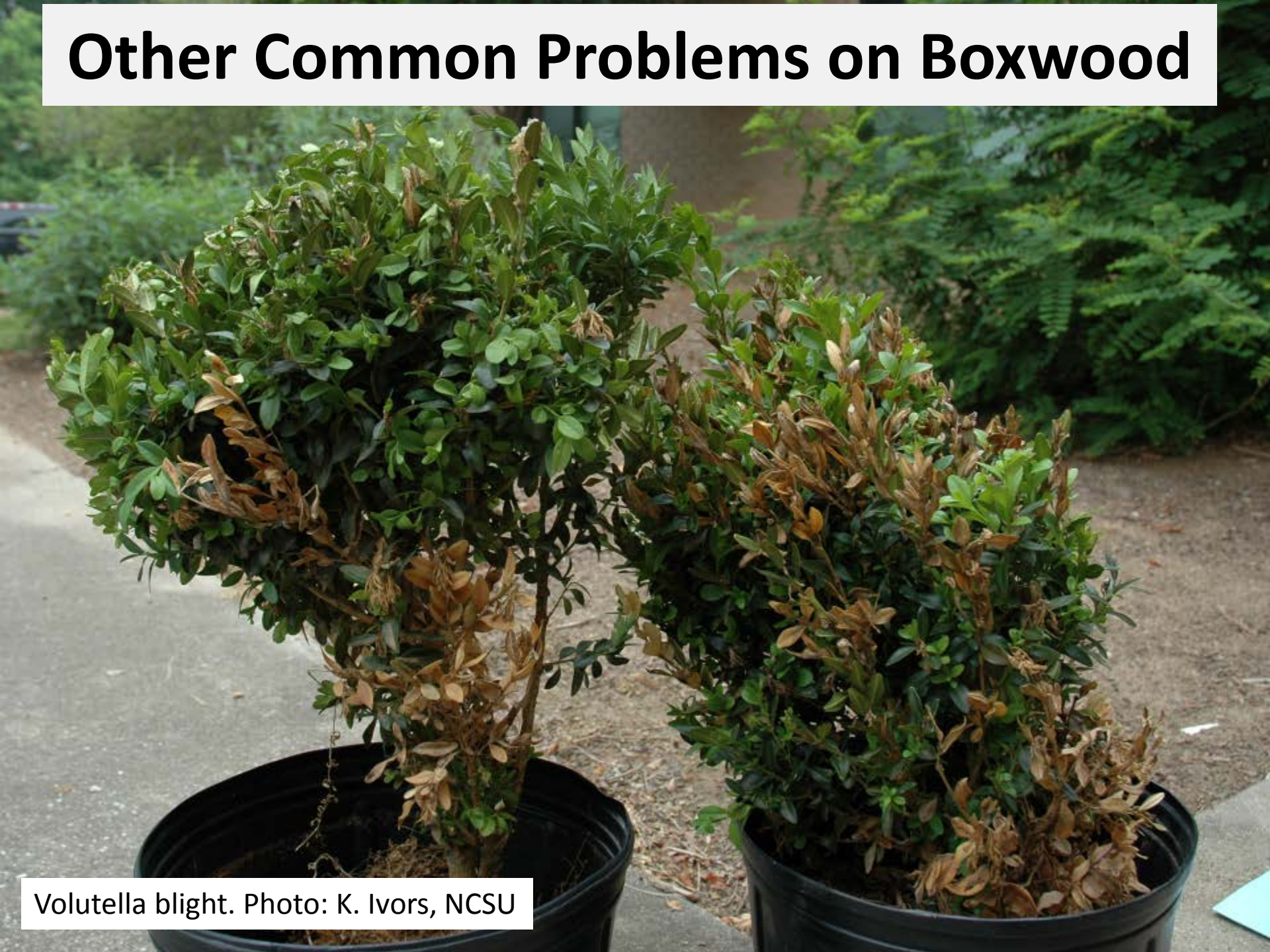

Photo by Jim LaMondia

Photos by Cristi Palmer

# Buxus cultivar susceptibility to box blight

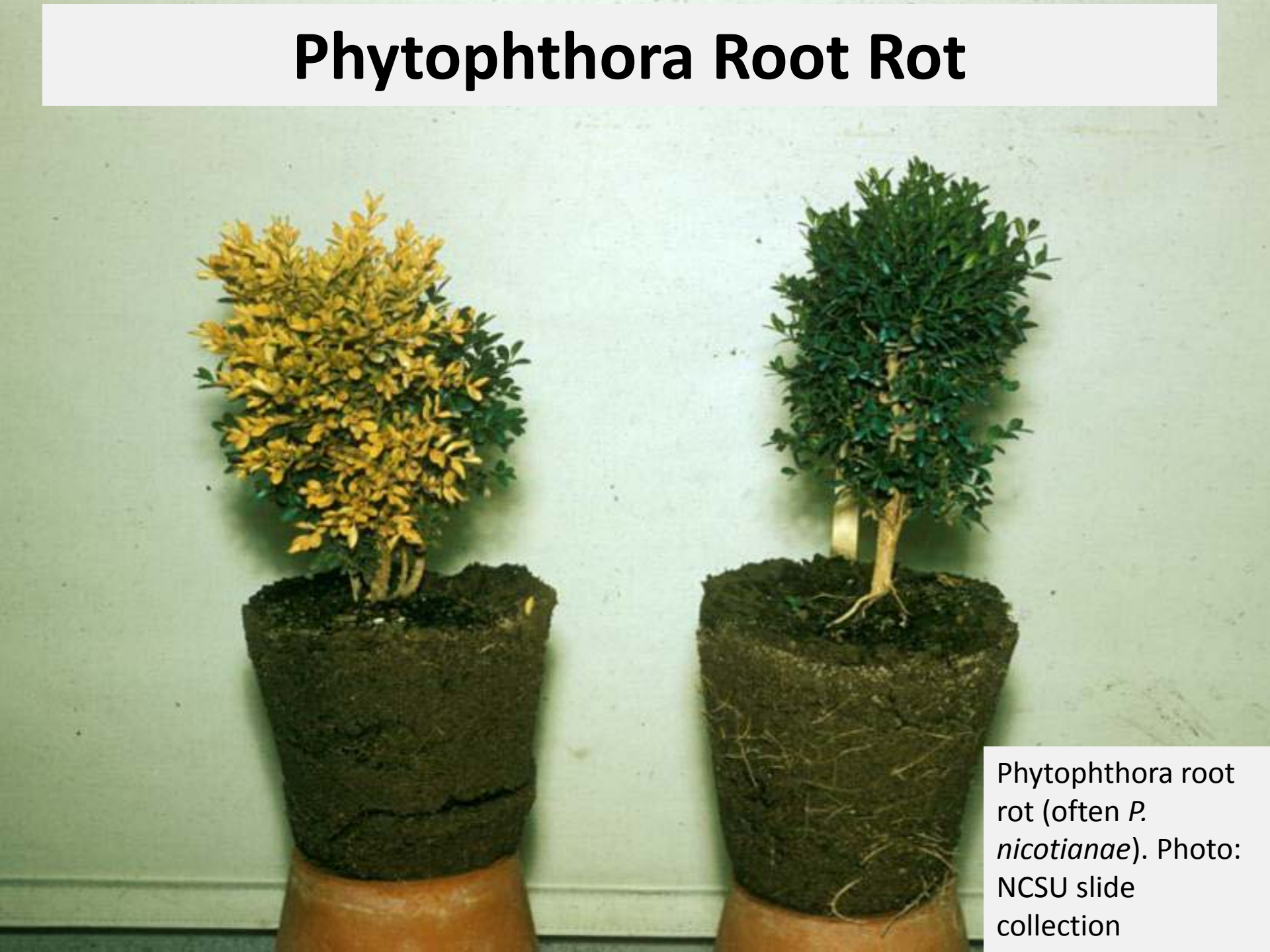


# Other Common Problems on Boxwood



Volutella blight. Photo: K. Ivors, NCSU

# Phytophthora Root Rot



Phytophthora root rot (often *P. nicotianae*). Photo: NCSU slide collection

# Phytophthora Root Rot

Phytophthora root rot (often *P. nicotianae*).
Photos: PDIC at NCSU

# Root Lesion Nematodes

Root lesion nematodes- *Pratylenchus* spp. Photo: NCSU slide collection

# Root Lesion Nematodes

Root lesion nematodes- *Pratylenchus* spp.
Photos: PDIC at NCSU

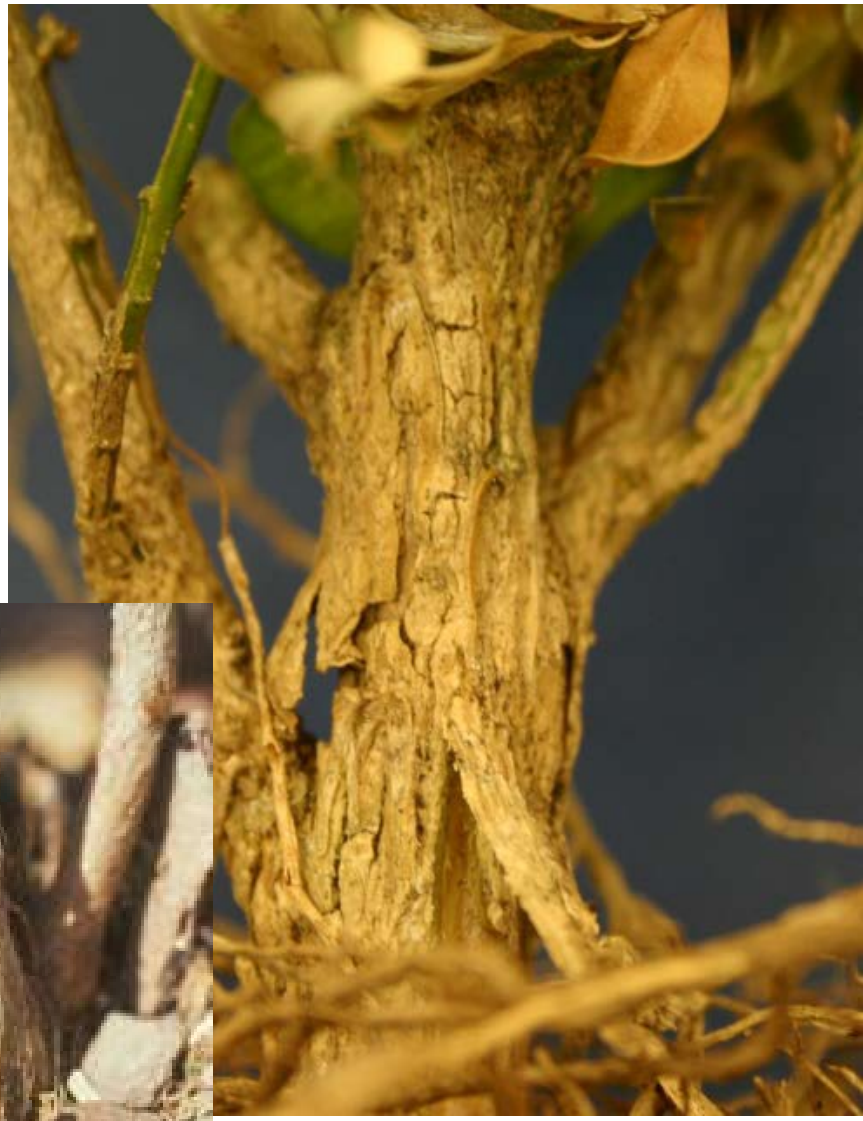
# Boxwood Leaf Miner

Photo: Dave Stephan, PDIC at NCSU

# Undetermined root rot and stress from low pH (3.4)

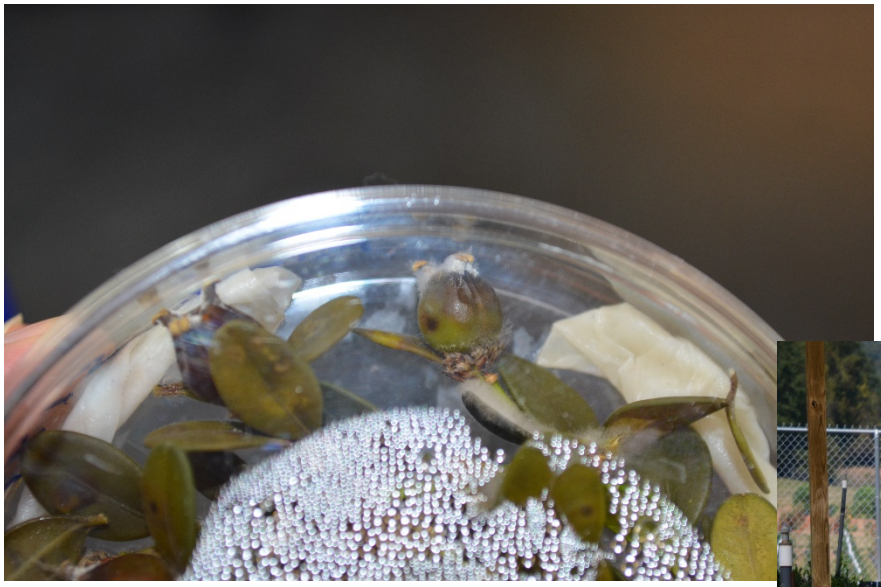
Photo: PDIC at NCSU

# Cold Injury



Photos: PDIC at NCSU

# Boxwood Blight Efficacy Research



Photos by Cristi Palmer

# Fungicides tested for efficacy against *C. ps.*

| Active Ingredient | Product Trade Name | FRAC Code |
|---|---|---|
| **Azoxystrobin** | Heritage 50WG, Ortiva 250SC, Amistar | 11 |
| **Boscalid *** | Edura 70WG | 7 |
| **Boscalid + pyraclostrobin** | Pageant 38WG, Signum | 7 + 11 |
| **Carbendazim *** | Delsene 50 Flo | 1 |
| **Carbendazim + flusilazole *** | Harvesan | 1 + 3 |
| **Chlorothalonil** | Daconil WeatherStik, Daconil 54F, Bravo 500 | M5 |
| **Cyprodinil + fludioxanil** | Palladium WG, Switch | 9 + 12 |
| **Difenconazole + azoxystrobin** | Alibi Flora SC | 3 + 11 |
| **Epoxiconazole + kresoxim-methyl + pyraclostrobin *** | Opponent | 3 + 11 + 11 |
| **Epoxiconazole + pyraclostrobin** | Opera | 3 + 11 |
| **Etridiazole **** | Truban 25EC | 14 |
| **Famoxadone + cymoxanil *** | Tanos DF | 11 + 27 |
| **Fenhexamid *** | Elevate 50WG | 17 |
| **Fludioxonil** | Medallion 50WDG | 12 |

* Not available in the U.S.

** Not expected to be efficacious based on MOA & activity on similar fungi

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# Fungicides tested for efficacy against *C. ps.*

| Active Ingredient | Product Trade Name | FRAC Code |
|---|---|---|
| **Fluoxastrobin + chlorothalonil** | Disarm C | 11 + M5 |
| **Hydrogen peroxide** | ZeroTol 2.0 | -- |
| **Hymexazole **** | Technical | 32 |
| **Iprodione** | OHP 26019 | 2 |
| **Kresoxim-methyl *** | Cygnus 50WG, Stroby WG | 11 |
| **Mancozeb** | Dithane 75DF, Protect DF, Dithane NeoTec | M3 |
| **Mandestrobin *** | S2200 | 11 |
| **Mandestrobin + metconazole *** | S2200 + Tourney 50WDG | 11 + 3 |
| **Metconazole** | Tourney 50WDG | 3 |
| **Myclobutanil** | Rally 40WP | 3 |
| **Penconazole *** | Fungus Clear | 3 |
| **Polyoxin D zinc salt** | Affirm WDG | 19 |
| **Potassium phosphite** | ProPhyt, Vital | -- |
| **Prochloraz *** | Mirage 45EC, Scotts Octave | 3 |
| **Propiconazole** | Banner MAXX, Procon-Z 14.3L, Tilt 250EC | 3 |

* Not available in the U.S.

** Not expected to be efficacious based on MOA & activity on similar fungi

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# Fungicides tested for efficacy against *C. ps.*

| Active Ingredient | Product Trade Name | FRAC Code |
|---|---|---|
| **Propiconazole + chlorothalonil** | Concert II | 3 + M5 |
| **Pyraclostrobin** | Insignia SC, Insignia 20WG | 11 |
| **Quinoxyfen **** | Quintec 22.58EC | 13 |
| **Tebuconazole** | Torque 3.6SC Torque 38.7SC | 3 |
| **Thiophanate-methyl** | 3336 F, 3336 50WP. Cercobin FL | 1 |
| **Thiophanate-methyl + chlorothalonil** | Spectro 90WDG | 1 + M5 |
| **Tolylfluanid *** | Euparen M WG | M6 |
| **Triadimefon + trifloxystrobin** | Strike Plus 50WDG, Armada 50WDG | 3 + 11 |
| **Trifloxystrobin** | Compass O 50WDG, Flint 50WG | 11 |
| **Triflumizole** | Terraguard, Procure 480SC | 3 |
| **Triticonazole** | Trinity 2SC | 3 |

* Not available in the U.S.

** Not expected to be efficacious based on MOA & activity on similar fungi

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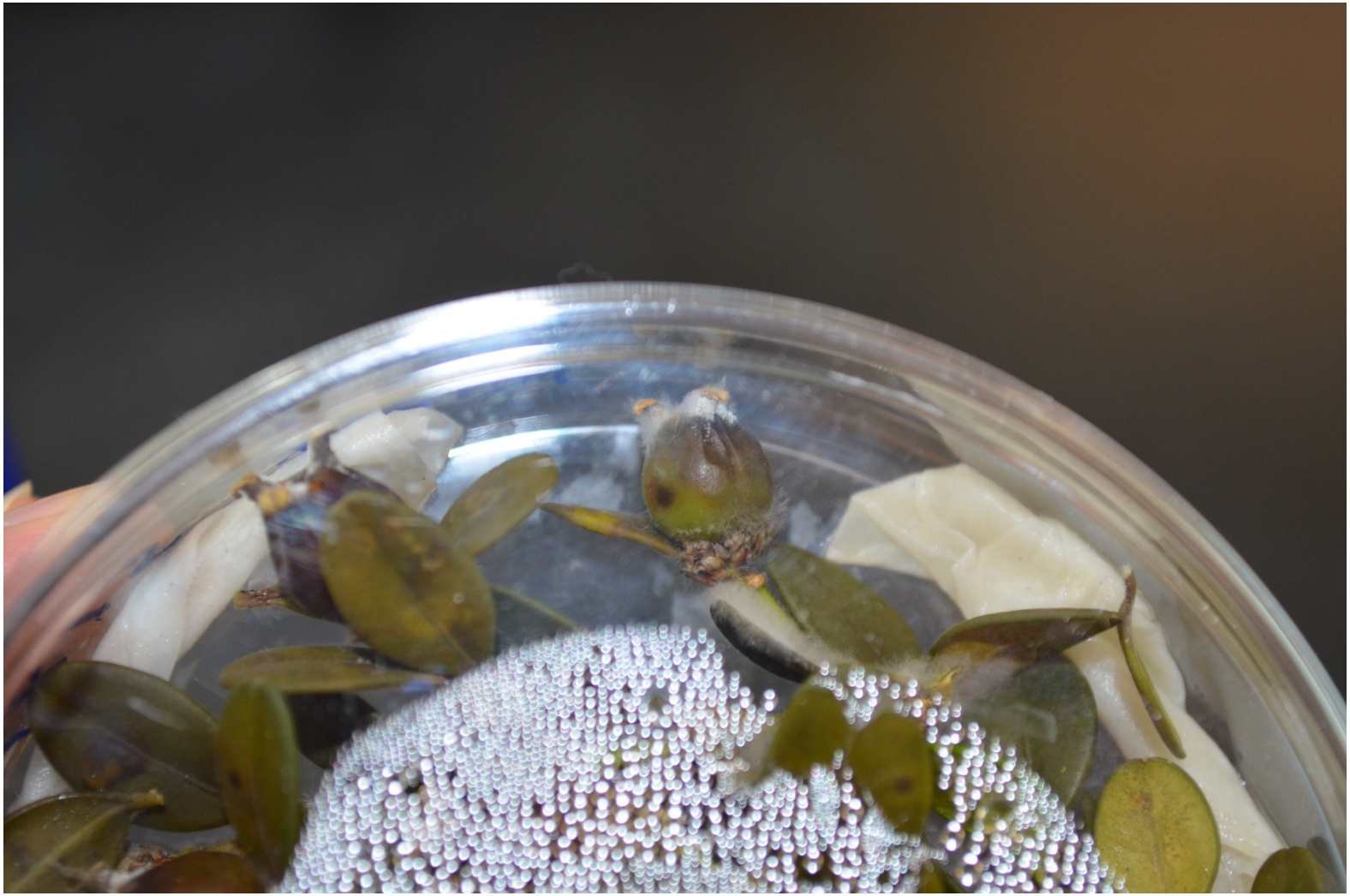
# Laboratory Efficacy:
# Conidial Germination & Mycelial Growth



# *C. ps*. Laboratory Efficacy - Conidia

| FRAC Mode of Action Group | Active Ingredient | Conidial Germination $EC_{50}$ ug/ml Isolate RHS PT25, genotype G1 Henricot, 2008 | $EC_{85}$ ug/ml Isolate CT-L1, genotype G1 LaMondia, 2014 | $EC_{100}$ ug/ml Brand, 2006 |
|---|---|---|---|---|
| **1** | Thiophanate-methyl | -- | > 50 | 500 |
| **3** | Myclobutanil | > 50 | > 50 | -- |
| **3** | Propiconazole | -- | > 50 | >30 |
| **3** | Tebuconazole | -- | > 50 | -- |
| **3** | Triflumizole | -- | > 50 | -- |
| **7 + 11** | Boscalid + pyraclostrobin | 0.23 | 0.18 | -- |
| **9 + 12** | Cyprodinil + fludioxanil | -- [z] | 0.19 | 37.5 + 25 |
| **11** | Azoxystrobin | 2.39 | 4.60 | 25 |
| **11** | Kresoxym-methyl | 0.07 | 0.07 | -- |
| **11** | Pyraclostrobin | -- | 0.11 | -- |
| **11** | Trifloxystrobin | -- | 0.12 | -- |
| **12** | Fludioxonil | -- | 0.20 | -- |
| **14** | Etridiazole | -- | > 50 | -- |
| **M3** | Mancozeb | 0.70 | 1.26 | 15 (1.5 was greater than 90% reduction) |
| **M5** | Chlorothalonil | 0.44 | 0.33 | 1 (0.1 was greater than 90% reduction) |
| **M6** | Tolylfluanid | -- | -- | 0.1616 |

# *C. ps*. Laboratory Efficacy - Mycelia

| FRAC Mode of Action Group | Active Ingredient | Mycelial Growth $EC_{50}$ ug/ml Isolate RHS PT25, genotype G1 Henricot, 2008 | Mycelial Growth $EC_{85}$ ug/ml Isolate CT-S1, genotype G1 LaMondia, 2014 | Mycelial Growth $EC_{100}$ ug/ml Brand, 2006 |
|---|---|---|---|---|
| **1** | Thiophanate-methyl | -- | 3.18 | 5 |
| **3** | Myclobutanil | 0.50 | 1.21 | -- |
| **3** | Propiconazole | -- | 0.43 | 3 |
| **3** | Tebuconazole | -- | 0.87 | -- |
| **3** | Triflumizole | -- | 0.58 | -- |
| **7 + 11** | Boscalid + pyraclostrobin | 0.33 | 6.07 | -- |
| **9 + 12** | Cyprodinil + fludioxanil | -- | 0.70 | > 375 + 250 (37.5 + 25 was greater than 90% reduction) |
| **11** | Azoxystrobin | 1.65 | > 50 | > 250 |
| **11** | Kresoxym-methyl | 0.09 | 1.77 | -- |
| **11** | Pyraclostrobin | -- | 5.28 | -- |
| **11** | Trifloxystrobin | -- | 22.7 | -- |
| **12** | Fludioxonil | -- | 5.88 | -- |
| **14** | Etridiazole | -- | > 50 | -- |
| **M3** | Mancozeb | 2.70 | 4.91 | 1,500 |
| **M5** | Chlorothalonil | 2.48 | 3.31 | > 1,000 |
| **M6** | Tolylfluanid | | | > 1,616 |

# *C. ps.* Field Efficacy Studies

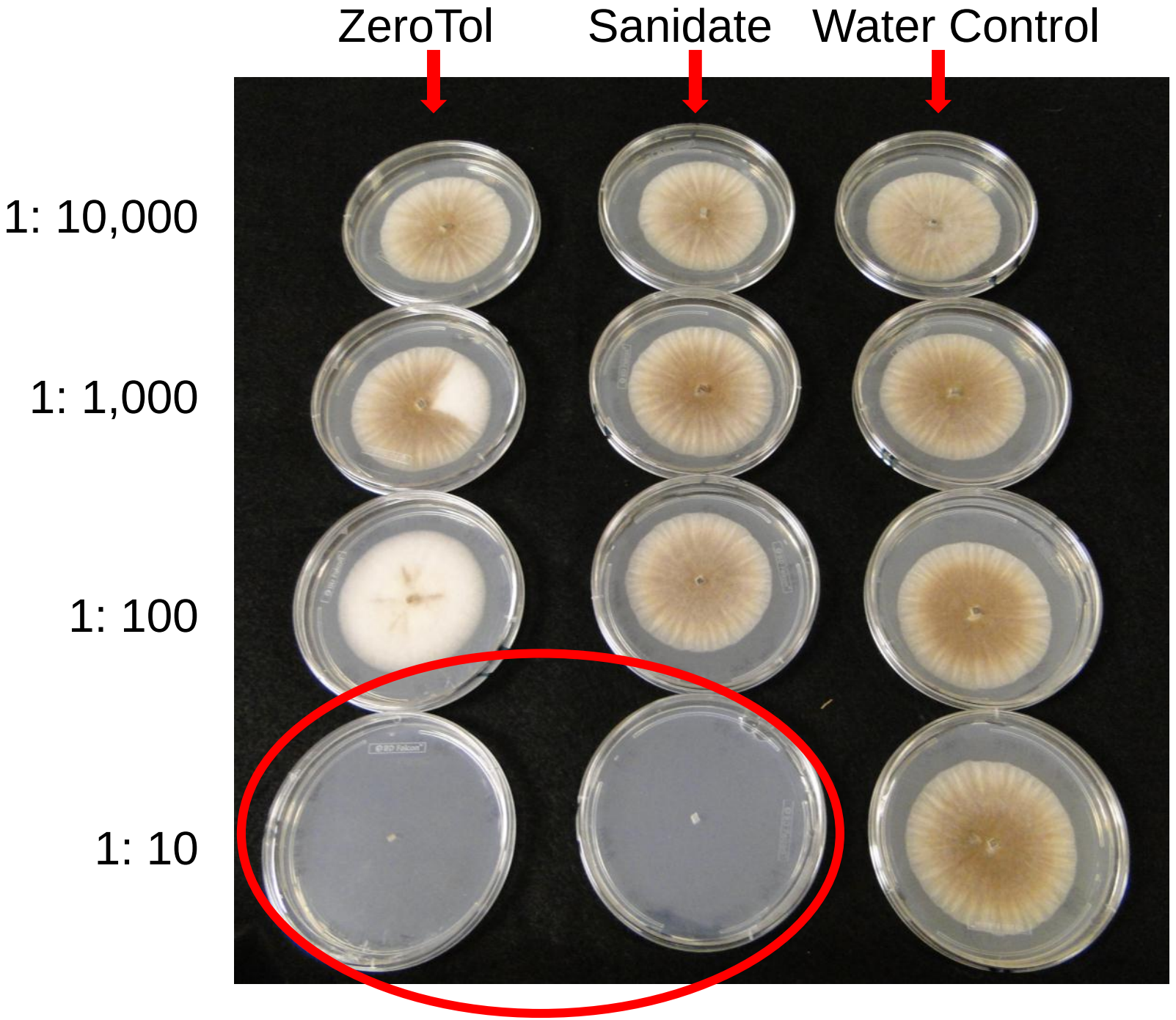
# Boxwood Blight Preventative Efficacy

| FRAC MOA Group | Active Ingredient | Rate (ug ai per ml) | AUDPC (Percent Control) Ivors et al 2012 Preventive | Ivors et al 2013a Preventive |
|---|---|---|---|---|
| -- | Hydrogen peroxide | 2,939 | -- [z] | 2,922.8 (0%) a |
| -- | Potassium phosphite | 2,513 | -- | 1,302.9 (54%) c |
| 1 | Thiophanate-methyl | 598 | 0.5 (97%) d | 254.1 (91%) fghi |
| 1 + M5 | Thiophanate-methyl + chlorothalonil | 324 + 1,294 | 0.0 (100%) d | 0.2 (99%) i |
| 2 | Iprodione | 1,197 | 6.4 (74%) cd | -- |
| 3 | Metconazole | 150 | 0.9 (96%) d | 39.1 (98%) hi |
| 3 | Propiconazole | 159 | 12.7 (48%) bc | -- |
| 3 | Tebuconazole | 366 | 0.5 (97%) d | 1.0 (99%) i |
| 3 | Triflumizole | 651 | 14.4 (41%) ab | -- |
| 3 | Triticonazole | 206 | 14.4 (41%) ab | -- |
| 3 + 11 | Triadimefon + trifloxystrobin | 292 + 58 | -- | 47.7 (98%) ghi |
| 3 + M5 | Propiconazole + chlorothalonil | 1,316 + 99 | 0.0 (99%) d | 15.5 (99%) i |
| 7 + 11 | Boscalid + pyraclostrobin | 264 + 134 | 0.7 (97%) d | 156.1 (94%) fghi |
| 9 + 12 | Cyprodinil + fludioxanil | 169 + 113 | 0.0 (100%) d | 209.5 (92%) fghi |
| 11 | Azoxystrobin | 300 | 0.4 (98%) d | 664.0 (76%) de |
| 11 | Pyraclostrobin | 150 | 0.6 (97%) d | 322.6 (88%) efghi |
| 11 | Trifloxystrobin | 75 | 0.5 (98%) d | 116.0 (95%) fghi |
| 11 + M5 | Fluoxistrobin + chlorothalonil | 25 + 407 | 0.0 (100%) d | 15.6 (99%) i |
| 12 | Fludioxonil | 150 | 0.0 (99%) d | 32.7 (98%) ghi |
| 19 | Polyoxin D zinc salt | 68 | 0.6 (97%) d | 1,648.7 (42%) b |
| M3 | Mancozeb | 1,920 | -- | 404.8 (85%) efg |
| M5 | Chlorothalonil | 1,256 | 0.0 (100%) d | 6.8 (99%) i |
| | Non-inoculated negative control | | -- | 744.7 (--) d |
| | Non-treated inoculated control | | 24.6 (0%) a** | 2,876.7 (0%) a |

# Boxwood Blight Curative & Preventative Efficacy

**K. Ivors, NCSU, 2013**
**Inoculation 1 DAT Preventive/6 DAT Curative,**
**Treatments applied on 14 d schedule except Zerotol**

| FRAC MOA Group | Active Ingredient | Rate (ug ai per ml) | AUDPC (Percent Control) Ivors et al 2013b Preventive | Curative |
|---|---|---|---|---|
| **1 + M5** | Thiophanate-methyl + chlorothalonil | 324 + 1,294 | 18.3 (99%) e | 1,198.0 (37%) c |
| **3** | Metconazole | 150 | 502.8 (73%) b | 1,239.3 (35%) c |
| **3** | Tebuconazole | 366 | 341.8 (82%) bc | 1,216.7 (36%) c |
| **3 + 11** | Triadimefon + trifloxystrobin | 292 + 58 | 5.4 (99%) e | 1,175.5 (38%) c |
| **3 + M5** | Propiconazole + chlorothalonil | 1,316 + 99 | 12.8 (99%) e | 1,196.3 (37%) c |
| **11 + M5** | Fluoxistrobin + chlorothalonil | 25 + 407 | 26.5 (98%) de | 1,526.0 (20%) ab |
| **12** | Fludioxonil | 150 | 230.4 (87%) cd | 1,459.0 (23%) b |
| **M5** | Chlorothalonil | 1,256 | 5.4 (99%) e | 1,198.0 (37%) c |
| | Non-inoculated negative control | | 21.6 (--) de | 21.6 (--) de |
| | Non-treated inoculated control | | 1,916.8 (0%) a | 1,916.8 (0%) a |

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# Recommendations for Growers:

- Be very careful sourcing new boxwood or pachysandra plants; sequester new plants in one part of the nursery away from existing stock
- Sanitize all trimming tools frequently, especially if you see disease symptoms
  - Quaternary ammonia, chlorox
- Scout both boxwood and pachysandra for symptoms
- If you do find symptoms of boxwood blight:
  - Send samples to Rutgers Diagnostic Clinic for confirmation
  - Do not visit another property with boxwoods until clothes, shoes, etc are cleaned/sanitized
  - Sanitize truck beds and any equipment used to move infected plants
  - Carefully dispose of plants in waste stream, burning, or burying several feet under soil (do not compost)
  - Make sure all litter is removed
  - Treat any remaining plants with preventative fungicides

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# Recommendations for Landscape:

- Be very careful sourcing and installing new boxwood or pachysandra plants next to existing landscape plantings
- Visit properties with boxwoods later in the day
- Sanitize all trimming tools frequently, especially if you see disease symptoms
  - At the very least, sanitize between properties
  - Quaternary ammonia, chlorox
- Scout both boxwood and pachysandra for symptoms
- If you do find symptoms of boxwood blight:
  - Send samples to Rutgers Diagnostic Clinic for confirmation
  - Do not visit another property with boxwoods until clothes, shoes, etc are cleaned/sanitized
  - Carefully dispose of plants in waste stream, burning, or burying several feet under soil (do not compost)
  - Make sure all litter is removed
  - Replace with other plants with similar characteristics
  - Treat any remaining plants with preventative fungicides

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# Current and Future Research

- Developing genetic diagnostic tools using loop-mediated isothermic amplification
- Assessing *C. ps.* genetic variability and mating types
- Examining putative biocontrol organisms for impact on *C. ps* infections
- Determining whether fungicides can prevent or delay microsclerotium formation
- Correlating real time rainfall and temperatures with disease incidence and severity to develop a disease forecasting model
- Identifying boxwood species and cultivars at the U.S. National Arboretum with reduced susceptibilities

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# Resources

- AmericanHorts's website www.**boxwoodblight**.org
- Connecticut Ag Experiment Station
- North Carolina State University

# Thank you !

















***Funding for IR-4 Research:***
USDA-NIFA
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USDA-APHIS
Land Grant Institutions

***Researchers:***
All the fine researchers throughout the US and in cooperating countries

***Growers:***
Who donate time to complete the biennial survey and all those plant materials!

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Diane Infante
Edith Lurvey
Satoru Miyazaki
Mika Pringle-Tolson
Becky Sisco
Ely Vea


Thank you