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Impact of Fungicide Inputs on the Severity of Entomosporium Leaf Spot on Selections of Dwarf Indian Hawthorn[1]

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Abstract

In a simulated landscape planting in Brewton, AL, the impact of fungicide treatments on severity of Entomosporium leaf spot was assessed on 13 selections of Indian hawthorn, which range from highly susceptible to resistant to this disease. Chlorothalonil [Daconil 2787 4.17F] at 1.25 g ai/liter was applied at 2- and 4-week intervals to a randomly selected plant in each plot. The remaining plant in each plot was not sprayed and was the untreated control. From mid-winter to mid-spring in 1997, 1998, and 1999, fungicide applications were made over a 13- to 15-week period. When compared to unsprayed controls, reductions in the severity of Entomosporium leaf spot were noted on the fungicide-treated plants of nearly all selections, regardless of their susceptibility to Entomosporium leaf spot. As expected, disease severity was usually lower on those plants sprayed at 2-week rather than 4-week intervals. While chlorothalonil significantly reduced disease severity on the Entomosporium leaf spot resistant selections 'Indian Princess'®, 'Clara', 'Snow White', 'Olivia'™, and 'Eleanor Tabor'™, only a limited reduction in the number of infected leaves in the canopy and perhaps a minor reduction in premature leaf loss were seen. In contrast, substantially less leaf spotting and defoliation on the selections such as 'Spring Rapture'®, 'White Enchantress'®, 'Enchantress'®, 'Heather', 'Harbinger of Spring'®, 'Pinkie', and 'Bay Breeze'® were obtained with chlorothalonil, particularly when this fungicide was applied at 2-week intervals. When treated with chlorothalonil at 2-week intervals, disease severity on susceptible selections was, however, comparable to the damage levels observed on the unsprayed leaf spot resistant selections. When compared with costly and labor-intensive fungicide inputs, production and establishment of disease resistant selections is the preferred strategy for preventing destructive outbreaks of Entomosporium leaf spot on Indian hawthorn in the nursery and landscape.

Index words: *Rhaphiolepis umbellata*, *R. indica*, *Rhaphiolepis* sp. disease resistance.

Species used in this study: Indian hawthorn (*R.* sp. (Thunb.) Mak.).

Significance to the Nursery Industry

From the coastal South into California, Indian hawthorns are widely used as foundation and accent plants in commercial and residential landscape plantings. For years, Entomosporium leaf spot has been responsible for considerable damage to Indian hawthorn in the nursery and landscape, particularly in the wet and humid Coastal South. An intensive fungicide program, production and establishment of resistant selections, or combination of the two are the options available for controlling Entomosporium leaf spot in the nursery and landscape. Overall, choosing a resistant selection proved as effective against this disease as was a program of twice monthly applications of the fungicide chlorothalonil applied over a 3- to 4-month period to Entomosporium leaf spot-susceptible Indian hawthorn. On resistant selections such as 'Indian Princess'®, 'Clara', 'Snow White', 'Olivia'™, and 'Eleanor Tabor'™, significant reductions in disease severity were obtained with chlorothalonil, particularly on the plants treated at 2-week intervals. When compared with disease levels on the untreated controls of the above selections, however, the lower level of leaf spotting did not justify the additional cost of an intensive fungicide treatment program.

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Introduction

Indian hawthorn (*Rhapiolepis* sp. (Thunb.) Mak.), an evergreen shrub with lustrous dark-green foliage, mounded canopy, and typically a compact growth habit, is well adapted for use in mass, hedge, and foundation plantings in commercial and residential landscapes from the Birmingham area to the Gulf Coast of Alabama (2). While the majority of Indian hawthorn selections are dwarf-type plants, a few such as 'Majestic Beauty'® (*R.* sp. 'Montic') and 'Rosalinda'® (*R.* sp. 'Conda') are large shrubs with an open canopy and an upright growth habit.

Entomosporium leaf spot, which is caused by the fungus *Entomosporium mespili*, is the most widespread and damaging disease on Indian hawthorn found in the nursery and landscape (4). Indian hawthorn damaged by leaf spot are often unsalable and must be discarded. Unlike photinia, loquat, and other hosts of *E. mespili*, disease development on Indian hawthorn typically begins in late fall and continues through late spring until all but the youngest leaves at the shoot tips are shed. Disease spread is particularly rapid during extended periods of wet, overcast weather (Hagan, personal observation). Little if any spread of Entomosporium leaf spot occurs during the summer and early fall.

In a production nursery, blocks of container-grown Indian hawthorn are highly vulnerable to Entomosporium leaf spot. Two major components of an Entomosporium leaf spot control program are the production of resistant selections and/or use of protective fungicides. In Georgia, Corley (1) noted that several selections had high levels of resistance to this disease, while several others suffered from heavy Entomosporium leaf spot-related leaf spotting and prema-

ture defoliation. Recent field studies in Alabama (4), Louisiana (5), and Georgia (6) have shown that 'Olivia'™ (*R.* sp. 'Conia') has a high level of resistance to this disease. 'Indian Princess'® (*R.* sp. 'Monto') and 'Eleanor Tabor'™ (*R.* sp. 'Conor') are also resistant to Entomosporium leaf spot. As a result, production has begun to shift, particularly in the Southeast, from Entomosporium leaf spot-susceptible selections to those with a high level of resistance to this disease.

While fungicides have been recommended for the control of Entomosporium leaf spot, little specific information is available concerning their value in a disease control program on Indian hawthorn. When applied at 2-week intervals, chlorothalonil [Daconil Ultrex] completely protected the susceptible Indian hawthorn selection 'Becky Lynn'® from Entomosporium leaf spot (3). However, the response of other leaf spot-resistant and susceptible selections of Indian hawthorn to fungicide inputs in a nursery or landscape setting is unknown.

The objective of this multi-year field study was to assess the impact of fungicide inputs on the severity of Entomosporium leaf spot on 13 selections of dwarf Indian hawthorn (*Rhaphiolepis* sp.).

Materials and Methods

Prior to planting, soil fertility and pH of a Benndale (A) fine sandy loam soil were adjusted to recommended levels according to results of a soil fertility assay conducted at the Auburn Soil Testing Laboratory. In March 1994, selections of dwarf Indian hawthorn (*Rhaphiolepis* sp.) were established on 1.6 m (5 ft) centers spaced in rows 2 m (6 ft) apart on the Brewton Experiment Field in Brewton, AL (USDA Plant Hardiness Zone 8a). In March 1995 and March 1996, 'Snow White' and 'Bay Breeze'® (*R.* sp. 'Hines Darkleaf'), respectively, were planted. A drip irrigation system was installed immediately after planting, and the plants were watered as needed. Beds were mulched periodically with 2.5 to 5.0 cm (1 to 2 in) of aged pine bark. Twice each spring, approximately 85 g (3 oz) of 16N–4P_2O_5–8K_2O fertilizer was uniformly distributed around each plant. Directed applications of 0.68 kg ai/ha (1 lb/A) of Gallery™ DF and 2.2 kg ai/ha (2 qt/A) of Surflan T/O™ were made early each spring to control annual weeds. Hand weeding and spot applications of recommended rates of the herbicides Roundup™ or 912 Herbicide 6S™ (monosodium acid methanearsonate [MSMA]) were used to control escaped weeds and encroaching centipedegrass. The centipedegrass alleys between the rows were periodically mowed.

This study consisted of a split plot consisting of 6 replications with dwarf Indian hawthorn selections as the main plot and fungicide treatment as the split-plot. The contact fungicide chlorothalonil [Daconil 2787™ 4F] was applied at 2- or 4-week intervals at 1.25 g ai/liter (2 pt/100 gal) of spray volume to randomly selected plants in each plot. One plant in each plot was not treated with chlorothalonil. Fungicide applications were made to run-off with a CO_2-pressurized backpack sprayer from February 21 to June 4, 1997; January 21 until May 5, 1998; and from January 6 until May 17, 1999.

Before fungicide applications began in 1997, Entomosporium leaf spot was well established in this planting of Indian hawthorn. Visual ratings of Entomosporium leaf spot were made for 13 cultivars of Indian hawthorn on a scale of 1 to 5 where 1 = no disease, 2 = 1 to 25%, 3 = 26 to 50%, 4 = 51 to 75%, and 5 = 76 to 100% of leaves diseased or prematurely shed. In 1997, disease ratings were logged on March 6, April 20, May 19, June 29, and September 8. The following year, severity ratings for Entomosporium leaf spot were recorded on January 16, February 27, April 8, June 13, August 5, October 16, and December 3, 1998. For the 1999 growing season, disease ratings were taken on March 10, April 16, May 27, July 12, September 10, and November 17. Average disease rating for each year was calculated by totaling the Entomosporium leaf spot ratings recorded for each sub-plot treatment and then dividing by the total number of disease observations made in that year. Significance of Indian hawthorn selection and fungicide treatment interval effects in each year were tested by analysis of variance. Means for each fungicide treatment on selections of Indian hawthorn were compared with Fisher's protected least significance difference (LSD) test with a level of significance at $P \leq 0.05$. Due to significant differences ($P \leq 0.05$) in severity of Entomosporium leaf spot between years, disease rating data for each selection of Indian hawthorn was not pooled across years.

Results and Discussion

In 1997, the least leaf spot damage on the unsprayed controls was noted on 'Olivia'™ and 'Eleanor Tabor'™ (*R.* sp. 'Conor') (Table 1). On both of these cultivars, damage was restricted to light spotting of the leaves in the lower canopy. Other dwarf Indian hawthorn cultivars that also showed relatively light leaf spotting and defoliation included 'Indian Princess'®, 'Snow White', and 'Clara'. In contrast, considerable defoliation and heavy spotting of the remaining leaves was observed on 'Heather', 'Springtime'® (*R.* sp. 'Monme'), 'Enchantress'® sp. 'Moness'), 'Harbinger of Spring', 'Pinkie', 'Spring Rapture'® (*R.* sp. 'Monrey'), 'Bay Breeze'®, and 'White Enchantress'® sp. 'Monat').

As indicated by a significant selection × treatment interval interaction ($P \leq 0.001$), response to fungicide inputs differed significantly among the selections of Indian hawthorn (Table 2). For 10 of 13 dwarf Indian hawthorn selections, severity of Entomosporium leaf spot was lower on plants treated with chlorothalonil at 2- and 4-week intervals than on the unsprayed plants (Table 1). In contrast, disease severity on unsprayed 'Olivia'™ and 'Eleanor Tabor'™ was similar to the ratings recorded for plants treated with chlorothalonil at 2- and 4-week intervals. Chlorothalonil gave better protection from Entomosporium leaf spot when applied at 2-week rather than at 4-week intervals on 'Spring Rapture'®, 'Springtime'®, 'Pinkie', 'Bay Breeze'®, 'Heather', 'Harbinger of Spring' and 'Indian Princess'® . In contrast, 'White Enchantress'®, 'Enchantress'®, 'Snow White', and 'Clara' suffered similar damage levels at both treatment intervals. As indicated by disease ratings of 2.9 or above, the above selections treated at 2-week intervals still suffered from moderate leaf spotting and some defoliation. Leaf spotting and defoliation levels observed on 'Spring Rapture'®, 'Enchantress'®, 'Bay Breeze'®, and 'Heather' treated monthly with chlorothalonil were similar to those recorded for the unsprayed plants of the same selection.

As was observed in 1997, light leaf spotting and minimal leaf shed were seen on 'Olivia'™, 'Eleanor Tabor'™, 'Indian Princess'®, 'Snow White', and 'Clara' (Table 1). In contrast, moderate to heavy spotting of the leaves, as well as noticeable defoliation was noted on the remaining 8 selections of Indian hawthorn in 1998.

Table 1. Impact of fungicide inputs on the severity of Entomosporium leaf spot on selections of Indian hawthorn, 1997 to 1999.

Cultivar	1997 Treatment interval[z]			1998 Treatment interval[z]			1999 Treatment interval[z]		
	2 week	4 week	UTC[y]	2 week	4 week	UTC[y]	2 week	4 week	UTC[y]
'Spring Rapture'®	3.1	3.8	4.0	2.2	2.9	3.3	2.2	3.1	3.6
'Springtime'®	3.3	4.0	4.4	2.3	3.0	3.7	2.0	2.7	3.8
'White Enchantress'®	3.2	3.5	3.9	2.2	2.9	3.4	2.2	2.9	3.9
'Enchantress'®	3.5	3.9	4.2	2.4	3.1	3.6	2.0	3.0	3.8
'Snow White'	2.0	2.1	2.9	1.4	1.7	2.6	1.1	1.3	2.0
'Clara'	2.1	2.4	2.9	1.7	2.0	2.8	1.1	1.4	2.1
'Pinkie'	3.1	3.7	4.1	2.7	3.2	3.5	2.1	2.8	3.7
'Bay Breeze'®	2.5	3.2	3.4	2.0	2.3	3.2	1.7	2.2	3.4
'Harbinger of Spring'	2.9	3.4	4.2	2.3	2.4	3.5	2.1	2.5	3.6
'Heather'	2.9	3.4	3.5	2.4	2.8	3.6	2.5	3.2	3.5
'Olivia'®	1.8	1.8	1.9	1.6	1.8	2.0	1.4	1.8	1.9
'Eleanor Tabor'®	2.0	1.9	2.2	1.4	1.7	2.4	1.3	1.5	2.1
'Indian Princess'®	2.0	2.4	2.4	1.8	2.1	2.2	1.9	2.5	2.6
LSD for each year ($P \leq 0.05$)[x]			0.4			0.3			0.6

[z]Chlorothalonil at a rate of 1.26 g ai/liter of spray volume was applied at 2- and 4-week intervals from February 21 to June 4, 1997; January 21 to May 5, 1998; and January 6 to May 17, 1999.

[y]UTC = unsprayed control.

[x]Mean separation for disease severity data in each year was according to Fisher's protected least significance test ($P \leq 0.05$).

Disease severity ratings for all Indian hawthorn selections were not pooled at each treatment interval because the selection × treatment interval interaction ($P \leq 0.0001$) was significant (Table 2). When treated with chlorothalonil at 2-week intervals in 1998, severity of Entomosporium leaf spot on all 13 Indian hawthorn selections was significantly lower than levels on the unsprayed controls (Table 1). In addition, disease severity was significantly lower on most of the Indian hawthorn selections when treated with chlorothalonil at 2-week rather than at 4-week intervals. With the exception of 'Olivia'™ and 'Indian Princess'®, Entomosporium leaf spot severity was also significantly lower on selections treated with chlorothalonil at 4-week intervals in comparison to the unsprayed controls.

For the 1999-growing season, light to moderate leaf spotting, as well as some premature leaf loss was noted on unsprayed 'Olivia'™, 'Eleanor Tabor'™, 'Snow White', 'Clara', and 'Indian Princess'® Indian hawthorn (Table 1). Extensive leaf spotting and premature leaf shed were observed on the unsprayed 'Spring Rapture'®, 'Springtime'®, 'White Enchantress'®, 'Enchantress'®, 'Bay Breeze'®, 'Harbinger of Spring', 'Heather', and 'Pinkie'.

As noted in the previous two years, a significant selection x treatment interval interaction ($P \leq 0.0001$) was recorded in 1999 (Table 2). In comparison with the unsprayed controls, chlorothalonil applied at 2-week intervals significantly reduced the severity of Entomosporium leaf spot on all Indian hawthorn selections (Table 1). However, disease severity ratings were observed for 'Spring Rapture'®, 'Heather'®, 'Olivia'™, and 'Indian Princess'® treated with chlorothalonil at 4-week intervals and on the unsprayed controls did not significantly differ. Disease severity ratings for 'Spring Rapture'®, 'White Enchantress'®, 'Enchantress'®, 'Heather', 'Pinkie', 'Springtime'®, and 'Indian Princess'® Indian hawthorn treated with chlorothalonil at 2-week intervals were significantly lower than those recorded on the same selections receiving monthly applications of the same fungicide. Lengthening the treatment interval from 2 to 4 weeks did not

Table 2. Summary of analysis of variance by year for Indian hawthorn selection, fungicide treatment interval, and interaction of Indian hawthorn selection and treatment interval.

Source of variance	df[z]	Mean square	Probability
1997			
Selection	12	9.0	< 0.0001
Treatment interval	2	9.8	< 0.0001
Selection × Treatment interval	24	0.2	0.0001
1998			
Selection	12	4.2	< 0.0001
Treatment interval	2	18.7	< 0.0001
Selection × Treatment interval	24	0.2	< 0.0001
1999			
Selection	12	6.5	< 0.0001
Treatment interval	2	26.4	< 0.0001
Selection × Treatment interval	24	0.4	0.0002

[z]df = degrees of freedom.

result in significantly better disease control on 'Snow White', 'Clara', 'Bay Breeze'®, 'Harbinger of Spring', 'Olivia'®, and 'Eleanor Tabor'®.

Substantial differences in the reaction of selections of Indian hawthorn to Entomosporium leaf spot have previously been reported in field studies conducted in Alabama (4), Georgia (1, 6) and Louisiana (5). In the Alabama (4) and Georgia (1) studies, 'Snow White' suffered less damage than the susceptible selections 'Springtime'® and 'Enchantress'®. Ruter (6) noted that disease severity was higher on 'Snow White' and 'Clara' Indian hawthorn than had been recorded previously (4). The recently released selections 'Olivia'™ and 'Eleanor Tabor'™ have consistently demonstrated a high level of resistance to Entomosporium leaf spot (4, 5, 6).

In all three years, significant reductions in symptom severity were observed on the fungicide-treated 'Indian Princess'®, 'Clara', 'Snow White', 'Olivia'™, and 'Eleanor Tabor'™ compared to the untreated controls. With few exceptions, disease severity was lower on the plants treated with chlorothalonil at 2-week rather than at 4-week intervals. However, a fungicide was not necessarily required to protect the above selections from Entomosporium leaf spot, particularly in landscape plantings. Symptoms on the unsprayed 'Indian Princess'®, 'Clara', 'Snow White', 'Olivia'™, and 'Eleanor Tabor'™ were often limited to light, unobtrusive spotting of the leaves in the lower canopy with little or, in some cases, no defoliation. Reductions in disease severity obtained with the fungicide treatments were largely limited to reducing the number of diseased leaves in the lower canopy and would be insufficient to justify the approximately $25 per acre cost for multiple applications of the protective fungicide chlorothalonil (Daconil Ultrex or Daconil 2787).

Routine bimonthly or monthly applications of chlorothalonil significantly reduced the severity of Entomosporium leaf spot on 'Spring Rapture'®, 'White Enchantress'®, 'Enchantress'®, 'Heather', 'Harbinger of Spring', 'Pinkie', and 'Bay Breeze'® Indian hawthorn. Without fungicide protection, however, the above selections usually suffered from extensive leaf spotting and premature defoliation. For the majority of the above cultivars, bimonthly applications of chlorothalonil gave better control than did the same fungicide applied at monthly intervals. In two of three years, symptoms on the Entomosporium leaf spot-susceptible selections, which were sprayed with chlorothalonil at 2-week intervals, were usually limited to leaf spotting in the lower canopy and light, unobtrusive defoliation. However, disease levels similar to those recorded for the above selections treated with chlorothalonil were seen on the unsprayed Entomosporium leaf spot resistant selections.

In summary, establishment of resistant selections is the key component of a sustainable program for preventing outbreaks of Entomosporium leaf spot in the nursery, as well as in residential and commercial landscape plantings of Indian hawthorn. An attractive landscape planting of leaf spot-resistant cultivars 'Indian Princess'®, 'Olivia'™, 'Snow', 'Clara', and 'Eleanor Tabor'™ Indian hawthorn can be maintained without protective fungicide treatments, and these cultivars would be excellent choices for low-maintenance landscapes. On the other hand, 'Spring Rapture'®, 'White Enchantress'®, 'Enchantress'®, 'Heather', 'Harbinger of Spring', 'Pinkie', and 'Bay Breeze'® are too susceptible to Entomosporium leaf spot for use in landscapes in Alabama and adjacent southern states without fungicide protection. In addition, the fungicide regime needed to produce and maintain attractive and relatively spot-free plants would be too costly in terms of time and money to justify the continued use of Indian hawthorn selections that are susceptible to Entomosporium leaf spot.

Literature Cited

1. Corley, W.L. 1980. Leafspot ratings of ten *Raphiolepis* cultivars. Proc. Southern Nursery Assoc Res. Conf. 25:140–141.

2. Dirr, M.A. 1998. Manual of Woody Landscape Plants, 5th Ed., Stipes Publishing Co. Champaign, IL, 1187 pp.

3. Hagan, A.K., J.W. Olive, L.C. Parrott, Jr., and M. Rivas-Davila. 2000. Compass screened for the control of Entomosporium leaf spot on photinia and Indian hawthorn. Proc. Southern Nursery Assoc Res. Conf. 45:221–224.

4. Hagan, A.K., J.R. Akridge, K.L. Bowen, J.W. Olive, and K.M. Tilt. 2001. Resistance of selected cultivars of Indian hawthorn to Entomosporium leaf spot, fireblight, and anthracnose in Alabama. J. Environ. Hort. 19:43–46.

5. Holcomb, G.E. 1998. Reaction of Indian hawthorn cultivars to Entomosporium leaf spot, 1997. Biol. Cult. Test Cont. Plant Dis. 13:39.

6. Ruter, J.M. 1999. Susceptibility of 13 Indian hawthorn cultivars to Entomosporium leaf spot, 1998. Biol. Cult. Test Cont. Plant Dis. 14:63.