Chlorothalonil, Trifloxystrobin, and Mancozeb Decrease Anthracnose Symptoms on Three Cultivars of Wintercreeper Euonymus

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SUMMARY. The effectiveness of chlorothalonil, mancozeb, and trifloxystrobin applied alone or in rotations of two or three fungicides to control anthracnose symptoms caused by *Colletotrichum gloeosporioides* was evaluated on three cultivars of field- and container-grown wintercreeper euonymus (*Euonymus fortunei*) during the 2001 growing season. Studies were conducted at Stillwater, Okla.; Fayetteville, Ark.; and Park Hill, Okla. Rooted cuttings of wintercreeper euonymus 'Emerald Gaiety', 'Emerald 'n Gold', and 'Emerald Surprise' were transplanted from 1-gal plastic containers into field soil at the Oklahoma State University Nursery Research Station and at the University of Arkansas Horticulture Farm on 10 May 2001. In a parallel study, recently transplanted rooted cuttings of the same cultivars in 1-gal pots containing substrate consisting of pine bark and sand were placed in a shadehouse under 30% shade at Stillwater and Fayetteville and 73% shade at Park Hill on 11 May 2001. 'Emerald Gaiety' had fewer disease symptoms than 'Emerald 'n Gold' or 'Emerald Surprise' in the field and in containers at Stillwater and Fayetteville. At Fayetteville, mancozeb applied alone or in rotation with chlorothalonil or trifloxystrobin provided better anthracnose control than treatments without mancozeb, but no fungicide eliminated anthracnose symptoms. Application of fungicides in rotations that include mancozeb and use of resistant cultivars can help decrease anthracnose symptoms.

Colletotrichum gloeosporioides has been identified as the causal organism for anthracnose on wintercreeper euonymus (Mahoney and Tattar, 1980a, 1980b). Typical symptoms include leaf lesions, leaf abscission, stem lesions, and stem dieback. During the growing season, *C. gloeosporioides* consists of a mass of

hyphae within lesions on the stem and leaf tissue, which produces conidia on the host surface that cause secondary infection (Agrios, 1997; Alexopoulos et al., 1996). *Colletotrichum gloeosporioides* reinfects its host throughout the growing season by producing conidia in acervuli below the cuticle surface. The cuticle eventually ruptures and releases more conidia, allowing the disease to spread to other plants (Agrios, 1997; Alexopoulos et al., 1996). Conidia can spread by wind, insects, or in splashing water from rain or overhead irrigation. *Colletotrichum gloeosporioides* is capable of overwintering as mycelium in infected host tissue (Agrios, 1997) and can survive in the soil for a few weeks (Ekefan et

al., 2000). Past research has shown that environmental conditions such as high night temperatures and high light intensities favor disease development on wintercreeper euonymus (Ningen et al., 2004, 2005).

Several fungicides have been tested for control of *C. gloeosporioides* on wintercreeper euonymus. Mahoney and Tattar (1980a, 1980b) showed that maneb, mancozeb, and chlorothalonil controlled *C. gloeosporioides* on wintercreeper euonymus 'Emerald 'n Gold'. Benomyl reduced symptoms, but some lesions developed (Mahoney and Tattar, 1980a, 1980b).

Growers have suggested that some chemicals are less effective at controlling *C. gloeosporioides* in routine fungicide spray schedules than they once were, suggesting that *C. gloeosporioides* may have developed some fungicide resistance. In vitro studies using leaf and stem lesions from four Connecticut nurseries showed that *Colletotrichum gloeosporioides* was resistant to iprodione and thiophanate methyl, while varying levels of resistance to chlorothalonil were noted (LaMondia, 2001a, 2001b). LaMondia (2001a) examined fungicidal management of anthracnose on wintercreeper euonymus and concluded that combinations of fungicides were more effective at controlling *C. gloeosporioides* than the same fungicides used alone. Cole et al. (2005) observed that chlorothalonil, trifloxystrobin, and mancozeb were most effective in reducing symptoms of *C. gloeosporioides*, but none of the fungicides completely controlled the fungus at rates and timing used.

The objective of this study was to determine the efficacy of chlorothalonil, mancozeb, and trifloxystrobin applied alone or in rotations for controlling anthracnose in field and container production of wintercreeper euonymus. Three cultivars were tested to determine cultivar tolerance to *C. gloeosporioides*. Typical nursery cultural practices were used whenever possible to generate results applicable to current management programs.

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
3.7854	gal	L	0.2642
25.4000	inch(es)	mm	0.0394
119.8264	lb/gal	g·L ⁻¹	0.0083
(°F - 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

Materials and methods

Uniform rooted cuttings from anthracnose-infected mother plants of wintercreeper euonymus 'Emerald Gaiety', 'Emerald 'n Gold', and 'Emerald Surprise' (Greenleaf Nursery Co., Park Hill, Okla.) were tested in field and container studies. High disease incidence in the field at the time that cuttings were taken eliminated the need to further inoculate.

Symptomatic leaves and stems were collected from plants in field and container studies throughout the growing season and cultured on potato dextrose agar to confirm the causal organism. Plants were hand-sheared on 21 May, 25 June, and 17 July 2001 using the standard nursery practice at Greenleaf Nursery Co. About 25% of the plant was removed using non-sterilized hand shears. Shearing tools are often not sterilized at nurseries, and the disease can be transmitted by shearing.

Field and container plants were sprayed to runoff with water (control, no fungicide), chlorothalonil (Echo 720; Sipcam Agro, Roswell, Ga.) at 211 g·L⁻¹ a.i., mancozeb [Fore (Rohm and Haas, Philadelphia) at Stillwater and Fayetteville and Protect (Cleary Chemical Corp., Dayton, N.J.) at Park Hill] at 1.4 g·L⁻¹ a.i., or trifloxystrobin (Compass; Bayer Corp., Kansas City, Mo.) at 0.3 g·L⁻¹ a.i. Fungicides were applied alone or in rotations of two or three fungicides. Fungicides were applied using the longest labeled spray interval for each product. Chlorothalonil and trifloxystrobin were sprayed at 14-d intervals while mancozeb was sprayed at 7-d intervals. Chlorothalonil and trifloxystrobin were applied in alternate weeks. Control plants were sprayed to runoff with tap water at 7-d intervals. Fungicide and water treatments were applied with a carbon dioxide-pressurized backpack sprayer with an output of 670 mL·min⁻¹. Plants were first sprayed on 15 May 2001 and last sprayed on 10 Sept. 2001.

Plants were visually rated for disease symptoms at 4-week intervals beginning 15 May 2001 using a modification of an assessment key for common leafspot (*Phoma medicaginis*) of alfalfa (*Medicago sativa*) [Key No. 2.2 (James, 1971)] on a scale of 0 to 100 with 0 = a plant with no visual lesions and 100 = defoliation. Plants with disease ratings greater than about

10 (about 10% of the plant having disease symptoms) would be considered nonsalable by many growers. The study was terminated at all sites on 10 Sept. 2001.

Asplit plot design with 10 replications was used for field and container studies. Fungicide was the main plot (eight treatments) while cultivar was the subplot (three cultivars). Data were analyzed using analysis of variance (SAS Institute, Cary, N.C.). Means of significant interactions and main effects were separated using a protected least significant difference (LSD) procedure.

FIELD STUDY. Cuttings were transplanted from 1-gal plastic containers into Norge loam (fine-silty, mixed, thermic, Udic Paleustol) field soil at the Oklahoma State University Nursery Research Station, Stillwater, and into Captina silt loam (fine-silty, siliceous, active, mesic, Typic Fragiudults) field soil at the University of Arkansas Horticulture Farm, Fayetteville, on 10 May 2001. Soil tests at both sites prior to planting showed no mineral deficiencies so no supplemental fertilizer was applied at either site.

Weed control was by cultivating between rows, hand-weeding within rows, and applying glyphosphate (Roundup Pro; Monsanto Co., St. Louis) at 2.7 lb/gal a.i. with a wick applicator. Plants were irrigated with drip irrigation as needed. Daily high and low temperatures and rainfall were documented (Table 1). Photosynthetic photon flux (*PPF*) was determined periodically using an integrating quantum/radiometer/photometer (model No. LI-188B; LI-COR,

Lincoln, Nebr.). Maximum *PPF* was 1503 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at plant height at Stillwater and 1329 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at plant height at Fayetteville.

CONTAINER STUDY. Cuttings were planted into 1-gal containers with substrate consisting of 6 pine bark : 1 sand amended with 5 lb/yard³ dolomitic lime, 10 oz/yard³ 0N-19.8P-0K (triple superphosphate), 5 oz/yard³ 0N-0P-49.8K (potassium chloride), 3 oz/yard³ trace elements [Frit 504 HF; Frit (UK) Ltd., Cambridge, U.K.], 1.5 lb/yard³ ferrous sulfate, 1.2 lb/yard³ 46N-0P-0K (urea), and 2 lb/yard³ iron oxide (GU-49; Master Builders, Cleveland, Ohio) and placed under 30% shade at the Oklahoma State University Nursery Research Station (Stillwater) and at the University of Arkansas Horticulture Farm (Fayetteville) (maximum *PPF* was 1070 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ and 952 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at plant height, respectively) and under 73% shade (maximum *PPF* was 435 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at plant height) at Greenleaf Nursery Co. (Park Hill). Trifluralin plus isoxaben (Snapshot; Dow AgroSciences, Indianapolis) was applied to container media at 4.6 lb/1000 ft² on 21 May 2001 to control weeds. Containers were hand-weeded as needed, and plants were irrigated daily with about 1 inch of water using overhead sprinkler irrigation. Daily high and low temperatures and rainfall were documented (Table 2).

Results

FIELD STUDY, STILLWATER. No significant interaction between fungicide and cultivar occurred for disease ratings in June, July, or August. During

Table 1. Average daily high and low temperatures and total rainfall between rating dates for anthracnose damage on wintercreeper euonymus in field fungicide studies at Stillwater, Okla., and Fayetteville, Ark., in full sun.

Location	Rating period	Avg daily temp (°C ± SE) ^z		Total rainfall (inches) ^y
		High	Low	
Stillwater	15 May–13 June 2001	39.0 ± 0.9	16.2 ± 1.0	5.75
	14 June–10 July 2001	42.6 ± 0.7	19.5 ± 0.5	---
	11 July–14 Aug. 2001	46.9 ± 0.5	22.7 ± 0.3	3.63
	15 Aug.–10 Sept. 2001	41.9 ± 0.5	20.0 ± 0.3	2.32
Fayetteville	15 May–12 June 2001	25.3 ± 1.6	15.2 ± 1.9	4.64
	13 June–10 July 2001	30.1 ± 0.9	19.6 ± 0.9	3.86
	11 July–7 Aug. 2001	33.0 ± 1.0	22.6 ± 1.1	3.83
	8 Aug.–4 Sept. 2001	31.9 ± 0.6	20.6 ± 0.7	2.73

^zPlants were rated on the ending date of each time period. Average daily high and low temperatures were calculated by summing the daily high and low temperatures, respectively, and dividing by the number of days in the time period; (1.8 × °C) + 32 = °F.

^yRainfall data were missing for several dates in late June at Stillwater, so rainfall data were not included for this rating period; 1 inch = 25.4 mm.

these months, disease ratings differed among cultivars but not among fungicides. Disease symptoms were less on ‘Emerald Gaiety’ (2.5, 6.3, 7.7) than ‘Emerald ’n Gold’ (6.7, 10.6, 14.6) or ‘Emerald Surprise’ (6.3, 9.3, 13.3) in June, July, and August, respectively ($LSD_{0.05} = 1.6, 1.6, \text{ and } 1.7$ for June, July, and August, respectively).

A significant interaction existed between fungicide and cultivar in September disease ratings (Table 3). Regardless of fungicide treatment used, ‘Emerald Gaiety’ plants had lower disease ratings than ‘Emerald ’n Gold’ or ‘Emerald Surprise’ plants receiving the same treatments. ‘Emerald ’n Gold’ and ‘Emerald Surprise’ plants receiving chlorothalonil, chlorothalonil and mancozeb, mancozeb and trifloxystrobin, or chlorothalonil, trifloxystrobin, and mancozeb did not differ in disease ratings within fungicide treatment. ‘Emerald Gaiety’ plants receiving chlorothalonil and mancozeb, chlorothalonil and trifloxystrobin, mancozeb and trifloxystrobin, or chlorothalonil, trifloxystrobin, and mancozeb did not differ in disease ratings among fungicide treatments and had lower disease ratings than the same cultivar receiving chlorothalonil, mancozeb, trifloxystrobin, or water. The lowest disease ratings for ‘Emerald ’n Gold’ plants occurred when plants were treated with chlorothalonil and trifloxystrobin or mancozeb and trifloxystrobin. ‘Emerald Surprise’ plants treated with mancozeb, trifloxystrobin, chlorothalonil and trifloxystrobin, or mancozeb and trifloxystrobin had lower disease ratings than ‘Emerald Surprise’ plants receiving any other fungicide treatment.

FIELD STUDY, FAYETTEVILLE. No significant interactions existed between cultivar and fungicide for disease ratings in May, June, or July (data not presented). Disease ratings did not differ among cultivars or among fungicide treatments in May, June, or July (data not presented).

A significant interaction existed between fungicide and cultivar in disease ratings in August (Table 4). Plants receiving any fungicide treatment had lower disease ratings than water control plants. ‘Emerald ’n Gold’ plants treated with chlorothalonil, trifloxystrobin, or chlorothalonil and trifloxystrobin had higher disease ratings than ‘Emerald Gaiety’ or ‘Emerald Surprise’ receiving

Table 2. Average daily high and low temperatures and total rainfall between rating dates for anthracnose damage on wintercreeper euonymus in container fungicide studies at Stillwater, Okla., and Fayetteville, Ark., under 30% shade and under 73% shade at Park Hill, Okla.

Location	Rating period	Avg daily temp (°C ± SE) ^z		Total rainfall (inches) ^y
		High	Low	
Stillwater	15 May–13 June 2001	34.3 ± 0.9	16.2 ± 1.0	5.75
	14 June–10 July 2001	38.4 ± 0.6	19.7 ± 0.5	---
	11 July–14 Aug. 2001	42.0 ± 0.5	22.4 ± 0.2	3.63
	15 Aug.–10 Sept. 2001	38.8 ± 0.6	20.1 ± 0.2	2.32
Fayetteville	15 May–12 June 2001	25.0 ± 1.3	15.0 ± 1.1	4.64
	13 June–10 July 2001	30.0 ± 0.8	19.4 ± 0.8	3.86
	11 July–7 Aug. 2001	33.3 ± 0.9	22.8 ± 0.4	3.83
	8 Aug.–4 Sept. 2001	31.7 ± 0.6	20.6 ± 0.6	2.73
Park Hill	15 May–12 June 2001	28.1 ± 1.1	16.8 ± 1.2	6.57
	13 June–12 July 2001	30.1 ± 0.8	20.4 ± 0.9	4.45
	13 July–7 Aug. 2001	33.9 ± 0.7	22.8 ± 0.6	1.54
	8 Aug.–12 Sept. 2001	29.7 ± 0.9	21.1 ± 0.5	7.15

^zPlants were rated on the ending date of each time period. Average daily high and low temperatures were calculated by summing the daily high and low temperatures, respectively, and dividing by the number of days in the time period; $(1.8 \times ^\circ\text{C}) + 32 = ^\circ\text{F}$.

^yRainfall data were missing for several dates in late June at Stillwater, so rainfall data were not included for this rating period; 1 inch = 25.4 mm.

Table 3. Disease ratings in Sept. 2001 of three cultivars of wintercreeper euonymus grown in the field and treated with various fungicides alone and in rotations at Stillwater, Okla. (n = 10).

Fungicide treatment	Cultivar	Disease rating ^z
Chlorothalonil	Emerald ’n Gold	17.0
	Emerald Gaiety	8.7
	Emerald Surprise	17.0
Mancozeb	Emerald ’n Gold	19.5
	Emerald Gaiety	11.0
	Emerald Surprise	13.0
Trifloxystrobin	Emerald ’n Gold	16.5
	Emerald Gaiety	11.0
	Emerald Surprise	14.5
Chlorothalonil + mancozeb	Emerald ’n Gold	19.0
	Emerald Gaiety	7.0
	Emerald Surprise	19.0
Chlorothalonil + trifloxystrobin	Emerald ’n Gold	11.5
	Emerald Gaiety	6.5
	Emerald Surprise	13.5
Mancozeb + trifloxystrobin	Emerald ’n Gold	12.5
	Emerald Gaiety	6.5
	Emerald Surprise	13.5
Chlorothalonil + trifloxystrobin + mancozeb	Emerald ’n Gold	14.5
	Emerald Gaiety	5.5
	Emerald Surprise	15.5
Water	Emerald ’n Gold	25.5
	Emerald Gaiety	11.5
	Emerald Surprise	17.0
Significance ($LSD_{0.05}$)		
Cultivar for same treatment		1.9
Cultivar for different treatment		2.1

^zAnthracnose damage rating scale ranged from 0 to 100 with 0 = no damage and 100 = a dead plant. Plants with ratings greater than 10 would be considered nonsalable by many nurseries.

the same treatments. ‘Emerald ’n Gold’ and ‘Emerald Gaiety’ plants receiving water, mancozeb, mancozeb and trifloxystrobin, or chlorothalonil, trifloxystrobin, and mancozeb had higher disease ratings than ‘Emerald Surprise’ plants receiving the same fungicide treatment. Cultivars did not differ in disease ratings when the rotation of chlorothalonil and mancozeb was applied. Plants receiving the rotation of chlorothalonil and mancozeb did not differ in disease rating compared to the same cultivar receiving the rotation of mancozeb and trifloxystrobin, and these two fungicide treatments resulted in the lowest disease ratings overall.

No significant interaction occurred between cultivar and fungicide for disease ratings in September. Disease ratings differed among cultivars and among fungicide treatments in September. ‘Emerald ’n Gold’ plants had higher disease ratings (13.8) than ‘Emerald Gaiety’ (9.3) or ‘Emerald Surprise’ (9.4) plants ($LSD_{0.05} = 2.4$). Plants treated with mancozeb (2.8), mancozeb and trifloxystrobin (2.7), chlorothalonil and mancozeb (6.3), or mancozeb and trifloxystrobin and chlorothalonil (4.0) had lower disease ratings than plants treated with water (26.2), chlorothalonil (17.5), trifloxystrobin (13.2), or chlorothalonil and trifloxystrobin (14.0) in September ($LSD_{0.05} = 8.9$).

CONTAINER STUDY, STILLWATER.

Disease ratings did not differ among cultivars in May, June, or July (data not presented). ‘Emerald Gaiety’ was damaged less (3.0, 6.5) than ‘Emerald ’n Gold’ (7.4, 13.3) or ‘Emerald Surprise’ (8.9, 17.6) in August and September, respectively ($LSD_{0.05} = 3.7$ and 4.8 for August and September, respectively). Disease ratings did not differ among fungicide treatments in the container study on any rating date (data not presented). No interaction between cultivar and fungicide occurred among disease ratings at any rating date.

CONTAINER STUDY, FAYETTEVILLE.

No interaction occurred between fungicide and cultivar for disease ratings on any rating date. Disease ratings differed among fungicides and among cultivars only in September. Mancozeb alone and rotations that included mancozeb controlled anthracnose symptoms better than the water control, trifloxystrobin, chlorothalonil, or a rotation of trifloxystrobin and chlorothalonil (Table 5). Fewer anthracnose symp-

Table 4. Disease ratings in Aug. 2001 of anthracnose on three cultivars of wintercreeper euonymus grown in the field and sprayed with various fungicides alone and in rotation at Fayetteville, Ark. (n = 10).

Fungicide treatment	Cultivar	Disease rating ^z
Chlorothalonil	Emerald ’n Gold	15.0
	Emerald Gaiety	4.0
	Emerald Surprise	5.0
Mancozeb	Emerald ’n Gold	5.5
	Emerald Gaiety	6.0
	Emerald Surprise	1.5
Trifloxystrobin	Emerald ’n Gold	12.0
	Emerald Gaiety	2.5
	Emerald Surprise	3.0
Chlorothalonil + mancozeb	Emerald ’n Gold	2.0
	Emerald Gaiety	2.5
	Emerald Surprise	1.0
Chlorothalonil + trifloxystrobin	Emerald ’n Gold	10.5
	Emerald Gaiety	8.5
	Emerald Surprise	3.0
Mancozeb + trifloxystrobin	Emerald ’n Gold	3.0
	Emerald Gaiety	4.0
	Emerald Surprise	0.0
Chlorothalonil + trifloxystrobin + mancozeb	Emerald ’n Gold	4.5
	Emerald Gaiety	7.0
	Emerald Surprise	0.5
Water	Emerald ’n Gold	18.0
	Emerald Gaiety	19.5
	Emerald Surprise	7.0
Significance ($LSD_{0.05}$)		
Cultivar for same treatment		2.2
Cultivar for different treatment		2.8

^zAnthracnose damage rating scale ranged from 0 to 100 with 0 = no damage and 100 = a dead plant. Plants with ratings greater than 10 would be considered nonsalable by many nurseries.

Table 5. Disease ratings in Sept. 2001 of three cultivars of wintercreeper euonymus grown in containers and treated with various fungicides alone and in rotations at Fayetteville, Ark. [n = 30 (fungicide), n = 80 (cultivar)].

Treatment	Disease rating ^z
<i>Fungicide main effect</i>	
Chlorothalonil	22.2
Mancozeb	11.1
Trifloxystrobin	22.8
Chlorothalonil + Mancozeb	8.9
Chlorothalonil + Trifloxystrobin	23.6
Mancozeb and Trifloxystrobin	13.9
Chlorothalonil + Trifloxystrobin + Mancozeb	16.4
Water	36.1
Significance ($LSD_{0.05}$)	15.4
<i>Cultivar main effect</i>	
Emerald ’n Gold	23.7
Emerald Gaiety	12.0
Emerald Surprise	22.5
Significance ($LSD_{0.05}$)	6.3

^zAnthracnose damage rating scale ranged from 0 to 100 with 0 = no damage and 100 = a dead plant. Plants with ratings greater than 10 would be considered nonsalable by many nurseries.

toms appeared on 'Emerald Gaiety' than 'Emerald 'n Gold' or 'Emerald Surprise' (Table 5).

CONTAINER STUDY, PARK HILL. Anthracnose symptoms were minimal (ratings <1) on all rating dates. Disease ratings did not differ among cultivars or fungicides in the container study at Park Hill on any rating date. No significant interaction occurred between cultivars and fungicides for disease ratings on any rating date.

Discussion

Low disease ratings and lack of differences in ratings among cultivars and among fungicide treatments in the container study at Park Hill may be attributed to the study being conducted under 73% shade. Ningen et al. (2005) found fewer anthracnose symptoms on wintercreeper euonymus grown under higher shade intensities than at lower shade intensities.

'Emerald Gaiety' generally had lower disease ratings than 'Emerald 'n Gold' or 'Emerald Surprise' at Stillwater and Fayetteville. These results were similar to those of several studies that have noted fewer anthracnose symptoms on 'Emerald Gaiety' than on 'Emerald 'n Gold' (Mahoney and Tattar, 1980a, 1980b; Ningen et al., 2004, 2005). LaMondia (2001a) found that 'Emerald 'n Gold' had more lesions per leaf, but defoliation was greater on 'Emerald Gaiety'.

Mahoney and Tattar (1980a, 1980b) found that mancozeb and chlorothalonil completely controlled *C. gloeosporioides* on wintercreeper euonymus 'Emerald 'n Gold'. Our results differed from those of Mahoney and Tattar (1980a, 1980b) in that mancozeb and chlorothalonil suppressed anthracnose symptoms but did not provide complete control. LaMondia (2001a, 2001b) also noted varying amounts of resistance of *C. gloeosporioides* to chlorothalonil in vitro.

LaMondia (2001a, 2001b) suggested that combinations of fungicides

with different modes of action might be more effective at controlling *C. gloeosporioides* on wintercreeper euonymus than the same fungicides used alone. Each of the fungicides tested in this study had a different mode of action. Chlorothalonil is an aromatic hydrocarbon protectant fungicide that reacts with thiol groups in the enzyme systems of fungi (Hutson and Miyamoto, 1998). Mancozeb is an organic, protectant fungicide that converts to ethylene diisothiocyanate and reacts with enzymatic sulfhydryl groups (Copping and Hewitt, 1998). It inhibits enzyme activity in metal-containing enzymes that are involved with production of adenosine triphosphate (ATP) (Copping and Hewitt, 1998, Hutson and Miyamoto, 1998). Trifloxystrobin interferes with mitochondrial respiration of the pathogenic fungus (Copping and Hewitt, 1998). Results of our research indicate that fungicide rotations, particularly those containing mancozeb, were more effective at reducing anthracnose symptoms on wintercreeper euonymus than each fungicide alone.

From this study, use of resistant cultivars is recommended when possible. Fungicide rotations that include mancozeb help decrease but do not eliminate disease symptoms. Implementing cultural practices such as growing under shade with afternoon irrigation (Ningen et al., 2005) can also reduce disease incidence.

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