Survey of Cultural Practices Used in Production of Wintercreeper Euonymus

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SUMMARY. A survey of commercial nursery growers was conducted to identify cultural practices used in wintercreeper euonymus (*Euonymus fortunei*) production. Growers that have or have not experienced anthracnose incited by *Colletotrichum gloeosporioides* on wintercreeper euonymus participated in the survey. Nurseries reported using a variety of practices to produce quality plants for sale. Plant culture appeared similar between nurseries with anthracnose problems on wintercreeper euonymus and those without anthracnose problems.

Wintercreeper euonymus is a fast-growing, woody evergreen species that is used to add color to the landscape. Numerous cultivars with different growth habits and leaf variegation patterns have been described (Dirr, 1998; Whitcomb, 1996). Wintercreeper euonymus is an integral part of the nursery inventory because of the cultivars available and popularity with consumers.

Wintercreeper euonymus is susceptible to *Colletotrichum gloeosporioides* during production and in the landscape, resulting in anthracnose symptoms. Mahoney and Tattar (1980a, b) first identified anthracnose incited by *C. gloeosporioides* on field- and container-grown wintercreeper euonymus from several New England nurseries in 1978. Typical disease symptoms included leaf and stem lesions, stem dieback, and defoliation.

Mahoney and Tattar (1980a, b) noted that maneb, mancozeb, and chlorothalonil controlled anthracnose symptoms on wintercreeper euonymus. Recent studies have shown that mancozeb reduces but does not eliminate anthracnose symptoms (Boyer et al., 2007; Cole et al.,

2005; Ningen, 2003; Schupbach-Ningen et al., 2006). This indicates that *C. gloeosporioides* has developed resistance to mancozeb. Other fungicides, including thiophanate-methyl (LaMondia, 2001a, b; Ningen, 2003), copper hydroxide (Cole et al., 2005; LaMondia, 2001a, b), azoxystrobin (Cole et al., 2005; LaMondia 2001a), myclobutanil (Cole et al., 2005), trifloxystrobin (Cole et al., 2005; Schupbach-Ningen et al., 2006), propiconazole (Ningen, 2003), iprodione (LaMondia, 2001b), and copper sulfate pentahydrate (Boyer et al., 2007), have also been tested with little success in controlling anthracnose symptoms on wintercreeper euonymus.

An alternative to using fungicides to control anthracnose symptoms is an altered growing environment that reduces plant stress and creates less favorable conditions for *C. gloeosporioides* growth. Ningen et al. (2004) found that disease symptoms were more severe on plants grown with 28.6 °C than 19.3 °C night temperatures. Subsequent research showed that anthracnose symptoms decreased as shade intensity under which plants were grown increased (Ningen et al., 2005). Disease severity was also lower when plants were irrigated in the afternoon rather than in the early morning (Ningen et al., 2005).

The objective of this research was to identify cultural practices used in commercial production of

wintercreeper euonymus by nurseries that do and those that do not experience anthracnose on wintercreeper euonymus.

Materials and methods

A list of production nurseries was obtained from the American Nursery and Landscape Association. Based on nursery name and information obtained from websites, nurseries that did not grow wintercreeper euonymus were eliminated, leaving a mailing list of 448 nurseries. On 2 Mar. 2005 each nursery was mailed a letter describing the project, a survey, and a postage-paid envelope in which to return the completed survey. The nurseries were also given the option of completing the survey online. About 6 weeks after the first mailing, follow-up letters and surveys were mailed to nurseries that had not responded. This was repeated again ≈6 weeks after the second mailing if no response was received.

All data were analyzed using SAS (PC SAS version 9; SAS Institute, Cary, NC). Each response was entered as an observation in the data set. Relationships among the responses to various questions were assessed by constructing two-way contingency tables using PROC FREQ in SAS.

Results and discussion

Of 448 surveys mailed, 242 (54%) were completed and returned. Three respondents used the online survey and the other 239 returned paper surveys in the postage-paid envelopes provided. Twenty-two respondents indicated that they grew wintercreeper euonymus at one time but no longer produce it whereas 62 respondents said that they currently grow wintercreeper euonymus. Only surveys from nurseries that currently grow wintercreeper euonymus or have grown it in the past were included in data analysis. Most of the respondents that currently grow wintercreeper euonymus were located in the midwestern United States

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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
3.7854 (°F - 32) ÷ 1.8	gal °F	L °C	0.2642 (1.8 × °C) + 32

(Table 1). Almost half of the nurseries that experienced anthracnose problems were located in U.S. Department of Agriculture cold hardiness zone 5, 20% were located in zone 6, and $\approx$ 17% were in zone 7. None of the nurseries that responded from zone 4 had experienced anthracnose in wintercrawler euonymus. The percentages of nurseries reporting no anthracnose on wintercrawler euonymus were about equal among zones 4 through 8, with 15% to 19% of production in each of the zones, except for zone 5, in which about 25% of nurseries reported no anthracnose.

About 20% of the nurseries indicated that they grew wintercrawler euonymus in the past but have stopped production. Of nurseries that have stopped production, 45% said they stopped production during the past 5 years whereas 41% said they stopped production 6 to 10 years ago. Fifty-seven percent of nurseries indicated that production was stopped because of too many disease problems, whereas 14% said there was not enough market interest to warrant production. Fifty-two percent of the nurseries that had stopped production said they would not produce wintercrawler euonymus again, even if suitable disease control measures were available.

Of the nurseries currently growing wintercrawler euonymus, 66% said they have disease problems. Of the nurseries with disease problems, 73% attributed those disease problems to anthracnose. Most respondents (82%) said that annual percentage crop loss was from 1% to 25% of their crop.

Nurseries were asked about their management practices for controlling anthracnose on wintercrawler euonymus. Most of the nurseries that have anthracnose problems attempted control with fungicide applications (Table 2). Several fungicides were being used, but mancozeb and chlorothalonil were used by about half of the nurseries with anthracnose (Table 3). Some nurseries also attempt to control anthracnose symptoms by growing in shade and by timing the irrigation to minimize disease problems (Table 2). Of the nurseries that did not report anthracnose problems, about one-third apply fungicides whereas a few grow wintercrawler

Table 1. Geographical distribution of U.S. nurseries that grow or have grown wintercrawler euonymus with or without anthracnose.

U.S. region	Proportion of nurseries (%) ^z	
	With anthracnose	Without anthracnose
Northeast	26.7 ^z	9.4
Northwest	3.3	21.9
Midwest	46.7	40.7
Southeast	13.3	15.6
Southwest	10.0	13.3

^zPercentages are calculated based 30 respondents with anthracnose and 32 respondents without anthracnose.

Table 2. Cultural practices used by U.S. nurseries to reduce anthracnose symptoms on wintercrawler euonymus.

Cultural practice	Proportion of nurseries (%) ^z	
	With anthracnose	Without anthracnose
Fungicide application	94.1	36.0
Growing in shade	32.4	12.0
Irrigation timing (morning vs. afternoon)	52.9	12.0
Use of fans to circulate air	0	4.0
Other	20.6	20.0

^zPercentages are calculated based 34 respondents with anthracnose and 25 respondents without anthracnose.

Table 3. Fungicides used to control anthracnose on wintercrawler euonymus in U.S. nurseries with or without anthracnose symptoms.

Fungicide	Proportion of nurseries (%) ^z	
	With anthracnose	Without anthracnose
Mancozeb	55.9	20.0
Maneb	11.8	4.0
Copper hydroxide	26.5	8.0
Copper sulfate	17.6	16.0
Trifloxystrobin	5.9	4.0
Chlorothalonil	50.0	4.0
Thiophanate-methyl	41.1	8.0
Azoxystrobin	20.6	0
Myclobutanil	5.9	0
Propiconazole	17.6	4.0
Other	11.8	4.0

^zPercentages are calculated based 34 respondents with anthracnose and 25 respondents without anthracnose.

euonymus in shade and carefully time the irrigation. None of the nurseries with anthracnose and only one nursery without anthracnose use fans to circulate air around the crop.

Nurseries were asked about propagation practices. The parent source of wintercrawler euonymus planting stock was stock plants on site for 29% of nurseries surveyed with anthracnose and 28% nurseries without anthracnose. Cuttings from plants on sale blocks were used by 56% of nurseries with anthracnose and 24% of nurseries without anthracnose. Rooted cuttings or liner stock were purchased from elsewhere by

26% of nurseries with anthracnose and 4% of nurseries without anthracnose. During propagation, some nurseries use bleach (35% of nurseries with anthracnose and 12% of nurseries without anthracnose), Green-Shield (Whitmire Micro-Gen Research Laboratories, St. Louis; 18% of nurseries with anthracnose and 12% of nurseries without anthracnose), or alcohol (26% of nurseries with anthracnose and 16% of nurseries without anthracnose) for sanitizing tools to reduce disease spread. About one-third of the nurseries did not sanitize tools used for propagation.

Of the nurseries that reported having anthracnose, 88% reported that they shear the plants with hand shears or loppers, and 26% use a motorized shearing machine. Of the nurseries that reported no anthracnose problems, 48% used hand shears or loppers and 8% use a motorized shearing machine. Less than half (42% of nurseries with anthracnose and 40% of nurseries without anthracnose) indicated that they sanitize shears as they work. Table 4 shows the frequency with which wintercreeper euonymus is sheared in nurseries that reported anthracnose problems.

Of the nurseries reporting anthracnose on wintercreeper euonymus, production was evenly distributed among 1-gal, 2-gal, and larger than 2-gal pots (Table 5). One nursery reported growing wintercreeper euonymus in the ground. Just under half of the nurseries reported growing wintercreeper euonymus in full sun regardless of anthracnose severity. A few nurseries reported growing at least some cultivars in partial shade (data not presented). Shade intensities ranged from 25% to 73%. None of the nurseries used drip irrigation at any time. Most irrigate in the morning using overhead irrigation, but some irrigate in the afternoon with overhead irrigation.

Most nurseries overwinter wintercreeper euonymus in plastic houses, but some overwinter under fabric or with plants placed pot to pot (Table 6). No nursery used mulch for overwinter protection.

Nurseries were asked what cultivars of wintercreeper euonymus they produce. Many cultivars were listed, but 'Emerald Gaiety' and 'Emerald 'n Gold' were the two cultivars produced by the most nurseries regardless of anthracnose incidence (Table 7). Of the nurseries that cited anthracnose as a problem, more than half (59%) listed 'Moonshadow' as a cultivar that they produce.

Symptoms of anthracnose incited by *C. gloeosporioides* on wintercreeper euonymus have been shown to increase as nighttime temperatures increase (Ningen et al., 2004), thus symptoms would be expected to be more prominent in plants grown in more southern areas, where temperatures tend to be warmer for a greater

Table 4. Frequency in which U.S. nurseries with anthracnose problems shear wintercreeper euonymus.

Frequency	Proportion of nurseries with anthracnose (%)
≤3 weeks	0 ^z
Every 4 weeks	3.0
Every 5 weeks	9.1
Every 6 weeks	27.3
Every 7 weeks	6.1
Every 8 weeks	21.2
Other	33.3

^zPercentages were based on 33 respondents.

Table 5. Cultural conditions under which wintercreeper euonymus plants are grown in U.S. nurseries that experience anthracnose and those that do not.

Cultural condition	Proportion of nurseries (%) ^z	
	With anthracnose	Without anthracnose
Container grown, 1-gal pots ^y	52.9	— ^x
Container grown, 2-gal pots	55.9	—
Container grown, >2-gal pots	52.9	—
In ground	2.9	—
Full sun	44.1	48.0
Morning drip irrigation	0	0
Afternoon drip irrigation	0	0
Evening drip irrigation	0	0
Morning overhead irrigation	55.9	20.0
Afternoon overhead irrigation	23.5	8.0
Evening overhead irrigation	2.9	0
Other	2.9	0

^zPercentages are calculated based 34 respondents with anthracnose and 25 respondents without anthracnose.

^y1 gal = 3.7854 L.

^xNurseries with no anthracnose did not respond to questions regarding container size or in-ground production.

Table 6. Methods of overwintering wintercreeper euonymus in U.S. nurseries with or without anthracnose.

Overwintering method	Proportion of nurseries (%) ^z	
	With anthracnose	Without anthracnose
Plastic houses	88	44
Under fabric	9	4
Mulched	0	0
Pot to pot	18	12
Other	9	12

^zPercentages are calculated based 34 respondents with anthracnose and 25 respondents without anthracnose.

portion of the year than in more northern areas. However, survey results did not support this assumption, as a greater percentage of the nurseries that reported anthracnose problems were located in hardiness zones 5, 6, and 7, and a lower percentage of nurseries reported anthracnose in zones 8, 9, and 10.

Several fungicides have been tested for effectiveness in controlling anthracnose on wintercreeper euonymus. Evidence of increased fungicide resistance has been noted since an-

thrachnose on wintercreeper euonymus was first described. LaMondia (2001a, b) found that resistance to multiple fungicides was common and suggested that use of several different fungicides in a tank mixture or rotation provided better control of *C. gloeosporioides* than the use of a single fungicide when chemicals with different modes of action were used. Ningen (2003) tested chlorothalonil, trifloxystrobin, mancozeb, propiconazole, and thiophanate-methyl alone, in rotations, and in mixtures,

Table 7. Wintercreeper euonymus cultivars currently produced or produced in the past by U.S. nurseries that do or do not experience anthracnose problems.

Cultivars produced	Proportion of nurseries (%) ^z	
	With anthracnose	Without anthracnose
Canadale Gold	23.5	4.0
Canadian Gold	5.9	0
Canadian Variegated	2.9	0
Carrierei	2.9	0
Carrierei var. coloratus	5.9	8.0
Duet	2.9	0
Emerald Beauty	2.9	0
Emerald Cushion	2.9	0
Emerald Gaiety	73.5	44.0
Emerald 'n Gold	79.4	36.0
Emerald Surprise	8.8	8.0
Gold Prince	5.9	0
Gold Splash	17.6	4.0
Gold Spot	8.8	0
Gold Tip	2.9	0
Green Lane	17.7	0
Harlequin	20.6	12.0
Ivory Jade	17.6	1.7
Kewensis	11.8	8.0
Microphylla Variegata	8.8	8.0
Minimus	2.9	0
Moonshadow	58.8	12.0
Sarcoxic	20.6	8.0
Silver Queen	5.9	0
Sun Spot	11.8	12.0
Sunrise	8.8	8.0
Thunderbolt	0	4.0
Variegatus	5.9	0
Vegetus	20.6	8.0

^zPercentages are calculated based 34 respondents with anthracnose and 25 respondents without anthracnose.

and found that mancozeb alone or in rotations with chlorothalonil provided better control of *C. gloeosporioides* than mixtures or rotations of fungicides without mancozeb or chlorothalonil. However, no fungicide eliminated *C. gloeosporioides* symptoms. Although the fungicides found most effective (mancozeb or chlorothalonil) were used by many of the respondents, many fungicides that have been shown to be ineffective are also being used (Table 3). Respondents were not asked whether they rotate fungicides or apply tank mixtures of fungicides.

Research has shown that growing wintercreeper euonymus in partial shade (63%, 73%, or 80%) can almost eliminate anthracnose symptoms compared with growing in full sun (Ningen et al., 2005). Likewise, plants irrigated in the afternoon had fewer anthracnose symptoms than plants irrigated in the morning with overhead irrigation (Ningen et al.,

2005). Only a few survey respondents indicated that they grow wintercreeper euonymus in shade, and more respondents irrigate in the morning than in the afternoon.

The results of this survey show that all the cultural practices addressed were used by producers regardless of presence or absence of anthracnose symptoms. Thus, no recommendations for incorporating or eliminating practices from management of wintercreeper euonymus can be made from the survey. Instead, the study suggests that outreach efforts to inform producers of best management practices for this crop have not been effective. Based on past research, production of less susceptible cultivars under shade with afternoon irrigation is recommended.

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