Development of a Reduced Use Fungicide Program for Control of Botrytis Fruit Rot on Annual Winter Strawberry

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ABSTRACT

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Crop phenology and epidemiological information were used to design a reduced use fungicide program for control of Botrytis fruit rot in winter annual strawberry. Fungicide spray programs during early and late periods of the season using high and low rates of captan were evaluated with or without second peak bloom applications of fenhexamid during the 1999–2000 and 2000–2001 seasons. During the early harvest period, low rates of captan were as effective as high rates for controlling Botrytis fruit rot and maintaining yield. Late in the season, treatments with fenhexamid over the peak bloom period significantly improved control of Botrytis fruit rot and increased marketable yield. Application of both captan and fenhexamid during the second peak bloom did not reduce Botrytis fruit rot incidence or improve yield compared with fenhexamid alone during this time period. Late season applications of captan may be reduced or eliminated when bloom applications of fenhexamid are being applied without affecting Botrytis fruit rot control. The study generated new recommendations for use of low-rate applications of captan during the early season and applications of fenhexamid during the second peak bloom period for winter annual strawberry production in Florida.

Additional keywords: disease control, *Fragaria × ananassa*, gray mold

Botrytis fruit rot (gray mold), caused by the fungus *Botrytis cinerea*, is an internationally important preharvest and postharvest disease of strawberry. In Florida, this disease is the most important cause of yield reductions in fruit production fields. Even with regular applications of fungicides, Botrytis fruit rot can reduce marketable yields of susceptible cultivars by 10% or more (13).

Epidemics of Botrytis fruit rot are typically initiated by conidia produced on dead strawberry foliage within the field (3). Young strawberry leaves are quiescently infected by the pathogen, and as the leaves senesce, *B. cinerea* colonizes the dying tissue and sporulates (4). Conidia can be either air or water dispersed (19), and they infect floral parts including stamens and petals (5,16). Fruit decay as they approach maturity. Direct infection of fruit by co-

nidia is not considered important (19), although the disease can spread by fruit-to-fruit contact (D. E. Legard, *unpublished results*). After the epidemic begins, both diseased fruit and senescent foliage are important sources of secondary inoculum (20).

In central Florida, strawberry transplants produced in northern or high elevation nurseries (over 900 m) are planted in the field from late September to early November. Although strawberries flower throughout the winter in Florida, there are typically two peak bloom periods, one in November/December and the other in late January/February. Harvest usually begins in December, with fruit produced during this early period bringing the highest prices. Production increases in February as temperatures rise, and the season typically ends in March due to price declines resulting from the entry of California strawberries into the market.

Botrytis fruit rot is controlled by a combination of cultural and chemical methods. Resistant cultivars (8,12) and protected culture (22) can effectively control Botrytis fruit rot. Although no strawberry cultivar is completely resistant to Botrytis fruit rot, there are significant differences in susceptibility among commercial cultivars. For example, the cultivar Sweet Charlie is very susceptible, whereas Carmine and Camarosa are moderately resistant (12). Fruit production in large clear-plastic tun-

nels dramatically reduced Botrytis fruit rot incidence compared with open field production, even in the absence of fungicide applications (22). However, the relatively high costs of protected culture systems are currently prohibitive for large-scale use in the United States. The removal of senescent foliage (14) and increased plant spacing (12) can reduce Botrytis fruit rot, but these cultural practices are relatively ineffective and expensive compared with use of fungicides. Thus, current management of Botrytis fruit rot relies primarily on fungicide applications.

Strategies for chemical control focus on protecting flowers and foliage from infection (9,13,15,21) or reducing sporulation of the pathogen on infected plant material (2,4). In Florida, applications of fungicides only during peak bloom periods have been shown to provide significant control of Botrytis fruit rot (13,21). However, due to the current reliance on susceptible cultivars and the open field production system, weekly applications of captan or thiram still appear to be essential and are used routinely in Florida (13). The cost of fungicide applications corresponds to about 15% of preharvest costs, and net returns are decreasing every year. Due to these factors, any reduction in fungicide applications that does not compromise disease control is beneficial to growers and consumers. Since most infections occur on flowers, fungicide usage may be reduced by focusing applications during peak bloom.

Fungicides other than captan and thiram are effective against Botrytis fruit rot, but labeling restrictions limit their usage. One such fungicide is fenhexamid, a protectant fungicide that has been shown to reduce the colonization of flowers (15) and to improve control of Botrytis fruit rot when applied along with captan (11). Botrytis fruit rot epidemics are typically more severe later in the season (13), and the majority of fruit are harvested late in the season. Therefore, focusing applications of fungicides with superior activity against *B. cinerea* on the second bloom period may improve the effectiveness of disease control programs.

In this study, epidemiological information obtained previously and crop phenology were used to design fungicide programs that minimized the amount of product applied to the crop without affecting disease control. The utility of early-

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season applications of captan sprays was evaluated as well as the use of fenhexamid applications during peak bloom periods.

MATERIALS AND METHODS

Cultivation methods and experimental design. Experiments were conducted during the 1999–2000 and 2000–2001 seasons at the University of Florida, Gulf Coast Research and Education Center (GCREC) at Dover. Land preparation began in the fall with a broadcast application of fertilizer and fumigation at 392 kg/ha with a 67:33 mixture of methyl bromide and chloropicrin. The experiments were arranged in randomized complete blocks with 15 treatments with four replicate plots of 20 plants each. Canadian-grown, green-top, bare root plants of cv. Sweet Charlie were transplanted into four plastic-mulched raised beds on 11 October 1999 and 6 October 2000. Beds were planted on 1.22-m centers (71 cm wide, 18 cm high at the center, and 15 cm high at the edge). Plants were placed in two offset rows per bed, 30 cm apart. Within rows, the distance between plants was 38 cm. Plots were separated within beds by 1.1 m of unplanted space. Transplants were overhead-irrigated by sprinklers for 10 days to facilitate establishment, then irrigated and fertilized through drip lines as needed.

Fungicide treatments were applied with a CO₂-pressurized backpack sprayer using a two-nozzle wand (935 liters/ha, 310 kPa). Twelve of the spray programs differed from one another with respect to the amount of captan applied during the early or late seasons and whether the programs included four weekly applications of fenhexamid in addition to captan during the second peak bloom period. Late-season applications of captan were omitted in one treatment that received fenhexamid only. Captan (Captan 80WP; Micro Flo Company, Memphis, TN) was applied at the lowest label rate (1.68 kg a.i./ha) and the highest label rate (3.36 kg a.i./ha). Fen-

hexamid (Elevate 50WDG; Arvesta, San Francisco, CA) was applied at high label rate (0.84 kg a.i./ha). Early-season captan applications began after plant establishment (3 November 1999 and 3 November 2000) and were repeated weekly until the start of the second peak bloom period (12 January 2000 and 19 January 2001). Late season applications of captan began the week after the last early-season application (19 January 2000 and 26 January 2001) and were repeated weekly with the final application made on 1 March 2000 and 23 February 2001. Late-season peak bloom applications of fenhexamid were made on 19 and 24 January and 2 and 9 February during the 1999–2000 season and on 26 January, 2, 9, and 16 February of the 2000–2001 season. The split-bloom treatment consisted of fenhexamid applications in the early and late season with applications made 19 and 24 November 1999 and 19 and 26 January 2000 for the 1999–2000 season and on 24 November and 1 December 2000 and 26 January and 2 February 2001 for the 2000–2001 season.

Data collection. Fruit were harvested twice weekly, from 3 December 1999 to 7 March 2000 (28 harvests) and 30 November 2000 to 1 March 2001 (27 harvests). Fruit were graded as marketable or unmarketable on the day harvested. Marketable fruit were counted and weighed. Unmarketable fruit were sorted into those with *Botrytis* fruit rot and those with other cull characteristics (i.e., other diseases, misshapen fruit, small fruit, etc.), and enumerated. The incidence of *Botrytis* fruit rot was determined by dividing the number of fruit with *Botrytis* by the total number of marketable and unmarketable fruit harvested.

Statistical analysis. Analysis of variance was performed on *Botrytis* fruit rot incidence and marketable yield data from each season separately using PROC MIXED in SAS (SAS Institute Inc., Cary, NC). Treatment was included as a fixed

effect and replicate was considered a random effect in the analysis. The risk of type I error (α) was 0.05 for tests comparing means and was not adjusted for multiple comparisons. *Botrytis* fruit rot incidence was transformed to arcsine square root before analysis. For general comparisons, analyses of variance were performed for cumulative *Botrytis* fruit rot incidence and marketable yield for the early period (harvests from first 7 and 8 weeks, 1999–2000 and 2000–2001 season, respectively), late period (all harvests after early period), and the full season.

Plots received one of five spray programs during the early season, and it was not until late season sprays were applied that 15 whole season programs could be differentiated. During the early season, low-rate captan was applied to six treatments, high-rate captan to four treatments, high-rate captan plus two fenhexamid sprays at peak bloom to one treatment, and four treatments received no fungicide. The early season data were analyzed separately from those of the late and the whole season. Treatment means for both late season and whole season intervals are identified by spray applications that occurred over the course of the entire season. The effect of fenhexamid along with captan at the second bloom was determined by contrasting treatments with late season fenhexamid and captan applications with matched treatments in which captan alone was applied. The effect of early season captan applications on late or whole season *Botrytis* fruit rot incidence and marketable yield was determined in a similar manner, in that treatments that included an early season captan application plus a late season application of captan, fenhexamid, or both were contrasted with treatments having matched late season fungicide applications only. The effect of adding captan to fenhexamid sprays was determined by contrasting treatments with late season applications of both fenhexamid and captan with matched treatments in which fenhexamid alone was applied.

RESULTS

Development of *Botrytis* fruit rot epidemics and patterns of marketable yield. Weekly mean *Botrytis* fruit rot incidences in the untreated control were generally higher during the 1999–2000 season than in the 2000–2001 season at comparable times (Fig. 1). The final cumulative disease incidence in 2000–2001, 15.7%, was slightly less than the 17.7% disease incidence observed over the whole 1999–2000 season. The incidence of *Botrytis* fruit rot was affected significantly by treatment ($P < 0.001$) during the early, late, and full season periods of 1999–2000 and 2000–2001 (Tables 1 and 2).

Yield patterns were similar in both seasons, with a majority of marketable fruit harvested during the last 3 or 4 weeks

Fig. 1. Weekly incidence of *Botrytis* fruit rot in untreated control plots during the 1999–2000 and 2000–2001 seasons. Harvest began 3 December 1999 and 30 November 2000.

(Fig. 2). Total marketable yields were higher in 1999–2000. Fungicide treatments significantly affected cumulative yields over the early season ($P < 0.02$), late season ($P < 0.001$), and full season intervals ($P < 0.001$) (Tables 1 and 2).

Early season incidence of Botrytis fruit rot and marketable yield. The incidence of Botrytis fruit rot and marketable yield in plots treated with either low- or high-rate captan were not significantly different during the early harvest period in

either season (Table 1). Both captan treatments reduced the incidence of Botrytis fruit rot during this period compared with treatments that received no fungicide, and with the exception of the high-rate captan treatment in 2000–2001, marketable yields were significantly greater in plots treated with captan than in the nonsprayed control. Plots treated with captan supplemented with fenhexamid showed significantly lower incidence of Botrytis fruit rot than those plots treated with captan alone in 2000–2001, but not in 1999–2000.

Effect of late-season fungicide treatments on Botrytis fruit rot and marketable yield. Mean incidence of Botrytis fruit rot and marketable yields were determined for late and full season intervals for each of the individual fungicide spray programs (Table 2). Mean incidence of Botrytis fruit rot was lower during the late season for treatments that included fenhexamid sprays during the second bloom period than for treatments that did not receive fenhexamid. In addition, treatment programs that included captan sprays during the second half of the season tended to have less Botrytis fruit rot than those that

Table 1. Effect of spray programs on the incidence of Botrytis fruit rot and marketable yield during early season (first 7 weeks of the 1999–2000 season and for the first 8 weeks of the 2000–2001 season)

Season	Fungicide application	Number of replications	Mean ^x	
			Botrytis incidence ^y	Marketable yield (g/plot)
1999–2000	Captan + fenhexamid split bloom	4	2.3 a	2,379 bc
	Low rate captan	24	3.8 a	2,767 ab
	High rate captan	16	4.0 a	2,898 a
	No treatment	16	10.4 b	2,124 c
	Probability of a greater <i>F</i> value ^z		<0.001	<0.001
2000–2001	Captan + fenhexamid split bloom	4	1.2 a	2,501 a
	High rate captan	16	3.2 b	2,261 ab
	Low rate captan	24	3.6 b	2,360 a
	No treatment	16	8.1 c	2,027 b
	Probability of a greater <i>F</i> value		<0.001	0.018

^x Means within the same season followed by the same letter are not significantly different, least-squares means *t* tests ($P = 0.05$).

^y Incidence of Botrytis fruit rot is reported as mean percent of fruit infected and was calculated by back transforming the mean arcsine-square root of the proportion of fruit infected.

^z *F* statistic for overall treatment effect.

Table 2. Effect of 15 spray programs on incidence of Botrytis fruit rot and marketable yield for late season (final 8 weeks) and entire 1999–2000 season and for late season (final 6 weeks) and the entire 2000–2001 season in plots treated with 15 different spray programs

Year	Spray program			Mean ^v			
	Captan		Fenhexamid bloom	Botrytis incidence ^w		Marketable yield (g/plot)	
	Early	Late		Late season	Full season	Late season	Full season
1999–2000	Low	Low	2nd peak	7.8 abc	7.1 ab	7,169 ab	10,121 abcd
	Low	Low	-	14.5 e	12.3 de	6,175 bc	8,545 ef
	Low	High	2nd peak	6.5 a	6.1 a	8,096 a	10,818 ab
	Low	High	-	10.3 cd	8.8 bc	6,380 bc	9,301 cdef
	Low	-	2nd peak	8.3 abc	7.0 ab	7,102 ab	10,222 abcd
	Low	-	-	20.1 f	17.2 fg	5,792 c	8,308 ef
	High	High	2nd peak ^x	6.9 a	6.3 a	8,101 a	10,877 a
	High	High	2nd peak	7.1 ab	6.2 a	7,069 ab	10,093 abcd
	High	High	Split ^y	8.0 abc	7.0 ab	8,198 a	10,577 abc
	High	High	-	11.1 d	9.6 cd	6,537 bc	9,470 bcde
	High	-	-	16.6 ef	14.0 ef	6,278 bc	9,137 def
	-	High	2nd peak	10.3 cd	11.1 cde	6,502 bc	8,434 ef
	-	High	-	15.0 e	13.7 e	6,279 bc	8,482 ef
	-	-	2nd peak	9.5 bcd	9.9 cd	5,813 c	8,045 fg
	-	-	-	19.7 f	17.7 g	4,584 d	6,712 g
Probability of a greater <i>F</i> value ^z				<0.001	<0.001	<0.001	<0.001
2000–2001	Low	Low	2nd peak	5.5 ab	5.4 bcd	4,470 abc	6,779 abc
	Low	Low	-	14.2 e	10.8 ef	3,769 efg	6,036 def
	Low	High	2nd peak	3.9 a	4.0 abc	4,311 bcd	6,604 bcd
	Low	High	-	13.7 de	10.7 ef	3,976 def	6,448 bcd
	Low	-	2nd peak	3.8 a	3.7 ab	4,699 ab	7,319 a
	Low	-	-	15.6 ef	12.0 fg	3,295 gh	5,494 fg
	High	High	2nd peak	3.2 a	3.3 a	4,435 abcd	6,741 abc
	High	High	2nd peak ^x	3.4 a	3.7 ab	4,808 a	7,060 ab
	High	High	Split ^y	8.3 bc	6.0 cd	4,350 abcd	6,851 abc
	High	High	-	10.0 cd	7.9 de	4,179 cde	6,497 bcd
	High	-	-	20.2 f	15.2 g	3,559 fg	5,726 efg
	-	High	2nd peak	4.0 a	4.6 abc	4,022 cdef	6,272 cde
	-	High	-	13.7 de	12.9 fg	3,687 fg	5,719 efg
	-	-	2nd peak	3.9 a	5.0 abc	4,390 abcd	6,222 cde
	-	-	-	18.3 ef	15.7 g	3,075 h	5,069 g
Probability of a greater <i>F</i> value				<0.001	<0.001	<0.001	<0.001

^v Means within the same season followed by the same letter are not significantly different, least squares means *t* tests ($P = 0.05$).

^w Incidence of Botrytis fruit rot is reported as % of fruit infected and was calculated by back transforming the mean arcsine-square root of the proportion of fruit infected.

^x The high rate captan application in the late portion of the season was discontinued when plants were treated with fenhexamid.

^y Two weekly applications of fenhexamid during both the early and late blooms.

^z *F* statistic for overall treatment effect.

included no fungicide sprays. Using a linear contrast to compare plots treated with late-season applications of captan and fenhexamid with plants treated with late-

season applications of captan only, fenhexamid applications reduced *Botrytis* fruit rot and improved yield during both seasons compared with captan alone (Table

3). Results were similar when data from the late or the full season were analyzed. A linear contrast examining late or full season disease incidence between plants treated with late season applications of captan plus fenhexamid and plants treated with fenhexamid alone showed no differences between treatment groups either season (Table 3). Thus, captan provided no additional protection against *Botrytis* infection in the presence of fenhexamid. However, when marketable yield was examined using the same contrast, treatment groups with late-season applications of fenhexamid alone produced higher yields in late season than captan plus fenhexamid in 2000–2001, but not in 1999–2000. The treatment in which captan applications were discontinued when fenhexamid was applied did not have significantly more *Botrytis* fruit rot than plots treated with both fenhexamid and captan, demonstrating that captan was not needed to control *Botrytis* fruit rot when fenhexamid was used (Table 2). During the 1999–2000 season, split bloom (early and late) sprays of fenhexamid ranked among the best treatments for yield and *Botrytis* fruit rot control (Table 2). However, during the 2000–2001 season, disease incidence was significantly higher for the split bloom treatment than it was for other treatments with higher rates of captan the entire season when disease incidence was calculated over the late season interval and the entire season.

Effect of early season applications of captan on late season control of *Botrytis* fruit rot. The effect of early season captan applications on *Botrytis* fruit rot incidence

Fig. 2. Weekly marketable yield for selected treatments during the 1999–2000 and 2000–2001 seasons. Harvest began 3 December 1999 and 30 November 2000.

Table 3. Comparisons of late- and whole-season *Botrytis* fruit rot incidence and yields for treatments grouped according to early season and late season fungicide applications

Season	Contrast	Mean ^x			
		Botrytis incidence ^y		Marketable yield (g/plot)	
		Late season	Full season	Late season	Full season
1999–2000	Late season captan + fenhexamid at 2nd bloom vs.	7.9 a	7.5 a	7,209 a	9,866 a
	Late season captan	12.7 b	11.0 b	6,343 b	8,950 b
	Probability of a greater <i>F</i> value ^z	<0.001	<0.001	0.003	0.011
	Early season captan application + late season fungicide treatment vs.	8.5 a	7.4 a	7,048 a	10,021 a
	Late season fungicide treatment only	11.4 b	11.5 b	6,198 b	8,320 b
	Probability of a greater <i>F</i> value	<0.001	<0.001	0.008	<0.001
	Late season fenhexamid bloom application with captan vs.	8.6 a	8.7 a	7,067 a	9,451 a
	Late season fenhexamid bloom application without captan	8.9 a	8.4 a	6,458 a	9,133 a
2000–2001	Probability of a greater <i>F</i> value	0.721	0.218	0.122	0.490
	Late season captan + fenhexamid at 2nd bloom vs.	4.1 a	4.3 a	4,310 a	6,599 a
	Late season captan	12.8 b	10.5 b	3,903 b	6,175 b
	Probability of a greater <i>F</i> value	<0.001	<0.001	0.001	0.019
	Early season captan application + late season fungicide treatment vs.	5.9 a	5.2 a	4,383 a	6,821 a
	Late season fungicide treatment only	6.6 a	7.1 b	4,033 b	6,071 b
	Probability of a greater <i>F</i> value	0.413	0.008	0.008	<0.001
	Late season fenhexamid bloom application with captan vs.	4.3 a	4.6 a	4,206 b	6,481 a
	Late season fenhexamid bloom application without captan	3.8 a	4.3 a	4,544 a	6,770 a
	Probability of a greater <i>F</i> value	0.567	0.647	0.037	0.218

^x Mean for contrasted treatment groups. Means within contrasts that are followed by different letters are significantly different at the indicated level of probability.

^y Incidence of *Botrytis* fruit rot is reported as percentage of fruit infected and was calculated by back-transforming the mean arcsine-square root of the proportion of fruit infected.

^z *F* statistic for the two treatment groups listed above.

in the late season was evaluated in a linear contrast comparing treatments with both early season captan applications and late season programs with treatments that included only late season programs. Late-season disease incidence was significantly less with early season captan applications during the 1999–2000 season (Table 3). Early-season captan applications also reduced full-season disease incidence and increased full-season yield in both years. In both seasons, marketable yields in the late portion of the season were significantly increased by early season application of captan.

DISCUSSION

Effective control of Botrytis fruit rot on annual winter strawberry was achieved by combining reduced rate applications of captan during the early season with bloom applications of fenhexamid during the second peak bloom period. Applications of captan at the low rate during the early season were as effective as applications at the high-labeled rate in controlling Botrytis fruit rot and increasing marketable yield. Late-season applications of fenhexamid during the second peak bloom period were also highly effective at controlling Botrytis fruit rot and increasing yield. These results suggest that although early-season fungicide applications are necessary for effective control of Botrytis fruit rot, the rate of these applications can be reduced without compromising disease control. Second peak bloom application of fenhexamid consistently improved the control of Botrytis fruit rot and is an important disease management option for annual winter strawberry.

In a previous study, weekly applications of captan or thiram at high-labeled rate provided excellent control of Botrytis fruit rot in annual winter strawberry (13). Bloom applications of systemic fungicides were found to be effective in perennial production (21) and during the second peak bloom period in an annual system (13). Because of high disease pressure from *B. cinerea* in Florida, the captan label allows up to 24 applications at 1.7 to 3.4 kg a.i./ha during the season. Our results show that growers could apply captan at the low rate (1.7 kg a.i./ha) during the early season without reducing the control of Botrytis fruit rot, thereby dramatically reducing the amount of captan applied. In Florida, captan is commonly applied 10 to 12 times during the early season. Reducing the rate from 3.4 to 1.7 kg a.i./ha would decrease the amount applied by 17.0 to 20.4 kg a.i./ha during this period. Our results also suggest that late-season applications of captan may be reduced or eliminated when bloom applications of fenhexamid are used without compromising the control of Botrytis fruit rot or marketable yield. In this study, captan was applied five to seven times at weekly inter-

vals during the late period. Eliminating these applications would decrease the amount of captan applied by 17.0 to 23.8 kg a.i./ha per season when compared with high-rate applications and would reduce grower costs for material alone by \$136 to \$238 per ha. The combination of reduced-rate applications of captan during the early season and a reduced number of applications during the late season decreased the total amount of captan used in these studies by 34.0 to 44.2 kg a.i./ha per season when compared with weekly high-rate applications of captan. Fenhexamid is labeled for a maximum of 3.4 kg a.i./ha per season and is recommended at 0.61 to 0.84 kg a.i./ha per application. Thus, a maximum of five applications may be applied per crop. Using two applications of fenhexamid early and two late as in the split-bloom treatment improved the control of Botrytis fruit rot relative to captan sprays alone. Although, based on the data from the second season, disease control may be compromised with this spray program during the later portion of the season when disease levels are highest, this program complies with the label recommendation for resistance management of no more than two consecutive applications.

When fenhexamid is applied during the second peak bloom period (i.e., late season), supplemental applications of captan may not be needed during that period for an early yielding cultivar like Sweet Charlie. Epidemiological studies of Botrytis fruit rot support elimination of these applications of captan. Infections of *B. cinerea* in strawberry are initiated in the flower at anthesis (5,9,16), and stamens are considered the principal infection route (16,17). Direct infection of fruit by conidia is rare (9,16). Fungicide applications made to individual flowers at anthesis effectively controlled Botrytis fruit rot, whereas applications made after anthesis were progressively less effective and did not improve control when combined with an application at anthesis (15). Therefore, a limited number of bloom applications of an effective fungicide such as fenhexamid may be sufficient for late season control of Botrytis fruit rot. However, care should be taken when interpreting these data. No postharvest evaluations of fruit rot incidence were conducted during this experiment, and applications of fungicides after anthesis may reduce the incidence of Botrytis fruit rot. In a previous study, plants treated with high rates of captan or thiram during the entire season had less postharvest Botrytis fruit rot and longer storage life than plants treated with reduced rates (1).

The timing of bloom applications to provide protection during the peak flower periods can be difficult since differences in environmental conditions, cultivar, transplant date, and growing region can affect flowering patterns in strawberry (6,7,10,18,19). These experiments were conducted

with a highly susceptible cultivar that produced fruit during the early season. Reduced fungicide rates and schedules may be effective with other cultivars; however, implementation will require additional research. Day-neutral cultivars such as Diamante produce flowers more consistently throughout the season and do not have the concentrated peak bloom periods typical of short-day cultivars like Sweet Charlie. Thus, producers in other regions may need to apply fungicides more frequently to control Botrytis fruit rot. In Florida, many short-day cultivars have a peak bloom period that occurs later than 'Sweet Charlie'. These cultivars may produce large numbers of flowers under different environmental conditions and may respond differently to the control programs developed for 'Sweet Charlie'.

Because pesticide use on strawberries will continue to be affected by regulatory changes and increasing public health concerns, it is prudent to develop disease management programs that reduce fungicide use. More research combining reduced pesticide use with plant resistance should further decrease the dependence on fungicides for the control of Botrytis fruit rot.

These results show that the rate and number of fungicide applications for the control of Botrytis fruit rot on strawberry can be reduced without sacrificing disease control in annual winter strawberry. Applications of captan during the early season can be reduced in rate, and weekly applications during the late season can be replaced with several bloom applications of fenhexamid. We are currently investigating the effect of reduced fungicide applications on postharvest expression of Botrytis fruit rot. Postharvest losses to *B. cinerea* can be severe and are an important consideration for growers when making decisions about fungicide applications.

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