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# Management of Blackspot on Three Rose Cultivars Using Antitranspirants in Combination with Chlorothalonil<sup>1</sup>

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## Abstract

The efficacy of reducing fungicide use, by combining chlorothalonil with film-forming antitranspirant products and lengthening intervals between applications, was evaluated for control of blackspot of rose. Antitranspirants included three highly refined pine oil (pinolene) products (Nu Film 17, Vapor Gard, and Wilt Pruf) and two latex products (Stressguard and Transfilm), each of which were applied in combination with chlorothalonil fungicide. Antitranspirant solutions were applied at 2- or 3-week intervals, depending on recommended use of the antitranspirant. Blackspot severity, based on proportion of symptomatic foliage, did not differ among treatments in either year of the study. In both study years, defoliation was lower on plants treated weekly with the fungicide alone, with Stressguard (applied at 0.25% in combination with chlorothalonil every 2 weeks), or with Vapor Gard (applied at 2% in solution with chlorothalonil every 3 weeks) compared to nontreated plants. Overall, the above fungicide and antitranspirant solutions reduced season-long fungicide use by 40–69%, without a decrease in disease control, compared to the weekly chlorothalonil treatment. Plant vigor and/or growth, however, was lower with the antitranspirant treatments compared to chlorothalonil alone.

**Index words:** plant disease control; *Diplocarpon rosae*.

## Significance to the Nursery Industry

In the Southeast United States, the most destructive disease of rose in nursery production or in the landscape is blackspot. Blackspot causes defoliation, which decreases the plant's aesthetics, value, and longevity. Optimal control of this disease involves frequent and regular applications of fungicide, and this has become undesirable. One of the most commonly used fungicides on roses is chlorothalonil. The combination of chlorothalonil with an antitranspirant may allow reduction of fungicide use without loss of efficacy in controlling blackspot disease. Several antitranspirants, combined with chlorothalonil and applied less frequently than the recommended 7-day interval, were evaluated in this study. Defoliation due to blackspot was similar on plants treated weekly with chlorothalonil or treated with chlorothalonil combined with Stressguard at 0.25% at 2-week intervals, or combined with Vapor Gard and applied every 3 weeks. These antitranspirant treatments reduced season-long fungicide use by 40–69%. Treatments with longer intervals between applications did reduce plant vigor and growth; however, vigor did not substantially decrease from one year to the next with either weekly or bimonthly treatments. These results indicate that blackspot can be managed effectively with less frequent applications of chlorothalonil if the fungicide is applied in combination with certain film-forming antitranspirant products.

## Introduction

Blackspot is a common and destructive disease of cultivated rose (*Rosa* spp.) caused by the fungus *Marssonina rosae*

(Lib.) Lind, the imperfect stage of *Diplocarpon rosae*, F. A. Wolf (8). Once blackspot is established on plants, control is difficult and relies on a combination of sanitation measures and protective fungicide applications (1). Sanitation measures include removal of diseased leaves, annual replacement of mulch or ground cover, and avoidance of overhead irrigation. Application of liquid lime-sulfur is recommended when plants are dormant; and during the growing season, protective fungicide needs to be frequently applied (1). Protective fungicide applications should be initiated shortly after bud break in the spring and continued at seven- to ten-day intervals until the first hard frost. Such an intensive program can result in 20 to 30 applications annually in areas with long growing seasons (5). In studies conducted by Hagan et al. (3, 4), chlorothalonil applications provided better control of blackspot than other fungicides evaluated.

Control of plant pathogens through prolonged and frequent applications of fungicides has given rise to a number of concerns. Increased governmental regulation and environmental awareness has led to a search for effective, yet more benign, disease control methods. Because they are one of the most frequently sprayed garden plants and their flower production is easily quantified, roses are a good candidate for the study of alternative disease control treatment methods.

Ziv and Frederiksen (11) suggested that it may be possible to use foliar sprays of polymers to form a physical and/or chemical barrier to pathogenic fungi. These film-forming compounds, particularly the group of waxes, silicones, latexes, polyterpenes, oils, and high molecular weight alcohols collectively known as antitranspirants, might provide an effective alternative to fungicides. Researchers have studied antitranspirants as alternatives for control of a diverse range of foliar pathogens. Ziv and Frederiksen (11) evaluated ten antitranspirants for control of several diseases on seedlings of maize (*Zea mays*), sorghum (*Sorghum bicolor*), and wheat (*Triticum aestivum*). One or more of the tested products provided effective disease control for each plant species, although disease control was variable (11). Han (7) reported that several diseases were reduced with the use of the film-forming dodecyl alcohol antitranspirant, *gao-zhi-mo* (GZM). Han (7) also noted synergistic effects on disease control when either

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of the fungicides carbendazim or thiophanate-methyl were combined with the antitranspirant GZM.

Sandler (10) evaluated the combination of an antitranspirant (Wilt Pruf) with chlorothalonil fungicide for control of fruit rots on cranberry (*Vaccinium macrocarpon*). His results indicated that the use of reduced rates of chlorothalonil, when combined with Wilt Pruf, did not significantly improve fruit rot control but did offer the advantage of using less fungicide with each application (10). Reductions in fungicide use can also be achieved through a reduction in the number of applications. Hagan et al. (4) showed that weekly applications of chlorothalonil provided optimal disease control, and when application intervals were extended to 14 days, disease control efficacy was reduced by approximately 24%. When used in combination with a film-forming antitranspirant, fungicidal efficacy may be extended. The objective of the current study was to evaluate the effectiveness of antitranspirants in combination with chlorothalonil for controlling blackspot disease severity while reducing numbers of fungicide applications.

## Materials and Methods

**Field plots.** Studies were conducted at the Horticultural Subunit of the E. V. Smith Research Center, Alabama Agricultural Experiment Station System, located 5 km from Shorter, AL. Exterior beds of three rose cultivars were planted in a Norfolk fine sandy loam. Plots consisted of one each of three rose cultivars, 'Cary Grant', 'Princess Monaco', and 'Dolly Parton,' planted on 91 cm centers. Five rows, separated by 4 m (13.12 ft) mowed grass alley, of four contiguous plots, comprised a replication; replications were separated by 4 m. Plots were arranged in a randomized complete block design with four replications. Three replications had been established in the spring of 1992 with a fourth replication added in the spring of 1996. In February 1996, dead plants in the first three replications were replaced as needed. In February 1996 and 1997, mulch from the prior year was removed, replaced with a fresh 10 cm (4 in) layer of pine straw, and a lime-sulfur treatment applied to plant canes. Plants were pruned to a uniform height (25 to 30 cm) the last week of February 1996 and the first week of March 1997. A drip irrigation system was used to supply fertilizer during the growing season according to standard recommendations with weekly applications of 200 mg N liters<sup>-1</sup> from 20–10–20 (Peters General Purpose, Scotts-Sierra, Maryville, OH) (1). Supplemental water was supplied to plants through the drip irrigation system whenever weekly rainfall was less than 2.5 cm (1 in). Weeds between rows were controlled by mowing and periodic application of glyphosate.

**Treatments.** In 1996, treatments began July 26 and continued to October 11; in 1997, treatments began May 2 and continued to August 22. Products included in the treatments were: three highly refined pine oil (pinolene) products [Nu Film 17, Vapor Gard (Miller Chemical Corp., Hanover, PA), and Wilt Pruf (Wilt Pruf Products, Inc., Essex, CT)] and two latex products [Stressguard (CCT Corp., Carlsbad, CA) and Transfilm (PBI Gordon Corp., Kansas City, KS)]. Application regimes included antitranspirants applied in a tank-mix with chlorothalonil (Daconil Ultrex, Zeneca, Wilmington, DE). Treatments were: 1) a nonsprayed control; 2) chlorothalonil applied weekly; 3) 5% Wilt Pruf, 4) 2% Nu Film 17, and 5) 2% Vapor Gard, each combined with

chlorothalonil and applied at 3-week intervals; 6) 0.25% Stressguard, 7) 0.5% Stressguard, and 8) 0.25% Transfilm, each combined with chlorothalonil and applied every two weeks (Table 2). Rates of use and application intervals for antitranspirants were based on product recommendations. Chlorothalonil was applied at 1.3 g a.i./liter. Spray solutions were applied to foliage and canes of plants until run-off using a CO<sub>2</sub> backpack sprayer between 8:30 a.m. and 10:00 a.m. Central Daylight Time.

**Data collection.** Weekly visual assessments of plants were made for disease, defoliation, vigor, and flower production. Infection by the fungus *D. rosae* causes spots on leaves and premature loss of leaves from plants such that only the newest growth remains non-symptomatic. Thus, blackspot severity on an individual plant is reflected by both the proportion of symptomatic foliage and the proportion of the plant that has defoliated. Blackspot ratings of foliage were based on a scale of 0–5 where 0 = no disease, 1 = symptoms of blackspot on ≤ 20% of foliage, 2 = 20 to 40% of foliage with symptoms of blackspot; 3 = symptoms on 40 to 60% of foliage, 4 = 60 to 80% of foliage affected, and 5 = >80% of foliage with symptoms of blackspot. Defoliation ratings were based on a similar scale of 0–5 with 0 = no defoliation to 5 = defoliation of >80% of plant. Vigor was rated on a scale of 1–3 with 1 = poorly formed plant with little or no new growth and 3 = well-developed plant with abundant new growth. Flower production was the weekly sum of buds showing color, plus blooms and spent flowers. Root sprouts, diseased or dead canes, and spent flowers were removed with weekly pruning. Plant height, the number of canes, and diameter of the three largest canes at a height of 20 cm were measured and counted monthly. Temperature and rainfall data were obtained from the weather station located near the main buildings of the Horticultural Unit approximately one kilometer from field plots.

**Data analysis.** Average values of ratings were calculated for each plot in each year of the study. Treatment effects in each year were determined through analysis of variance (ANOVA) using data over all weeks for disease, defoliation, vigor ratings and flower number, and data over all months for plant height, and cane number and diameter. Means of observations from antitranspirant treatments were compared to both the non-treated control and the weekly chlorothalonil treatment using Dunnett's two-tailed *t*-test for differences to a specified control with significance set at *P* = 0.05 unless otherwise stated. Cultivars split each of the treatment plots, so differences among cultivars were determined through ANOVA for sub-plots of a split-plot arrangement using Fisher's protected LSD with *P* = 0.05. Correlation coefficients were calculated among all variables.

## Results and Discussion

**Environmental conditions.** In 1996, July through October, daily maximum and minimum temperatures averaged 29.3C (85F) and 16.9C (62F), respectively. In 1997, May through August, 29.8C (86F) and 17.2C (63F) were the average daily maximum and minimum temperatures, respectively. In 1996, 62.7 cm rain fell over 46 raindays, during July through October; and 45.2 cm fell in 45 raindays in 1997 from May 1 through August (Table 1). These data indicate that temperature was not a limiting factor for blackspot development and

**Table 1. Rainfall occurrence and amounts at the Horticultural Sub-unit of the E. V. Smith Research Center, Alabama Experiment Station near Shorter, Alabama for 1996 and 1997.**

| Month     | 1996  |      | 1997  |      | 30-year norm <sup>a</sup> |      |
|-----------|-------|------|-------|------|---------------------------|------|
|           | cm    | days | cm    | days | cm                        | days |
| May       | —     | —    | 9.58  | 9    | 9.60                      | 7    |
| June      | —     | —    | 17.22 | 16   | 10.41                     | 8    |
| July      | 23.83 | 13   | 6.65  | 9    | 11.96                     | 9    |
| August    | 14.48 | 14   | 11.71 | 11   | 10.62                     | 8    |
| September | 20.90 | 12   | —     | —    | 9.22                      | 6    |
| October   | 3.45  | 7    | —     | —    | 6.65                      | 6    |
| Totals    | 62.66 | 46   | 45.16 | 45   | 58.46                     | 44   |

<sup>a</sup>Thirty-year norms are for the period 1961–1990.

rainfall occurred on approximately one-third of the days of the study.

**Overall factor effects.** Dunnett's tests indicated differences between specific antitranspirant treatments and either the nontreated control or the weekly chlorothalonil treatment in defoliation, vigor, and flower production in both years of the study. Plant height, numbers of canes, and cane diameters differed from the nontreated and weekly chlorothalonil treatments only in 1997. During both years, disease, defoliation, vigor, flower production, plant height, number of canes, and cane diameters differed among the cultivars. There were no significant interactions between foliar treatments and cultivar in either year.

**Treatment effects.** In 1996, disease and defoliation ratings averaged 2.40 and 2.67, respectively, over all treatments. There was no difference in disease ratings on foliage between plants treated with the antitranspirant solutions and either the control (nontreated) plants or plants treated weekly with chlorothalonil (Table 2). However, plants treated with Vapor Gard every 3 weeks, and Stressguard (0.25%) every 2 weeks, combined with chlorothalonil, as well as those treated weekly

with chlorothalonil, had lower defoliation than nontreated plants (Table 2). In addition, only nontreated and Wilt Pruf-treated plants had higher defoliation than those treated weekly. Antitranspirant treatments required 40–60% fewer applications than the fungicide-only treatment because of the extended interval between applications (Table 2).

Mean vigor ratings of plants in 1996 was 1.66 over all treatments, and an average of 3.73 flowers were produced each week on each plant. Plants treated with any of the antitranspirant treatments had lower vigor and flower production than those treated with chlorothalonil alone (Table 2). Plants treated with the Vapor Gard regime had lower plant vigor and flower production than nontreated plants. Plant height (average 60.9 cm), number of canes (average = 4.7), and cane diameters (average = 9.7 mm) were not affected by treatment in 1996.

In 1997, disease and defoliation ratings across all treatments averaged 1.27 and 1.51, respectively. Disease ratings did not differ significantly among treatments. Defoliation was higher on nontreated plants than on plants treated with several of the antitranspirant plus fungicide regimes (Table 3). Defoliation of plants treated with any of the antitranspirant regimes were similar to those treated weekly with chlorothalonil alone. Antitranspirant solutions, applied on longer intervals, did reduce fungicide use by 50 to 69% compared to weekly application of the fungicide alone. Vigor ratings, flowers, height, and cane growth of plants treated with antitranspirant solutions did not differ from those of nontreated plants and were lower than for plants treated weekly with chlorothalonil (Table 3).

**Cultivar effects.** Data for both 1996 and 1997 indicated that 'Cary Grant' had greater vigor, more flowers, grew taller, and had larger cane diameters than the two other cultivars (Table 4). In both study years, 'Princess Monaco' had lower disease and vigor ratings, were shorter and had fewer canes than other cultivars. 'Dolly Parton' had lower defoliation and higher disease ratings than other cultivars. 'Cary Grant' performed better than other roses in this study for all plant growth parameters except numbers of canes (Table 4).

**Table 2. Average disease and defoliation ratings for blackspot on rose, and plant vigor ratings according to treatments applied July 26 to October 11, 1996 on three hybrid tea rose cultivars.**

| Product, rate (v/v) <sup>a</sup> | Spray interval (wks) | Fungicide sprays (no.) | Disease rating <sup>b</sup> | Defol. rating <sup>b</sup> | Vigor rating <sup>c</sup> | Flowers (no.) |
|----------------------------------|----------------------|------------------------|-----------------------------|----------------------------|---------------------------|---------------|
| Nontreated                       | —                    | 0                      | 2.36                        | 3.06 <sup>vw</sup>         | 1.74*                     | 4.30          |
| Wilt Pruf, 5%                    | 3                    | 4                      | 2.55                        | 2.93*                      | 1.66*                     | 3.34*         |
| Nu Film 17, 2%                   | 3                    | 4                      | 2.55                        | 2.75                       | 1.60*                     | 3.40*         |
| Vapor Gard, 2%                   | 3                    | 4                      | 2.60                        | 2.35a                      | 1.41a*                    | 3.91a*        |
| Stressguard, 0.25%               | 2                    | 6                      | 2.28                        | 2.51a                      | 1.58*                     | 3.58*         |
| Stressguard, 0.5%                | 2                    | 6                      | 2.26                        | 2.77                       | 1.67*                     | 3.48*         |
| Transfilm, 0.25%                 | 2                    | 6                      | 2.21                        | 2.60                       | 1.61*                     | 3.53*         |
| Chlorothalonil                   | 1                    | 10                     | 2.39                        | 2.36a                      | 2.00a                     | 5.15          |
| LSD                              |                      |                        | ns                          | 0.60                       | 0.26                      | 1.51          |

<sup>a</sup>All treatments except the nontreated control included chlorothalonil (1.3 g a.i./liter) in a tank-mix with the product listed.

<sup>b</sup>Disease and Defoliation were assessed on a scale of 0 to 5 where 0 = no disease and 5 = >80% of plant showing disease symptoms or defoliated.

<sup>c</sup>Vigor was assessed on a scale from 1–3 where 1 = poorly developed plants and 3 = well developed plants with new growth.

<sup>w</sup>Means in each column, when followed by an 'a,' were significantly different from the nontreated control according to Dunnett's two-tailed *t*-test for difference from a single control (*P* = 0.05); means followed by an '\*' were significantly different from weekly chlorothalonil treatments according to Dunnett's two-tailed *t*-test (*P* = 0.05).

**Table 3.** Average disease and defoliation ratings for blackspot on rose, and plant vigor ratings resulting from treatments applied May 2 to August 22, 1997 on three hybrid tea rose cultivars.

| Product, rate (v/v) <sup>2</sup> | Spray interval (wks) | Fungicide sprays (no.) | Disease rating <sup>1</sup> | Defol. rating <sup>1</sup> | Vigor rating <sup>3</sup> | Flowers (no.)     | Height (cm)       | Canes (no.)      | Cane size (mm)    |
|----------------------------------|----------------------|------------------------|-----------------------------|----------------------------|---------------------------|-------------------|-------------------|------------------|-------------------|
| Nontreated                       | —                    | 0                      | 1.34                        | 1.83 <sup>*w</sup>         | 1.50 <sup>*</sup>         | 1.93 <sup>*</sup> | 62.2              | 3.9 <sup>*</sup> | 8.38 <sup>*</sup> |
| Wilt Pruf, 5%                    | 3                    | 5                      | 1.31                        | 1.61                       | 1.30 <sup>*</sup>         | 1.88 <sup>*</sup> | 54.1 <sup>*</sup> | 3.3 <sup>*</sup> | 7.39 <sup>*</sup> |
| Nu Film 17, 2%                   | 3                    | 5                      | 1.26                        | 1.50a                      | 1.39 <sup>*</sup>         | 1.96 <sup>*</sup> | 52.9 <sup>*</sup> | 4.0 <sup>*</sup> | 7.53 <sup>*</sup> |
| Vapor Gard, 2%                   | 3                    | 5                      | 1.21                        | 1.44a                      | 1.33 <sup>*</sup>         | 1.84 <sup>*</sup> | 54.0 <sup>*</sup> | 3.8 <sup>*</sup> | 7.56 <sup>*</sup> |
| Stressguard, 0.25%               | 2                    | 8                      | 1.25                        | 1.47a                      | 1.58 <sup>*</sup>         | 2.03 <sup>*</sup> | 60.1              | 3.8 <sup>*</sup> | 7.80 <sup>*</sup> |
| Stressguard, 0.5%                | 2                    | 8                      | 1.30                        | 1.55                       | 1.64 <sup>*</sup>         | 2.13 <sup>*</sup> | 62.7              | 4.0 <sup>*</sup> | 8.85 <sup>*</sup> |
| Transfilm, 0.25%                 | 2                    | 8                      | 1.20                        | 1.50a                      | 1.56 <sup>*</sup>         | 2.22 <sup>*</sup> | 62.2              | 3.8 <sup>*</sup> | 8.49 <sup>*</sup> |
| Chlorothalonil                   | 1                    | 16                     | 1.30                        | 1.43a                      | 2.07a                     | 3.22a             | 71.1              | 5.1a             | 10.10a            |
| LSD                              |                      |                        | n.s.                        | 0.32                       | 0.34                      | 0.85              | 14.2              | 1.1              | 1.98              |

<sup>1</sup>All treatments except the nontreated control included chlorothalonil (1.3 g a.i./liter) in a tank-mix with the product listed.

<sup>2</sup>Disease and Defoliation were assessed on a scale of 0 to 5 where 0 = no disease/no defoliation and 5 = >80% of foliage with blackspot symptoms/plants > 80% defoliated.

<sup>3</sup>Vigor was assessed on a scale from 1–3 where 1 = poorly developed plants and 3 = well developed plants with new growth.

<sup>\*</sup>Means in each column, when followed by an ‘a,’ were significantly different from the nontreated control according to Dunnett’s two-tailed *t*-test for difference from a single control (*P* = 0.05); means followed by an ‘\*’ were significantly different from weekly chlorothalonil treatments according to Dunnett’s two-tailed *t*-test (*P* = 0.05).

**Correlation coefficients.** In both study years, defoliation was consistently correlated to plant height ( $r = 0.56$  and  $0.34$ , for 1996 and 1997, respectively) and cane diameter ( $r = 0.63$  and  $0.41$ , respectively), and disease was correlated to numbers of canes ( $r = 0.24$  and  $0.32$ ) (data not shown). These data indicate that greater defoliation is correlated to taller plants and thicker canes. Since cultivars differed from one another in disease reaction, correlation coefficients were also calculated for each cultivar. On Dolly Parton and Princess Monaco, disease and defoliation were positively correlated ( $r = 0.42$  and  $0.54$ , respectively). No other significant correlations were calculated.

This study was designed to evaluate the efficacy of extending fungicide application intervals and controlling blackspot disease of rose when chlorothalonil is combined

with antitranspirant products. Combination treatments were applied at two- or three-week intervals, thus reducing the number of fungicide applications. During both study years, weather conditions were favorable for blackspot disease development.

In this study, three products in combination with chlorothalonil were evaluated with 3-week intervals between applications; two products, one at each of two rates, were evaluated for application with chlorothalonil every 2 weeks. Two and 3-week intervals between applications allowed a reduction of 40% to 69% in the number of fungicide applications. In both years of our study, plants treated with all but one of the antitranspirant regimes had similar disease and defoliation to plants treated weekly with the fungicide alone. In 1996, plants treated with Wilt Pruf plus chlorothalonil, on

**Table 4.** Average disease and defoliation for blackspot, and vigor ratings, flower production, plant height, number of canes, and cane diameters for each of three rose cultivars in Shorter, AL. Data are means from four replications and were collected from July 26 to October 11, 1996, and from May 2 to August 22, 1997.

| Year and cultivar | Disease <sup>2</sup> | Defoliation <sup>2</sup> | Vigor rating <sup>1</sup> | Flower production | Plant height (cm) | No. canes (cm) | Cane dia. (cm) |
|-------------------|----------------------|--------------------------|---------------------------|-------------------|-------------------|----------------|----------------|
| 1996              |                      |                          |                           |                   |                   |                |                |
| Cary Grant        | 2.28b <sup>*</sup>   | 2.83a                    | 1.76a                     | 4.63a             | 66.3a             | 5.0a           | 11.0a          |
| Dolly Parton      | 2.74a                | 2.38b                    | 1.66b                     | 3.22b             | 59.0b             | 5.1a           | 8.6c           |
| Princess Monaco   | 2.18b                | 2.81a                    | 1.56c                     | 3.39b             | 58.3b             | 4.5b           | 10.0b          |
| LSD               | 0.13                 | 0.22                     | 0.10                      | 0.56              | 4.54              | 0.49           | 0.7            |
| 1997              |                      |                          |                           |                   |                   |                |                |
| Cary Grant        | 1.29a                | 1.61a                    | 1.75a                     | 2.81a             | 73.5a             | 4.5a           | 9.9a           |
| Dolly Parton      | 1.36a                | 1.39b                    | 1.53b                     | 2.02b             | 53.4b             | 4.1b           | 7.0c           |
| Princess Monaco   | 1.16b                | 1.64a                    | 1.37c                     | 1.67c             | 53.6b             | 3.3c           | 8.1b           |
| LSD               | 0.08                 | 0.13                     | 0.13                      | 0.32              | 5.39              | 0.4            | 0.8            |

<sup>1</sup>Disease and Defoliation were assessed on a scale of 0 to 5 where 0 = no disease/no defoliation and 5 = >80% of foliage with blackspot symptoms or plants > 80% defoliated.

<sup>2</sup>Vigor was assessed on a scale from 1–3 where 1 = poorly developed plants and 3 = well developed plants with new growth.

<sup>\*</sup>Means followed by same letter are not significantly different according to Fisher’s least significant difference.

3-week intervals, had greater defoliation than weekly chlorothalonil alone. Defoliation of plants treated with the Vapor Gard and Stressguard (0.25%) regimes, as well as the weekly chlorothalonil treatment, had lower defoliation in both study years than nontreated plants. These results indicate that film-forming antitranspirants, when used in combination with fungicide, might allow longer intervals between fungicide applications and still provide adequate disease control. The benefits of using less fungicide, and the time savings with fewer applications, may appeal to rose growers.

In both years of the this study, vigor and flower production were less on plants treated with the antitranspirant regimes than plants treated weekly with chlorothalonil alone. In the second year, only, plants treated with antitranspirant regimes applied on 3-week intervals were shorter than those treated weekly; plants treated weekly with chlorothalonil alone had the greatest number of canes and largest cane size. In a previous study, disease levels were found to be negatively correlated to vigor (2). Similar significant correlations were not observed in this study, perhaps because of the similarity of disease and defoliation levels among treatments. However, defoliation tended to be greater on plants treated with each of the antitranspirant regimes and nontreated plants, and while not significant, this could have impacted vigor and growth of plants. Vigor and growth parameters of plants treated with the antitranspirant regimes were generally similar to those of nontreated plants, which indicates that these products are not phytotoxic.

In a previous study, the vigor of nontreated plants declined about 13% from the first to the second year (2). That decrease in vigor is similar to observations from this study where vigor ratings of non-treated plants and plants treated on 3-week intervals decreased about 14% from the first to the second year. In the earlier study, plants treated for consecutive years with a reduced fungicide regime were observed to have about 6% lower vigor from the first to the second year, while vigor of plants treated weekly with chlorothalonil did not change from year to year (2). In this study, vigor of plants treated on 2-week intervals, as well as those treated weekly, did not change from year to year. These results indicate that the reduced fungicide regime of this study, i.e., the combination of a film-forming antitranspirant with chlorothalonil, may be comparable to weekly chlorothalonil applications in terms of effects on vigor with use over consecutive years.

Ziv and Fredricksen (11) identified three types of antitranspirants: 1) stomatal regulating compounds, 2) reflective materials that increase reflection of solar radiation, and 3) film-forming compounds. The latex and pinolene products used in this study are film-forming compounds. Scanning electron micrographs of plants treated with film-forming antitranspirants showed that stomata were closed and covered by the films (6, 9). Stomatal closure over an extended time period could interfere with leaf photosynthesis by limiting gas exchange and/or affecting temperature regulation. This interference with photosynthesis could possibly

be the cause of the reduction in plant growth (as measured by height, canes and diameters, and flower production) observed in this study.

In a previous study, weekly chlorothalonil applications provided about 23% better disease control than applications made on 2-week intervals (4). The ratings made in the 1991 study encompassed both spotting of foliage and defoliation of plants; thus, higher ratings observed in that study could be due to a greater intensity of spotting (i.e., disease), greater defoliation, or both (4). In the current study, disease (i.e., spotting of foliage) and defoliation on plants treated on extended intervals did not statistically differ from plants treated weekly; although, on average, there was 5 to 10% higher defoliation with reduced fungicide applications. This indicates that the efficacy of chlorothalonil might be extended when it is combined with an antitranspirant, thus allowing longer intervals between fungicide applications.

Blackspot severity differed between rose cultivars. As observed in previous studies (2), 'Cary Grant' sustained only moderate disease levels, had better vigor, more flowers, and was taller than other cultivars. However, 'Cary Grant' had higher levels of defoliation than 'Dolly Parton,' a parameter not measured in the previous study (2). These observations indicate that cultivar choice in situations where blackspot is a problem, could be an important component of disease management. In addition, the preferred cultivar might depend on a grower's preference for tall plants with more flowers but little foliage or a greater degree of foliage with disease and fewer flowers.

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