

FUNGICIDE SPRAYS AFFECT LEAF CONDITION AND TREE APPEARANCE OF SOUTHERN MAGNOLIA¹

by William D. Goff, Ronald L. Shumack, Ken M. Tilt, and Austin K. Hagan²

Abstract. Several fungicides and chemical combinations were sprayed on southern magnolia trees to improve leaf condition and tree appearance. Leaf spot and leaf scorch symptoms, induced by the fungus *Glomerella cingulata*, were reduced significantly by sprays with benomyl, chlorothalonil, propiconazole, myclobutanil, or copper hydroxide. Addition of a non-ionic surfactant in sprays resulted in phytotoxicity, visible as a ring spot or faded brown patch on leaves. Tank mixing of copper hydroxide with other fungicides also increased phytotoxicity and did not improve disease control or leaf condition. Benomyl and propiconazole treatments were among the best in improving overall tree appearance.

Southern magnolia (*Magnolia grandiflora*) is a broadleaf evergreen tree noted for the beauty and fragrance of its massive white flowers and deep green glossy foliage. Although the tree is widely planted in the southern United States, little is known regarding effects of fungicides on foliar disease incidence and leaf and tree appearance.

In south central Alabama, a large orchard of several hundred magnolia trees was established from 1957 through 1959. The orchard was planted so that the leaves could be harvested and used in floral arrangements. For leaves to be useful in flower arrangements, they need to be attractive and free from any defects, including fungal leaf spot, insect damage, and leaf scorch. A preliminary evaluation and identification of pests associated with the symptoms in this orchard had been made (5). The pest problems identified included the fungal pathogens *Phyllosticta* sp., *Alternaria* sp., *Gloeosporium* sp., and *Colletotrichum* sp., as well as *Cephaleuros* algal leaf spot, and a bacterial leaf spot caused by *Pseudomonas* sp. Each of these pathogens is described in the literature as causing leaf defects on magnolia (3,4,6,7).

Materials and Methods

An experiment was conducted in 1991 to examine the effectiveness of various fungicides and combinations on the incidence of foliar symptoms. The experimental design was a randomized complete block with 4 trees in each treatment. All sprays were applied with a Savage Model 500 airblast sprayer (Savage Equipment Co., Madill, Oklahoma) at the rate of 2.7 gal per tree (196 gal/acre). Trees were spaced 20 × 30 ft, and trees were approximately 33 years old and 30 ft tall. Chemicals and formulations used were benomyl (Benlate 50W); chlorothalonil (Daconil 2787 4.17 F); myclobutanil (Nova 40W); copper hydroxide (Kocide 101 77W); propiconazole (Orbit 3.6 EC), and a non-ionic surfactant, (Red Panther Surfactant: alkylpolyoxyethylene ethers 90%). Treatment combinations and rates used are listed in Table 1. Each of the 19 treatment combinations was applied on a 2-week application schedule in April and May, then every 3 weeks from June 1 through the end of August, when spraying was terminated. All treated trees were the cultivar Saint Mary, which was more seriously damaged in previous years than the other predominant cultivar, Samuel Sommer.

On May 21, 1991, following a wet spring, symptoms were obvious on untreated trees, and an evaluation of symptom development was conducted. Ten individual leaves were collected from randomly selected shoots within a height of 8 to 12 ft on each tree. On each selected shoot, the third leaf from the base was rated, since prior observation indicated that leaves in this position apparently were more severely affected. Leaves

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2. Department of Plant Pathology, Auburn University, Auburn, AL 36849.

Table 1. Effect of various fungicides and combinations against leaf spot symptoms on southern magnolia.

Chemical & rate per acre	Symptoms	
	Angular spot	Marginal scorch
Nova 40W 12 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.1 ^z a ^y	1.2 ab
Daconil 2787 4.17 F 6 pt + Red Panther surf. 2.0 pt	1.2 a	1.0 a
Orbit 3.6 EC 8 oz + Red Panther surf. 2.0 pt	1.2 a	1.0 a
Benlate 50W 1.0 lb + Red Panther surf. 2.0 pt	1.2 a	1.0 a
Benlate 50W .5 lb + Red Panther surf. 2.0 pt	1.2 a	1.0 ab
Orbit 3.6 EC 8 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.2 a	1.0 ab
Orbit 3.6 EC 4 oz + Red Panther surf. 2.0 pt	1.3 a	1.0 a
Daconil 2787 4.17 F 36 pt+ Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.3 a	2.0 d
Orbit 3.6 EC 4 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.3 a	1.7 cd
Daconil 2787 4.17 F 3 pt + Red Panther surf. 2.0 pt	1.3 a	1.0 a
Benlate 50W 1 lb + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.3 a	1.5 bc
Daconil 2787 4.17 F 3 pt + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.4 a	1.1 ab
Nova 40 W 6 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.5 ab	1.1 a
Benlate 50W .5 lb + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.6 ab	1.3 ab
Nova 40 W 12 oz + Red Panther surf. 2.0 pt	1.6 ab	1.0 a
Nova 40 W 6 oz + Red Panther surf. 2.0 pt	1.8 ab	1.0 a
Kocide 101 77W 10 lb	2.1 b	1.0 a
Red Panther surf. 2.0 pt	2.7 c	1.1 ab
Control (unsprayed)	2.8 c	1.4 abc

^z1 to 8 rating, where 1 = 0% leaf surface affected, 2 = trace–6%, 6 = 6%–25%, 4 = 25%–50%, 5 = 50%–75%, 6 = 75%–94%, 7 = 94%–99%, 8 = 100%. Symptoms rated are described in text.

^yMean separation in columns by Duncan's Multiple Range Test, 5% level.

were taken to the laboratory and rated for symptom occurrence using a modification of the Horsfall-Barratt rating system (1), which estimates the percentage of the leaf surface area affected by the symptoms. The scale uses a 1 to 8 rating, where 1 = 0% of leaf surface affected, 2 = from a trace to 6%, 3 = 6% to 25%, 4 = 25% to 50%, 5 = 50% to 75%, 6 = 75% to 94%, 7 = 94% to 99%, and 8 = 100%. In addition to the individual symptom ratings, leaf condition was rated using the same scale with 8 the best rating.

An overall visual rating of tree condition was also made, using a 0 to 4 scale, where 0 = no visible symptoms on new growth, 1 = very light visible symptoms, 2 = light, 3 = moderate, and 4 = heavy symptom occurrence, the majority of new leaves with visible symptoms. All data were analyzed according to the experimental design using analysis of variance, Duncan's Multiple Range Test when appropriate, and preselected contrasts of treatment effects.

Results and Discussion

Occurrence of individual symptoms. Numerous distinct symptoms were present on the leaves. Each commonly occurring symptom is described below and treatment effects are discussed. Ratings for symptom occurrence are given in Tables 1 through 3.

Angular Leaf Spot. The most prevalent symptoms were small sunken angular necrotic spots, 1 to 4 mm in diameter, medium to dark brown and visible on both leaf surfaces, surrounded by a yellow halo visible on the upper surface. Spores produced on lesions were *Colletotrichum* sp. Fowler (2) described a magnolia leaf spot caused by *Glomerella cingulata*, a common fungus causing bitter rot on apple and anthracnose on many plants. Since this fungus has a *Colletotrichum* imperfect stage, our observance of *Colletotrichum* conidia associated with the lesions suggests the *Glomerella* leaf spot as the cause of the angular spot symptom, even though symptoms we observed differ considerably from those described for this disease by Fowler (2).

All treatments containing any of the fungicides (Benlate, Orbit, Daconil, Nova, or Kocide) reduced spot incidence significantly ($P < 0.05$) when com-

pared to the control or to surfactant only (Table 1). For the 4 fungicides tested at 2 rates, occurrence of spots ranked worst with Nova, followed by Benlate, Daconil, and Orbit. There were no significant differences among the fungicides. Addition of Kocide to the fungicides did not affect angular spot incidence compared to the fungicides used alone. Kocide alone was less effective in lowering incidence than were Benlate, Daconil, or Orbit.

Marginal Scorch. This symptom was exhibited by a dark brown necrosis usually beginning at the leaf margin near the distal end of leaf. The similarity of this symptom to the angular spot, our observation that it often appeared to be a coalescing of the angular spots, and the presence of *Colletotrichum* spores suggest that this was a more severe manifestation of the *Glomerella* leaf spot described above. Those treatments that controlled angular leaf spot generally were effective in reducing marginal scorch (Table 1).

Ring Spots. A common symptom on many leaves was a green-to-yellowish or sometimes light brown sunken line forming a ring, commonly 2 to 5 mm in diameter. These ring spots, normally several per leaf, had green centers and were visible only on the upper leaf surface. Our occasional observation of chemical residue in the rings led to our speculation that the rings were formed from the accumulation of chemical deposits at the borders of droplets. A review of the results of the ratings (Table 2) supports this idea, as no ring spot was observed in the untreated controls. Since the treatment receiving Kocide also showed no evidence of ring spot, we suspect that the addition of surfactant was involved. When compared to the 17 treatments receiving surfactant statistically by a contrast with the 2 treatments not receiving surfactant, there was a significantly higher ($P < 0.05$) incidence of ring spot in those with surfactant. Similarly, the treatment receiving surfactant only also had higher ($P < 0.05$) ring spot occurrence than did either the unsprayed check or the Kocide-only treatment. It appears that the surfactant we used induced the ring spots in magnolia.

A similar symptom, which we refer to as brown line, occurred on some leaves. This symptom was noted as an irregular line roughly following the

Table 2. Phytotoxicity symptoms on southern magnolia associated with fungicide treatments.

Chemical & rate per acre	Symptoms	
	Ring spot	Faded patch
Kocide 101 77W 10 lb	1.0 ^a a ^y	1.1 a
Control	1.0 a	1.0 a
Benlate 50W .5 lb + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.2 ab	1.3 ab
Benlate 50W 1.0 lb + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.3 abc	1.0 a
Daconil 2787 4.17 F 36pt+ Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.3 abcd	1.5 bc
Orbit 3.6 EC 4 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.5 abcde	1.8 cd
Red Panther surf. 2.0 pt	1.5 abcde	1.0 a
Nova 40W 6 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.5 abcde	1.4 ab
Nova 40W 12 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.6 bcdef	2.0 d
Benlate 50W 1.0 lb + Red Panther surf. 2.0 pt	1.6 bcdef	1.2 ab
Nova 40W 12 oz + Red Panther surf. 2.0 pt	1.6 bcdef	1.1 a
Daconil 2787 42.17 F 3 pt + Red Panther surf. 2.0 pt	1.7 bcdef	1.3 ab
Nova 40W 6 oz + Red Panther surf. 2.0 pt	1.8 cdef	1.1 ab
Orbit 3.6EC 8 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.8 cdef	1.1 a
Daconil 2787 4.17F 3 pt + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.9 efg	1.2 ab
Orbit 3.6EC 8 oz + Red Panther surf. 2.0 pt	1.9 efg	1.0 a
Benlate 50W .5 lb + Red Panther surf. 2.0 pt	1.9 defg	1.0 a
Daconil 2787 4.17F 3 pt + Red Panther surf. 2.0 pt	2.1 fg	1.3 ab
Orbit 3.6EC 4 oz + Red Panther surf. 2.0 pt	2.3 g	1.1 a

^a1 to 8 rating, where 1 = 0% leaf surface affected, 2 = trace-6%, 6 = 6%-25%, 4 = 25%-50%, 5 = 50%-75%, 6 = 75%-94%, 7 = 94%-99%, 8 = 100%. Symptoms rated are described in text.

^yMean separation in columns by Duncan's Multiple Range Test, 5% level.

leaf margin up to 2.5 cm from the edge visible on the lower surface. Similarity of the symptom to ring spots, and the fact that response to treatments closely paralleled response of ring spot occurrence to treatments, suggests that the brown line occurring on the lower leaf, like the ring spots occurring on the upper leaf surface, is a phytotoxic effect induced by the surfactant.

Faded Patch. Some leaves showed a light brown scorched discoloration, which is noted as a faded patch, on the upper surface. The symptom appeared to begin in the middle of one-half of the leaf and progress outward toward the leaf margin and inward toward the midvein. Typically, the affected area would form an irregular ellipse 3 to 5 cm long and 1.5 to 3 cm wide. On the undersurface, a distinctive light brown elliptical discoloration was apparent.

This symptom was completely absent in the untreated control, in the treatment receiving Kocide only, and in the treatment receiving surfactant only (Table 2). Occurrence was also absent in some of the Benlate treatments. When we averaged the ratings for all treatments containing a particular fungicide, average rating for the symptoms was lowest (1.1) with Benlate, followed by Orbit (1.2), Daconil (1.3), and Nova (1.4). With both Nova and Orbit, symptom occurrence was higher with the higher rate, and occurrence was higher when Kocide was tank-mixed with these 2 chemicals than when the chemicals were used alone.

Evidence suggests the discolored patch is a phytotoxic response that may be induced by spraying chemicals, especially if high rates and tank mixes are used. The symptom is somewhat similar to sunburn symptoms on other plants, and may be a result of increased sensitivity to sunburn on the chemically treated leaves.

Leaf and tree condition. Leaf condition ratings (Table 3) indicate that none of the treatments improved the percentage of symptom-free leaf surface area significantly ($P < 0.05$) when compared to the unsprayed control. While several treatments dramatically lessened incidence of the diseases, the chemicals increased the incidence of the phytotoxicity symptoms. These 2 effects counteracted each other, so that overall leaf rating

Table 3. Effect of various fungicides and combinations on leaf and tree appearance on southern magnolia.

Chemical & rate per acre	Symptoms	
	Tree appearance rating ^z	Leaf rating ^y
Orbit 3.6EC 8 oz + Red Panther surf. 2.0 pt	1.0 a ^x	6.8 b
Benlate 50W 1.0 lb + Red Panther surf. 2.0 pt	1.1 a	7.0 a
Benlate 50W .5 lb + Red Panther surf. 2.0 pt	1.1 a	7.0 a
Orbit 3.6EC 8 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.6 ab	6.7 abc
Nova 40W 12 oz + Red Panther surf. 2.0 pt	1.6 a	6.8 ab
Orbit 3.6EC 4 oz + Red Panther surf. 2.0 pt	1.6 abc	6.8 ab
Kocide 101 77W 10 lb + Benlate 50W 1.0 lb + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.6 abc	6.9 ab
Daconil 2787 4.17 F 3 pt+ Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	1.8 bcd	6.7 ab
Daconil 2787 4.17 F 3 pt+ Red Panther surf. 2.0 pt	1.9 bcd	6.4 abcd
Benlate 50W .5 lb + Red Panther surf. 2.0 pt	1.9 bcd	6.9 ab
Nova 40W 6 oz + Red Panther surf. 2.0 pt	2.2 bcde	6.2 bcd
Daconil 2787 4.17 F 6 pt+ Red Panther surf. 2.0 pt	2.3 cde	6.6 abc
Daconil 2787 4.17 F 6 pt+ Red Panther surf. 2.0 pt	2.4 de	6.5 abc
Nova 40W 6 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	2.6 ef	6.3 abcd
Control	2.8 ef	6.3 abcd
Nova 40W 12 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	3.0 fg	6.4 abcd
Daconil 2787 4.17 F 6 pt+ Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	3.1 fg	6.0 cd
Orbit 3.6EC 4 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	3.3 g	5.8 d
Orbit 3.6EC 4 oz + Kocide 101 77W 10 lb + Red Panther surf. 2.0 pt	3.4 g	5.8 d

^z0 to 5 rating, where 0 = no visible symptoms on new growth, 1 = very light visible symptoms, 2 = light, 3 = moderate, 4 = heavy symptom occurrence, majority of new leaves with visible symptoms.

^y1 to 8 rating, where 1 = 0% leaf surface affected, 2 = trace–6%, 6 = 6%–25%, 4 = 25%–50%, 5 = 50%–75%, 6 = 75%–94%, 7 = 94%–99%, 8 = 100%. Symptoms rated are described in text.

^xMean separation in columns by Duncan's Multiple Range Test, 5% level.

did not change. The addition of the surfactant, which increased the ring spot symptom, resulted in a lower leaf rating in several treatments that would have had excellent ratings otherwise. Similarly, the tank mixing of the fungicides with Kocide, which had been aimed at bacterial spot control, increased phytotoxicity. In this evaluation, bacterial spot did not develop to an appreciable extent, so there was no improvement in control of diseases by adding Kocide.

Several treatments appear to be very promising, if the phytotoxicity problem can be eliminated by omitting surfactant. The 8.0 oz per acre rate of Orbit had the best ranking of overall tree condition (Table 3) and controlled *Glomerella* leaf spot symptoms well. Benlate at either 1.0 lb or 0.5 lb per acre also gave excellent overall results, with the exception of the ring spot. With Benlate, however, fungi have commonly developed tolerance when the chemical is used routinely, and we would caution against its regular use.

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*Department of Horticulture
Auburn University
Auburn, AL 36849*