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EVALUATION OF FUNGICIDES FOR CONTROL OF ALTERNARIA BROWN SPOT AND CITRUS SCAB

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Abstract. **From 1991-96, registered and experimental fungicides were evaluated for control of Alternaria brown spot caused by *Alternaria alternata* pv. *citri* and citrus scab caused by *Elsinoe fawcettii*. In most cases, three fungicide applications were made to susceptible tangerines or tangerine hybrids from March to May and fruit was evaluated at harvest for disease severity and percentage of marketable fruit. Iprodione (Rovral), captafol (Difolatan), chlorothalonil (Bravo), azoxystrobin and copper fungicides provided control of Alternaria brown spot. Neem oil (Trilogy) was effective in some tests, but not in others. Tebuconazole (Folicur), fosetyl-Al (Aliette), propiconazole (Tilt), captan, thiophanate-methyl, and benomyl (Benlate) were ineffective against Alternaria brown spot. Benomyl, ferbam (Carbamate), fluazinam, fenbuconazole, tebuconazole, thiophanate-methyl + ziram, kresoxim-methyl, and copper fungicides all reduced the severity of citrus scab. Iprodione, fosetyl-Al (Aliette), and Neem oil (Triology) were ineffective for control of this disease. A limited number of new fungicides may be registered for use on citrus in the next few years.**

Alternaria brown spot of tangerine, caused by *Alternaria alternata* (Fr.) Keissler pv. *citri*, was first recorded in Florida in 1974 (Whiteside, 1976). The disease was initially observed on Dancy tangerines although it was known to attack Minneola tangelos and some other tangerines and their hybrids (Whiteside, 1976). In the 1980s after a series of freezes, many growers diversified their holdings and planted more fresh fruit varieties such as Minneola and Orlando tangelos, Murcotts, and other tangerine hybrids which were susceptible to Alternaria brown spot. Captafol (Difolatan) was highly effective in reducing fruit drop and fruit blemishes caused by *Alternaria* (Whiteside, 1979). Copper fungicides reduced fruit blemishes but were less effective at preventing fruit losses. Usually one application at petal fall followed by sprays 1 and 2 months later of either of the above products provided acceptable control.

Currently brown spot is a serious problem on Minneola tangelos and Murcotts. It may also be severe on Orlando, Lee, and Nova tangelos, Dancy tangerines, and some other cultivars. However, prices for the latter cultivars have not been sufficiently high in recent years to pay for extensive control programs. Some groves of susceptible varieties have been removed to avoid having to deal with the problem. Robinson, Fallglo, and Sunburst tangerines have been largely unaffected, although some Sunburst groves have had significant problems recently and even grapefruit has been affected (Timmer and Peever, 1997a). Captafol is no longer registered for use on citrus and copper fungicides are the only products recommended for control of brown spot. Iprodione (Rovral) was available for use on 4,000 acres under an experimental use permit for several years, but the temporary tolerance on this product was canceled in 1997. Its future availability remains in question. In an attempt to control the disease, some growers have made as many as 10-15 applications of copper fungicides from first flush until mid-July.

Citrus scab, caused by *Elsinoe fawcettii* Bitancourt and Jenkins, is a serious problem on fruit for the fresh market in Florida. It is most severe on Temples, Murcotts, some other tangerines and tangerine hybrids, and grapefruit. The disease has become much more severe in many areas following several years of high rainfall.

Captafol (Difolatan) and benomyl (Benlate) were the primary products used for scab control and were highly effective (Whiteside, 1981). The registration of captafol has been canceled and scab in many groves has developed resistance to benomyl (Whiteside, 1980). Thus growers have had to resort to the use of copper fungicides and ferbam which were the primary products used in the 1970s (Whiteside, 1981). These products were much less effective than captafol and benomyl. Currently, 3 applications are often needed for control, one at first flush, a second at petal fall, and the third three weeks after petal fall.

Producing high quality fruit for the fresh market has been an increasing challenge to the ingenuity of growers and production managers because of the limited number of registered fungicides. The Citrus Research and Education Center has an ongoing program of evaluation of fungicides for control of foliar fungal diseases to support registration of products and provide information to growers. This paper presents the results of these tests for control of Alternaria brown spot and citrus scab conducted over the last several years. Results of some of these tests have been published elsewhere (Timmer and Zitko, 1994; 1995).

Materials and Methods

Alternaria brown spot. Six experiments were established to evaluate fungicides for their ability to control Alternaria brown spot from 1991-1996 (Table 1). In all cases, treatments were arranged in randomized complete block designs. The cultivars used, tree age, location, number of replications, number of trees per replication and fungicide application dates are presented in Table 1. In Experiments 1, 4, 5 and 6, fungicides were applied with a handgun at 200-250 psi using about 1-2 gal/tree depending on tree size. In Experiments 2 and 3, fungicides were applied with an airblast sprayer using 100 gal/acre. Except where trees were small and widely spaced, an unsprayed guard tree was located between treated plots. In experiments where airblast sprayers were used an untreated guard row was located between treated rows.

Citrus scab. Four experiments were established to evaluate fungicides for their ability to control citrus scab from 1991-96 (Table 1). As with the experiments for Alternaria brown spot, treatments were arranged in a randomized complete block design and experimental details are presented for Experiments 5 and 7-9 in Table 1. All treatments were applied with a handgun at 200-250 psi using about 1 gal/tree except in Experiment 9 where about 7 gal/tree were used. No guard trees were used for the young trees in Experiment 5,

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Table 1. Cultivars, grove locations, dates of applications, and specific details of experiments to evaluate fungicides for control of Alternaria brown spot and citrus scab.

Expt. no.	Cultivar	Grove location	No. of replications	Trees/replication	Tree age (yr)	Dates of applications
1	Dancy tangerine	Arcadia	9	1	3	3/20, 5/1, 5/24/91
2	Minneola tangelo	Polk City	7	3	5	4/12, 5/27, 6/11/93
3	Minneola tangelo	Polk City	7	3	6	3/4, 4/6, 5/13/94
4	Dancy tangerine	Haines City	6	2	7	3/21, 4/21, 5/15/95
5	Murcott	Sebring	6	2	4	3/14, 4/17, 5/8/95
6	Murcott	Sebring	5	2	5	3/7, 4/23, 5/14, 6/4/96
7	Murcott	Arcadia	7	1	3	3/20, 5/1, 5/24/91
8	Murcott	Sebring	5	2	3	2/22, 3/29, 5/4/94
9	Duncan grapefruit	Bowling Green	5	3	>25	3/29, 4/23, 5/14/96

7 and 8, but guard trees were located between treated plots in Experiment 9.

Disease assessment. Evaluations of disease control were made after the fruit had developed some color in the fall usually in October or November of each year. Disease severity was rated on a scale of: 0 = no lesions present; 1 = low numbers of small lesions, fruit marketable as fresh; 2 to 5 = fruit marketable only for processing, increasing disease severity. The percentage of the fruit in categories 0 and 1 was calculated for each treatment and presented as the percentage of the fruit suitable for the fresh market. In some of the tests for evaluations of control Alternaria brown spot, the number of fruit per tree was counted since this disease is known to cause fruit drop (Whiteside, 1976; 1979).

In Experiment 2, severity of Alternaria brown spot on foliage was rated on a scale of 0 to 5 on 23 Apr. 1991, after the first spray since disease was severe at that time. In Experiment 5, scab severity on foliage was rated on the same scale on 25 May 1995.

Disease severity ratings, the percentages of marketable fruit and fruit counts were subjected to analysis of variance and treatment means separated by the Waller-Duncan k-ratio t test, P ð 0.05. Fruit counts were square-root transformed prior to analysis.

Results

Alternaria brown spot. In Experiment 1, nearly all of the products tested significantly reduced the disease severity rating and increased the percentage of marketable fruit and also increased fruit production (Table 2). Fosetyl-Al alone and iprodione at the low rate were the least effective treatments. The copper fungicides, iprodione alone at the high rate or at a reduced rate combined with fosetyl-Al, and captafol provided the best control. The best fungicides in the test were slightly less effective with 3 applications than the grower program (Table 2). However, the grower made 9 applications intended for Alternaria brown spot control.

In Experiment 2, disease pressure was high especially in late spring and early summer which resulted in severe fruit blemishes but little fruit loss (Table 3). All of the treatments except propiconazole reduced the disease severity rating but only iprodione at the high rate of the 4SC formulation significantly increased the percentage of marketable fruit. Captafol did not give significantly better control than copper fungicides or iprodione on leaves or fruit.

Experiment 3 was conducted in the same grove as the previous experiment a year later. Disease was extremely severe and yield was reduced to near zero in the unsprayed controls (Table 4). Even with 3 applications of captafol only a few fruit remained until harvest and most of the fruit was blemished. Iprodione, captafol, and copper hydroxide significantly reduced disease severity and increased fruit numbers, but captan and propiconazole were ineffective.

For Experiment 4 in 1995, a Dancy tangerine grove where the disease was much less severe was used for fungicide evaluations. All of the formulations of iprodione as well as copper hydroxide and neem oil significantly reduced disease severity and increased the percentage of marketable fruit (Table 5).

In Experiment 5, a number of products that were included in the test were intended more for control of citrus scab, but were also evaluated for Alternaria brown spot. Only spray programs which included at least one copper hydroxide spray effectively reduced the disease severity on fruit, increased the percentage of marketable fruit, and increased the fruit count (Table 6). None of the other products was effective in controlling Alternaria brown spot and some of the treatments with thiophanate-methyl actually increased disease severity.

Table 2. Evaluation of fungicides for control of Alternaria brown spot of Dancy tangerine near Arcadia in 1991. Experiment 1.

Fungicide	Trade name and formulation	Rate/acre	Fruit rating (0-5)[z]	Marketable fresh (%)[z]	No. of fruit/tree
Unsprayed control	—	—	1.98 a[y]	13.8 d	8.7 d
Fosetyl-Al	Aliette 80 WP	5.0 lb	1.72 ab	37.4 c	25.4 cd
Iprodione	Rovral 4 SC	0.375 gal	1.67 ab	40.5 c	41.6 bc
Copper hydroxide	Kocide DF	8.0 lb	1.35 c	61.4 a	47.5 abc
Iprodione	Rovral 4 SC	0.5 gal	1.34 c	60.1 ab	77.1 ab
Copper ammonium carbonate	Copper-Count-N	2 gal	1.56 bc	43.4 bc	77.7 ab
Captafol	Difolatan 80 Sprills	5.0 lb	1.32 c	62.1 a	83.0 ab
Iprodione + fosetyl-Al	Rovral + Aliette	0.19 gal + 5.0 lb	1.46 bc	52.0 abc	93.6 a
Grower program[x]	—	—	1.25	73.0	97.9

[z]All trees with less than 6 fruit remaining were eliminated from the analysis.
[y]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.
[x]The following applications were made at the indicated rate per acre: Difolatan 80 Sprills, 5.0 lb (1 Mar.); Kocide 606, 1 gal (18, 27 Apr., 5 May); Kocide 606, 1.5 gal (21 May); Kocide 606, 2 gal (30 May) and Kocide 606, 1.2 gal (18, 25 June, 18 July).

Table 3. Evaluation of fungicides for control of Alternaria brown spot on Minneola tangelo near Polk City in 1993. Experiment 2.

Fungicide	Trade name and formulation	Rate/acre	Foliage rating (0-5)	Fruit rating (0-5)	Marketable fresh (%)	No. of fruit/tree
Unsprayed control	—	—	3.1 a[x]	2.65 a	7.1 b	56
Propiconazole[z]	Tilt 3.6 E	8.0 oz	2.7 ab	2.50 ab	13.7 b	61
Copper hydroxide	Kocide DF	8.0 lb	2.3 bc	2.21 bc	24.1 ab	60
Captafol	Difolatan 80 Sprills	5.0 lb	2.1 bcd	2.06 c	36.9 ab	86
Iprodione[y]	Rovral 50 WG	1.5 lb	1.7 cd	1.81 bc	27.7 ab	79
Iprodione[y]	Rovral 50 WG	2.0 lb	1.6 d	2.06 c	24.5 ab	65
Iprodione[y]	Rovral 4 SC	0.75 qt	2.1 bcd	2.15 c	28.0 ab	64
Iprodione[y]	Rovral 4 SC	1.0 qt	1.8 cd	1.88 c	41.6 a	87 N.S.

[z]Sun 7N spray oil 435 added at 0.5%.
[y]Triton CS-7 added at 1.6 oz/100 gal.
[x]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.

Table 4. Evaluation of fungicides for control of Alternaria brown spot on Minneola tangelos near Polk City in 1994. Experiment 3.

Fungicide	Trade name and formulation	Rate/acre	Fruit rating (0-5)	No. fruit/tree
Unsprayed control	—	—	3.6 a[x]	0.7 e
Captan	Captec 4 L	1.0 gal	3.2 ab	1.7 de
Captan	Captec 4 L	0.5 gal	3.1 ab	1.1 e
Propiconazole[z]	Tilt 3.6 E	8.0 oz	3.0 ab	1.1 e
Copper hydroxide	Kocide 101 50 WP	8.0 lb	2.6 b	3.8 cd
Iprodione[y]	Rovral 10566A 2.2 SC	0.45 gal	2.8 b	6.7 bc
Iprodione[y]	Rovral 10370A 50 WG	2.0 lb	2.6 b	12.1 a
Iprodione[y]	Rovral 10370A 50 WG	1.5 lb	2.6 b	7.7 abc
Iprodione[y]	Rovral 4 SC	1.0 qt	2.8 b	9.9 ab
Iprodione[y]	Rovral 4 SC	0.75 qt	2.8 b	11.5 ab
Captafol	Difolatan 80 Sprills	5.0 lb	2.9 b	13.2 a

[z]Citrus spray oil added at 0.5%.
[y]Kinetic added at 6 oz/100 gal.
[x]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.

Experiment 6 was conducted in 1996 in the same Murcott grove as the previous experiment. The treatments which included copper hydroxide, chlorothalonil, and kresoxim-methyl significantly reduced disease severity and increased the percentage of marketable fruit (Table 7). Thiophanate-methyl and tebuconazole were ineffective. Only the kresoxim-methyl treatment significantly increased the fruit counts.

Citrus scab. In Experiment 7, only captafol, benomyl, and fluazinam significantly decreased scab severity on fruit or increased the percentage of marketable fruit (Table 8). Iprodione and fosetyl-Al were ineffective for scab control. Even products like copper fungicides, fluazinam, and ferbam, which have controlled the disease in other tests were not effective in this case. However, ferbam was used at a much lower than the recommended rate. The grower program (Table 8) was as effective as most of the materials applied in the tests, but required 5 applications intended for scab control compared to the 3 used in the experiment.

In Experiment 8, the Murcott grove used was severely affected by scab (Table 9). Propiconazole was the most effective, but the third application was made on 19 Apr. just prior to a major infection period, whereas other products were applied on 4 May. The earlier application date for propiconazole was chosen due to residue considerations with this product. The fluazinam-copper hydroxide program was also quite effective. A number of other products such as fenbuconazole, myclobutanil, ferbam, and captan significantly reduced disease severity and increased the percentage of marketable fruit. Iprodione was generally ineffective for scab control, but the iprodione + fosetyl-Al tank mix provided some disease control.

Table 5. Evaluation of fungicides for control of Alternaria brown spot on Dancy tangerines near Haines City in 1995. Experiment 4.

Fungicide	Trade name and formulation	Rate/acre	Fruit rating (0-5)	Marketable fruit (%)
Unsprayed control	—	—	2.06 a[y]	24.5 b
Copper hydroxide	Kocide 101 50 WP	10.0 lb	1.52 b	56.7 a
Neem oil	NeemGard 90%	5.0 gal	1.42 b	63.3 a
Neem oil	NeemGard 90%	2.5 gal	1.54 b	50.3 a
Iprodione	Rovral 10566A	1.82 qt	1.59 b	53.0 a
Iprodione	Rovral 10566A	1.37 qt	1.47 b	58.7 a
Iprodione[z]	Rovral 10370A 50 WG	2.0 lb	1.39 b	66.5 a
Iprodione[z]	Rovral 10370A 50 WG	1.5 lb	1.43 b	61.5 a
Iprodione[z]	Rovral 4 SC	1.0 qt	1.63 b	47.2 ab
Iprodione[z]	Rovral 4 SC	0.75 qt	1.59 b	50.3 a

[z]Citrus spray oil added at 1%.
[y]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.

Table 6. Evaluation of fungicides for control of Alternaria brown spot and citrus scab on Murcotts near Sebring in 1995. Experiment 5.

			Scab			Alternaria brown spot		
Fungicide	Trade name and formulation	Rate/acre	Foliage rating (0-5)	Fruit rating (0-5)	Marketable fruit (%)	Fruit rating (0-5)	Marketable fruit (%)	No. of fruit/tree
Unsprayed control	—	—	3.5 a[x]	1.38 ab	63.3 de	1.72 bcde	49.9 cd	141 de
Thiophanate-methyl	Topsin 70 WP (1,2,3)[z]	1.5 lb	3.3 ab	1.32 abc	67.5 cd	1.90 abc	38.7 e	114 ef
Thiophanate-methyl +	Topsin 70 WP +	1.5 lb	0.9 de	0.51 e	96.1 a	1.98 a	37.8 e	92 f
ziram	Ziram 76 W (1,2,3)[y]	5.0 lb						
Thiophanate-methyl	Topsin 70 WP (1,2,3)	2.0 lb	2.2 c	0.99 d	79.3 b	1.82 abcd	46.2 cde	141 de
Neem oil	NeemGard 90% (1,2,3)	2.5 gal	2.9 b	1.24 bc	67.2 cd	1.64 def	52.9 bc	139 de
Neem oil	NeemGard 90% (1,2,3)	5.0 gal	3.0 ab	1.52 ab	57.6 e	1.69 def	52.3 bcd	125 ef
Benomyl	Benlate 50 WP (1,2,3)	2.0 lb	2.2 c	1.12 cd	73.4 bc	1.93 ab	41.8 de	107 efg
Ferbam	Carbamate 76 W (1,2,3)	12.0 lb	0.9 de	0.52 e	94.9 a	1.87 abc	45.3 cde	169 ad
Benomyl;	Benlate 50 WP (1);	2.0 lb	1.0 de	0.61 e	94.5 a	1.21 h	70.5 a	199 bc
copper hydroxide	Champ Formula II F (2,3)	1.0 gal						
Copper hydroxide	Champ Formula II F (2,3)	0.75 gal	1.2 d	0.55 e	96.0 a	1.40 gh	68.7 a	223 ab
Fluazinam;	Fluazinam (1,2)	2.5 pt	0.3 f	0.51 e	97.2 a	1.57 efg	61.0 ab	253 a
copper hydroxide	Champ Formula II F (3)	1.0 gal						
Fluazinam;	Fluazinam (1,2)	5.0 pt	0.6 ef	0.44 e	99.0 a	1.48 fg	67.0 a	252 a
copper hydroxide	Champ Formula II F (3)	1.0 gal						

[z]1,2,3 = product applied at the first, second, and third sprays.
[y]Applied as a tank mix in all three sprays.
[x]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.

The following year, 1995, products were evaluated for scab as well as for Alternaria brown spot in the same grove (Experiment 5, Table 6). The most effective treatments were the fluazinam-copper hydroxide program, the benomyl-copper hydroxide program, and copper hydroxide, fluazinam, or ferbam treatments individually. The scab organism in this grove had previously developed some resistance to benomyl and thus control was not highly effective with this product or the related compound thiophanate-methyl. However, the thiophanate-methyl plus ziram tank mix gave excellent scab control. Neem oil was ineffective for scab control. Ratings on foliage corresponded closely to those on fruit.

In Experiment 9, products were evaluated for scab control on Duncan grapefruit (Table 10). All of the products evaluated significantly reduced scab severity and increased the percentage of marketable fruit. There were no differences among products except that kresoxim-methyl at the high rate was more effective than copper hydroxide + oil.

Discussion

Relatively few of the products tested were highly effective for control of Alternaria brown spot. The sterol-biosynthesis-inhibiting fungicides such as propiconazole and tebuconazole had limited effects on Alternaria brown spot. Tebuconazole was reported to be as effective as iprodione in South Africa (Schutte et al., 1992), but was used at much higher rates than those evaluated in Florida tests

Table 7. Evaluation of fungicides for control of Alternaria brown spot on Murcotts near Sebring in 1996. Experiment 6.

Fungicides	Trade name and formulation	Rate/acre	Fruit rating (0-5)	Marketable fruit (%)	No. of fruit/tree
Unsprayed control	—	—	1.87 ab[w]	34.8 ef	297 bcde
Thiophanate-methyl;	Topsin 70 W (1,2,3)[z];	1.5 gal	1.97 a	27.4 f	319 bcd
copper hydroxide	Champ Formula II F (4)	1.0 gal			
Thiophanate-methyl + ziram;	Topsin 70 W + Ziram 76 W (1,2,3)[y];	1.5 lb + 5.0 lb	1.92 a	31.8 ef	265 cde
copper hydroxide	Champ Formula II F (4)	1.5 gal			
Thiophanate-methyl;	Topsin 70 W (1,2,3);	2.0 lb	1.89 ab	32.2 ef	242 e
copper hydroxide	Champ Formula II F (4)	1.0 gal			
Tebuconazole[x]	Folicur 3.6 F (1,2,3,4)	4 oz	1.87 ab	38.2 def	306 bcde
Tebuconazole[x]	Folicur 3.6 F (1,2,3,4)	6 oz	1.95 a	34.2 efg	322 bcd
Tebuconazole[x]	Folicur 3.6 F (1,2,3,4)	8 oz	1.77 abc	40.8 cde	315 bcd
Chlorothalonil	Bravo 720 (1,2,3,4)	4 pt	1.60 cd	49.6 bcd	332 abc
Chlorothalonil	Bravo Ultrex (1,2,3,4)	3.64 lb	1.52 d	54.4 b	365 ab
Neem oil;	Trilogy (1,3);	2.5 gal	1.60 cd	50.0 bc	252 de
copper hydroxide	Champ Formula II F (2,4)	1.0 gal			
Azoxystrobin	ICI A5504 80 WG (1,2,3,4)	2.0 lb	1.16 e	74.0 a	398 a
Copper hydroxide	Champ Formula II F (1,2,3,4)	1.0 gal	1.63 cd	48.6 bcd	346 ab
Copper hydroxide	Champ Formula II F (2,3,4)	1.0 gal	1.64 cd	51.4 bc	337 abc
Benomyl + ferbam;	Benlate 50 W + Carbamate 76 W (1,2,3)[y];	1.5 lb + 5.0 lb	1.64 cd	48.6 bcd	272 cde
copper hydroxide	Champ Formula II F (4)	1.0 gal			
Ferbam	Carbamate 76 W (1,2,3,4)	5.0 lb	1.68 bcd	47.8 bcd	310 bcde

[z]1,2,3,4 = product applied at the following times: 1 = first flush, 2 = petal fall, 3 = 3 wk after petal fall, 4 = 6 wk after petal fall.
[y]Applied as a tank mix in all three sprays.
[x]Added Surf Aid 80-20 at 4 oz/100 gal.
[w]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.

and was used only in combination with mancozeb. Benzimidazole

Table 8. Evaluation of fungicides for control of citrus scab on Murcotts near Arcadia in 1991. Experiment 7.

Fungicide	Trade name and formulation	Rate/acre	Fruit rating (0-5)	Marketable fruit (%)
Unsprayed control	—	—	1.76 a[y]	42.9 d
Iprodione	Rovral 4 SC	0.375 gal	1.63 ab	49.1 d
Iprodione	Rovral 4 SC	0.5 gal	1.59 ab	54.6 cd
Fosetyl-Al	Aliette 80 WP	5.0 lb	1.59 ab	54.8 cd
Iprodione + fosetyl-Al	Rovral + Aliette	0.19 gal + 5.0 lb	1.58 ab	54.6 cd
Fluazinam	Fluazinam 50 W	1.67 lb	1.51 abc	53.2 cd
Copper ammonium carbonate	Copper-Count-N	2 gal	1.50 abc	60.7 bcd
Ferbam	Carbamate 76 WP	5.0 lb	1.50 abc	58.2 bcd
Copper hydroxide	Kocide DF	8.0 lb	1.50 abc	59.6 bcd
Fluazinam	Fluazinam 50 W	3.3 lb	1.41bc	63.1 bcd
Captafol	Difolatan 80 Sprills	5.0 lb	1.24 cd	75.4 abc
Benomyl	Benlate 50 DF	3.0 lb	1.00 d	88.2 a
Grower program[z]	—	—	1.22	78.8

[z]The following applications were made at the indicated rate per acre: Benlate 50 WP 1.5 lb (2 Mar.); Kocide 606 1.0 gal (10, 18 Apr., 5 May); Kocide 606 1.5 gal (21 May); Kocide 606 2.0 gal (30 May); Kocide 606 1.25 gal (8 June); Kocide DF 4 lb (18 July).
[y]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.

fungicides such as benomyl and thiophanate-methyl were completely ineffective for Alternaria brown spot as they are for most diseases caused by this pathogen. Ferbam showed slight suppressive activity but could not be used alone for control of this disease. Captafol provided good control as in the past (Whiteside, 1979), but is no longer registered for use on citrus. Copper fungicides provided surprisingly good control in many cases and are currently the only reliable fungicides generally available. Iprodione provided good control, but its future availability is in doubt. Neem oil was effective in some tests and reduced brown spot lesions on fruit. Its utility in the future will depend on development of fungicide programs or combinations that provide consistent control.

Future prospects for highly effective products against Alternaria brown spot are limited. Chlorothalonil was ineffective in earlier work (Whiteside, 1979), but was used at a low rate with only 2 applications. In the current tests, chlorothalonil was effective and this product is widely used on peanuts, vegetables, and other crops. However, since Alternaria brown spot is the only citrus disease which it effectively controls; the prospects for future registration on citrus appear dim. Azoxystrobin appears very promising for use on citrus, but it is a new product and may not be registered anytime soon. It proved to be effective at lower rates in a 1997 test (Timmer and Zitko, unpublished).

Thus, in the near future, growers will have only copper products to deal with the brown spot problem. Where conditions are not so highly favorable for the disease, it is possible to manage the disease with these products. If iprodione had been used excessively, *Alternaria* would likely have developed resistance to the product as occurred in Israel (Solel et al., 1996). Resistance has not been detected in Florida. Cultural factors to reduce the disease such as the use of disease-free nursery stock, the planting of susceptible varieties on wider spacings in areas with good air drainage, and the avoidance over-fertilization and over-watering will need to be employed more frequently (Timmer and Peever, 1997b). It will probably not be possible to grow highly susceptible varieties such as Minneola tangelos in low lying areas on close spacings. Likewise some varieties which do not command high prices will not be able to support the necessary spray programs. If timing of fungicide applications can be improved to minimize the number of applications, it should be possible to continue to grow susceptible varieties until better control methods are developed.

Table 9. Evaluation of fungicides for control of citrus scab on Murcotts near Sebring in 1994. Experiment 8.

Fungicide	Trade name and formulation	Estimated rate/acre	Fruit rating (0-5)	Marketable fruit (%)
Untreated control	—	—	2.65 a[z]	2.1 e
Iprodione[z]	Rovral 10566A 2.2 SC (1,2,3)[x]	0.45 gal	2.63 a	5.4 de
Iprodione[z]	Rovral 4 SC (1,2,3)	1.0 qt	2.54 a	4.9 de
Iprodione[z]	Rovral 103070A 50 WG (1,2,3)	2.0 lb	2.15 b	20.1 cd
Iprodione + fosetyl-Al[z]	Rovral 4 SC + Aliette 80 WDG[w] (1,2,3)	1.0 qt + 5.0 lb	2.08 b	20.8 cd
Captan	Captec 4 L (1,2,3)	0.5 gal	1.92 bc	24.4 c
Captan	Captec 4 L (1,2,3)	1.0 gal	1.92 bc	26.2 c
Fluazinam + copper hydroxide	Fluazinam 500 F (1,2) + Blue Shield DF (3)	1.0 pt + 8.0 lb	1.91 bc	25.5 c
Copper hydroxide	Blue Shield DF (1,2,3)	8.0 lb	1.86 bc	27.1 c
Captan + copper hydroxide	Captec 4 L (1) + Blue Shield DF (2,3)	1.0 gal + 8.0 lb	1.79 bcd	31.7 c
Ferbam	Carbamate 76 WP (1,2,3)	10.0 lb	1.80 bcd	37.4 bc
Myclobutanil	Myclobutanil 40 W (1,2,3)	2.5 lb	1.67 cde	35.6 bc
Fenbuconazole	Fenbuconazole 2 F (1,2,3)	1.0 pt	1.61 cde	37.1 bc
Fluazinam + copper hydroxide	Fluazinam 500 F (1,2) + Blue Shield DF (3)	3.75 pt + 8.0 lb	1.46 de	60.8 ab

[z]Kinetic added as an adjuvant at 6.0 oz/100 gal.
[y]Citrus spray oil added at 1%.
[x]Applied at first flush (1), postbloom (2) and when fruit was 0.5-1.0 inch in diameter (3).
[w]Applied as a tank mix on all three dates.
[v]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.

Table 9. Evaluation of fungicides for control of citrus scab on Murcotts near Sebring in 1994. Experiment 8.

Fungicide	Trade name and formulation	Estimated rate/acre	Fruit rating (0-5)	Marketable fruit (%)
Propiconazole[y]	Tilt 3.6 E (1,2,3)	8.0 oz	1.35 e	61.0 a

[z]Kinetic added as an adjuvant at 6.0 oz/100 gal.
[y]Citrus spray oil added at 1%.
[x]Applied at first flush (1), postbloom (2) and when fruit was 0.5-1.0 inch in diameter (3).
[w]Applied as a tank mix on all three dates.
[v]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.

Table 10. Evaluation of fungicides for control of citrus scab on Duncan grapefruit near Bowling Green in 1996. Experiment 9.

Fungicide	Trade name and formulation	Rate/acre	Fruit rating (0-5)	Marketable fruit (%)
Unsprayed control	—	—	1.35 a[x]	56.2 b
Tebuconazole[z]	Folicur 3.6 F	4.0 oz	0.54 bc	83.6 a
Tebuconazole[z]	Folicur 3.6 F	6.0 oz	0.66 bc	80.6 a
Tebuconazole[z]	Folicur 3.6 F	8.0 oz	0.58 bc	86.0 a
Kresoxim-methyl[y]	BASF 490 DF	0.2 lb	0.52 bc	86.0 a
Kresoxim-methyl[y]	BASF 490 DF	0.4 lb	0.60 bc	83.2 a
Kresoxim-methyl[y]	BASF 490 DF	0.6 lb	0.44 c	88.9 a
Fenbuconazole	Fenbuconazole 2 F	0.5 pt	0.49 bc	88.6 a
Copper hydroxide	Kocide 101 + oil	10 lb + 5 gal	0.78 b	79.1 a

[z]Added Surf Aid 80-20 at 4 oz/100 gal.
[y]Added Triton B-1956 at 4 oz/100 gal.
[x]Mean separation by Waller-Duncan k-ratio t test, P ð 0.05.

The situation with scab is somewhat more positive. Clearly, good scab control is not as easily achieved now as it was in the days when captafol was registered. However, in groves where benomyl resistance has not developed, this product provides very good control. Although scab control with ferbam was considered previously to be mediocre (Whiteside, 1981; 1990), it proved fairly effective if used at higher rates than in the past. Copper fungicides appear to be effective especially when the fruit has sufficiently large surface area on which to apply a protective material. Only a few fungicides, such as iprodione, fosetyl-Al, and neem oil proved to be ineffective against scab.

Future prospects for new materials for scab control are quite good. Virtually all of the sterol-biosynthesis-inhibiting fungicides such as fenbuconazole, tebuconazole, and others have good activity against scab. Of that group, fenbuconazole is the most likely to be registered in the near future. It has the added advantage of being highly effective against greasy spot (Timmer et al., 1996). However, difenoconazole which proved to be exceptional for control of scab in Florida (Whiteside, 1990) has never been registered in the U.S., although it is marketed in other countries for this disease. Thiophanate-methyl is an analog of benomyl and is not effective against benomyl-resistant isolates. It is unlikely to be registered on citrus. Ziram is a dithiocarbamate like ferbam and would likely provide equivalent control should it be registered on citrus. Fluazinam and kresoxim-methyl are also promising, but fluazinam must be used at fairly high rates to achieve good control.

The prospect of having highly effective new fungicides available to control Alternaria brown spot and citrus scab in the short-term appears to be limited. However, there are a large number of effective fungicides which are already registered and widely used on other crops which would be useful on citrus. Hopefully, fungicide manufacturers will anticipate sufficient returns from the citrus market to develop and register some of these materials. Currently, no sterol-biosynthesis-inhibiting fungicide is registered on citrus, but these products are widely used for many diseases of other crops. These fungicides are effective against scab and frequently against greasy spot as well (Timmer and Zitko, unpublished). Strobilurin fungicides represent a newer chemistry and have activity against a number of citrus pathogens. Given the limited potential for new products, cultural controls will need to be exploited more fully and methods will need to be developed to optimize spray timing.

Literature Cited

Schutte, G. C., K. H. Lesar, P. du T. Pelser and S. H. Swart. 1992. The use of tebuconazole for control of *Alternaria alternata* on 'Minneola' tangelos and its potential to control postharvest decay when applied as a preharvest spray. Proc. Int. Soc. Citriculture 3:1070-1074.

Solel, Z., L. W. Timmer and M. Kimchi. 1996. Iprodione resistance of *Alternaria alternata* pv. *citri* from Minneola tangelo in Israel and Florida. Plant Dis. 80:291-293.

Timmer, L. W. and T. L. Peever. 1997a. Alternaria brown spot found on Sunburst and grapefruit. Citrus Industry 78(9):46.

Timmer, L. W. and T. L. Peever. 1997b. Managing Alternaria brown spot. Citrus Industry 78(6):24-25.

Timmer, L. W. and S. E. Zitko. 1994. Evaluation of fungicides for control of Alternaria brown spot, 1993. Fungicide and Nematicide Tests 49:369.

Timmer, L. W. and S. E. Zitko. 1995. Evaluation of nutritional products and fungicides for control of citrus greasy spot. Proc. Fla. State Hort. Soc. 108:88-92.

Timmer, L. W. and S. E. Zitko. 1995. Evaluation of fungicides for control of citrus scab, 1994. Fungicide and Nematicide Tests 50:399.

Whiteside, J. O. 1976. A newly recorded Alternaria-induced brown spot disease of Dancy tangerines. Plant Dis. Rep. 60:326-329.

Whiteside, J. O. 1979. Alternaria brown spot of Dancy tangerines and its control. Proc.Fla. State Hort. Soc. 94:32-37.

Whiteside, J. O. 1979. Control of Alternaria brown spot on 'Dancy' tangerines, 1976. Fungicide and Nematicide Tests 34:153.

Whiteside, J. O. 1980. Detection of benomyl tolerant strains of *Elsinoe fawcettii* in Florida citrus groves and nurseries. Plant Dis. 64:871-872.

Whiteside, J. O. 1981. Evolution of current methods for citrus scab control. Proc. Fla. State Hort. Soc. 94:5-8.

Whiteside J. O. 1990. Prospects for improved control of citrus scab with fungicide spray treatments. Proc. Fla. State Hort. Soc. 103:4-7.