Field Performance of Sterol-Inhibiting Fungicides Against Apple Powdery Mildew in the Mid-Atlantic Apple Growing Region

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ABSTRACT

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Eight sterol-inhibiting fungicides evaluated in 18 orchard spray trials were highly effective against apple powdery mildew. All were significantly more effective than standard fungicides. Because of their broad spectrum of disease control, they appeared promising as new orchard fungicides. Mildew incidence on terminal leaves of Rome Beauty apple ranged from 0 to 23% when treated seasonally under moderate to severe disease conditions. The amount of active ingredient required to provide commercial control (less than 20% incidence) varied among the fungicides. Subgroups based on the range of active ingredient needed were CGA 64251 and fenarimol at 10–20 mg/L, triarimol and triadimefon at 25–75 mg/L, bitertanol and triforine at 75–120 mg/L, and prochloraz and fenapanil at 180–300 mg/L.

The control of powdery mildew of apple, caused by *Podosphaera leucotricha* (Ell. and Everh.) Salm., has been a problem for many eastern orchardists since the introduction and wide usage of the organic fungicides in the mid-1940s. The problem first surfaced when the extensive use of elemental sulfur was reduced or eliminated in apple spray programs. The disease has been kept under control in most commercial orchards by including low rates of sulfur or by using dinocap in the spray mixture used for control of other diseases and insects (3). Mildew control was appreciably improved with the extensive use of benomyl during the past decade, but the level of control obtained with the rates commonly used for apple scab control was often unacceptable. This problem has persisted, requiring orchardists to mix benomyl with other unrelated fungicides to reduce the chances of selecting resistant strains of pathogens (1,6,8,10).

The mildew problem in orchards varies with region and cultivar. The problem is most severe in northern Virginia, eastern West Virginia, and Maryland; moderate in south central Pennsylvania, Kentucky, and Missouri; and less severe in the northeastern and north central states. Jonathan, Idared, and Rome Beauty are the most susceptible cultivars commercially grown. Other cultivars ranged from very low in susceptibility, requiring no special control measures, to moderate susceptibility, requiring sprays to prevent yield reduction (4). The problem of disease management has been intensified in many orchards because of the interplanting of two or more cultivars for effective pollination, often combined with a disregard for cultivar susceptibility to apple scab and mildew.

During the past decade, researchers have performed extensive evaluations of new fungicides for efficacy against several major apple diseases, including powdery mildew. A group of eight fungicides, commonly referred to as the sterol-inhibiting fungicides, has been evaluated in field tests since 1969. Chemically, these compounds have many structural similarities, but they do not form a homogeneous group. Their fungicidal activity involves the inhibition of ergosterol biosynthesis, which plays a crucial role in the structure and function of the membranes of many fungi. Against powdery mildew, the compounds affect haustorial formation. Because they penetrate the leaf cuticle, the compounds often bring curative action.

In an effort to evaluate this group of fungicides for control of mildew on apple, we have condensed in this paper the results of 18 fungicide trials conducted from 1969 to 1980 that included one or more of the sterol-inhibiting fungicides. Only the results obtained with the specific fungicide of concern and appropriate treatments for comparison are presented. During the series of field tests, conditions favorable for disease development were moderate to high; however, they varied by year and cultivar.

MATERIALS AND METHODS

The fungicide treatments were evaluated in test orchards near Biglerville, PA, and Winchester, VA, under somewhat similar environmental conditions and with moderate to high inoculum levels. Bearing apple trees of the cultivars Jonathan and Rome Beauty were maintained at a normal growth rate. The planting arrangement allowed satisfactory plot design, with adequate spray equipment movement and little spray drift to adjacent plots. Test trees were spaced 9 × 10.5 m apart and ranged in age from 10 to 20 yr. They were maintained at 3.5–5.5 m high with moderate density by either growth-controlling rootstock or pruning. Treatments were arranged in each test block in a randomized complete block design with four to six single-tree replicates.

Generally, fungicides were suspended in water and applied dilute to the point of

Table 1. Incidence of powdery mildew on Rome Beauty apple trees treated with dilute sprays of triarimol and standard fungicides

	Rate	Leaves infected (%)		
Fungicides	(mg a.i./L)	Test 1[v]	Test 2[w]	Test 3[x]
None	0	32.0 c[y]	37.5 c	43.9 b
Triarimol 4.5% EC	30	0.7 a	...[z]	...
Triarimol 4.5% EC	40	1.4 a	2.5 a	6.5 a
Triarimol 4.5% EC	50	0.5 a	...	...
Benomyl 50W	224	2.4 ab	3.8 ab	...
Benomyl 50 W	135	...	...	7.8 a
Dinocap 48% LC	144	2.4 ab	8.8 b	10.7 a

[v] Fungicide applied on 15 and 25 April, 7 and 22 May, 5 and 18 June, and 2 and 16 July 1969.
[w] Fungicide applied on 18 and 26 April, 6 and 20 May, 4 and 17 June, and 1 and 15 July 1969.
[x] Fungicide applied on 27 April; 4, 11, and 21 May; 4 and 17 June; and 1 and 14 July 1970.
[y] Small letters indicate Duncan's multiple-range groupings of means, which do not differ significantly at the 5% level.
[z] ... = Not tested.

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runoff at 15–30 L/tree (1,850–3,700 L/ha) with a single-nozzle spray gun at 2,800–3,800 kPa. In a few tests, sprays were applied to multitree plots with commercial airblast sprayers driven at 4.0 km/hr. Two airblast sprayers were used: a conventional type, Hardie model 525 (not presently available), with a pump pressure of 1,200 kPa and air delivery volume of 35 m^3/sec at a velocity of 34 m/sec; and a Kinkelder Royal (Marwald, Ltd., Burlington, Ontario) with a pump pressure of 152 kPa and air delivery volume of 7 m^3/sec and velocity of 49 m/sec. Fungicide sprays were applied at intervals of 6–7 days in the prebloom period and at 12–15 days in the postbloom period for a total of six to eight applications during the time of mildew infections (active leaf development). The fungicides evaluated in these field tests included benomyl, bitertanol, CGA 64251 (1-[[2-(2,4-dichlorophenyl)-4-ethyl-1,3-dioxolan-2-yl]methyl]-1*H*-1,2,4-triazole), dinocap, fenapanil, fenarimol, glyodin, pyrazophos, triadimefon, triarimol, triforine, and prochloraz.

Disease incidence was counted on leaves on terminal shoots that produced new susceptible leaves during a period of several weeks. Leaf counts were made in late July or early August when most leaf growth had stopped. Samples consisting of randomly selected shoots, ranging from 10 to 20 per tree depending on test and location, were taken 1.0–2.0 m high around the periphery of the tree. Disease incidence in all plots was calculated as the percentage of infected leaves. Where a more complete estimate of treatment efficacy was desired, a severity rating for mildew on the ventral leaf surface was made using the Horsfall-Barratt method (5).

The data from each experiment were tested for homogeneity of variances and were statistically analyzed by transforming X (percentage of leaves infected per tree) to square root, or to square root of X + 0.5, then calculating a standard analysis of variance of randomized block design. Treatment comparisons were based on Duncan's multiple range test (2) or Duncan's least significant difference test (9).

RESULTS

Powdery mildew development was high enough in all field tests to provide adequate efficacy tests for the various fungicide treatments. Disease levels on the unsprayed checks among the various tests were 23–75% of the terminal leaves infected on Rome Beauty and 74–82% on Jonathan.

Triarimol. The 4.5% EC formulation applied in dilute sprays controlled mildew equally or better than benomyl or dinocap standards under moderate disease conditions on Rome Beauty (Table 1). There was no significant difference in performance at rates of 30, 40, and 50 mg a.i./L. Triarimol 10W at 120 g a.i./ha applied in a seasonal spray program with a conventional airblast sprayer provided significantly better control than dinocap when applied at 767 and 384 L/ha. Disease level was somewhat higher at the spray volume of 192 L/ha, but control was equal to

Table 2. Incidence of powdery mildew on Rome Beauty apple trees treated with triarimol and standard fungicides applied with airblast sprayers

Fungicide	Rate (g a.i./ha)	Application rate (L/ha)	Leaves infected (%)	
			Test 1[w]	Test 2[x]
None	0	0	66.3 d[y]	53.7 c
Triarimol 10W	120	767	1.9 a	...[z]
Triarimol 10W	120	384	7.3 ab	...
Triarimol 10W	120	192	17.3 abc	...
Dinocap 48% LC	440	767	26.6 c	...
Triarimol 25W	123	192	...	16.6 ab
Triarimol 10W	123	47	...	17.7 ab
Dikar 76.7W (standard; dinocap 4.7%)	369	192	...	14.1 ab
Dikar 76.7W (standard; dinocap 4.7%)	369	47	...	12.0 a
Benomyl 50W	245	192	...	21.1 b

[w] Fungicide applied with a Hardie model 525 airblast sprayer operated at 4.0 km/hr on 28 April; 5, 14, and 21 May; 4 and 18 June; and 1 and 14 July 1970.
[x] Fungicide applied with a Kinkelder Royal airblast sprayer operated at 4.0 km/hr on 21 and 30 April, 10 and 20 May, 3 and 18 June, and 2 and 16 July 1971.
[y] Small letters indicate Duncan's multiple-range groupings of means, which do not differ significantly at the 5% level.
[z] ... = Not tested.

Table 3. Incidence of powdery mildew on Rome Beauty and Jonathan apple trees treated with dilute sprays of triforine and standard fungicides

Fungicide	Rate (mg a.i./L)	Leaves infected (%)			
		Test 1[v]		Test 2[w]	
		Rome	Jonathan	Rome	Jonathan
None	0	48.8 c[x]	78.8 c	62.5 c	74.1 c
Triforine 20% EC[y]	240	3.8 a	9.9 a	...[z]	...
Triforine 20% EC	180	7.3 a	11.5 a	16.7 a	20.8 a
Triforine 20% EC	120	...	...	20.5 b	23.1 a
Dinocap 48% LC	140	30.3 b	46.8 b	...	...
Dinocap 25W	150	...	...	11.5 a	35.7 b

[v] Fungicide applied on 19 and 26 April; 3, 10, and 19 May; 1, 14, and 28 June; and 12 and 27 July 1971.
[w] Fungicide applied on 9 and 28 April; 4, 11, and 19 May; and 2 and 26 June 1972.
[x] Formulation CA 70203 20 EC.
[y] Small letters indicate Duncan's multiple-range groupings of means, which do not differ significantly at the 5% level.
[z] ... = Not tested.

Table 4. Incidence of powdery mildew on Rome Beauty apple trees treated with triforine and standard fungicides applied with an airblast sprayer

Fungicide	Rate (g a.i./ha)	Test 1[w]	Test 2[w]	
		Leaves infected (%)	Leaves infected (%)	Leaf area affected (%)
None	0	55.8 a[x]	75.3 d	68.3 d
Triforine 20% EC				
CA 70203	560	17.1 ab	50.0 c	20.1 b
CA 70203	560[y]	31.1 b	...[z]	...
CA 73021	560	...	49.5 c	22.8 c
CME 74770	560	...	37.0 abc	6.6 a
CME 74770	672	...	36.6 abc	9.4 ab
Dinocap	560	25.3 ab	...	...
Dikar 76.7W (standard; dinocap 4.7%)	420	...	30.4 ab	4.6 a

[w] Fungicide treatments applied at 935 L/ha with a Hardie model 525 airblast sprayer operated at 4.0 km/hr. Dates for test 1 were 25 April; 1, 10, and 22 May; and 5, 19, and 29 June 1972. Dates for test 2 were 30 April; 6, 14, and 23 May; 5, 17, and 30 June; and 15 and 29 July 1974.
[x] Small letters indicate Duncan's multiple-range groupings of means, which do not differ significantly at the 5% level.
[y] Applied only on 1 and 10 May and 5 and 29 June 1972.
[z] ... = Not tested.

dinocap (Table 2, test 1). Low-volume sprays of triarimol 25W at volumes of 47 and 192 L/ha provided acceptable control of mildew equal to the dinocap standard. Spray volume did not significantly affect fungicide performance (Table 2, test 2) when applied with airblast sprayers.

Triforine. Control of mildew under high disease conditions in two tests where seasonal dilute sprays of triforine 20% EC (formulation CA 70203) at 120 and 180 mg a.i./L were applied was clearly superior to the dinocap program (Table 3). In the first test, no differences were found between rates of 180 and 240 mg a.i./L on either Rome Beauty or Jonathan cultivars. The level of control obtained in test 2 was somewhat lower. The 120-mg rate was significantly less effective than the 180-mg rate or the dinocap standard on Rome Beauty, but it was significantly better than dinocap on Jonathan. This same formulation applied with an airblast sprayer provided control of mildew equal to dinocap under high disease incidence (Table 4, test 1). A spray program consisting of only four postbloom applications in the same test significantly reduced disease incidence when compared with untreated trees, but the level was above commercial acceptance.

In a similar test, but under severe disease conditions, the results obtained with CME 74770 showed significantly less disease development on the ventral leaf surface than formulations CA 70203 and CA 73021. The incidence of leaves infected was not significantly different among the formulations, and the level of control was lower than obtained with dinocap. An 18.2% EC formulation, now sold commercially, gave control equal to dinocap in a dilute spray test at rates of 85 and 140 mg a.i./L (Table 5, test 2).

Triadimefon. Mildew infection on leaves was less than 10% in three separate tests where triadimefon 25W at 75 mg a.i./L or the combination of 37 mg a.i./L plus superior spray oil was applied in dilute sprays (Tables 6 and 7). Disease levels were very high in these tests, with 72–82% of leaves infected on untreated Jonathan (Table 6, tests 1 and 2) and 22–44% of leaves infected on trees sprayed with dinocap at 110 mg a.i./L. The level of control was not increased with a rate of 300 mg a.i./L and was equal to that obtained with benomyl 50W at 150 mg a.i./L when the 37-mg rate was applied (Table 7, test 1). The percentage of ventral leaf area affected was less than 2% on the highly susceptible Jonathan cultivar.

Fenarimol. Fenarimol 12.5% EC or 1E at rates of 19 to 38 mg a.i./L gave a high level of mildew control in three field tests under severe to moderate disease conditions on Jonathan and Rome Beauty cultivars, respectively (Tables 5, 6, and 7). The combination of 19 or 28 mg a.i./L with glyodin or superior spray oil, respectively, provided control significantly better than the dinocap standard. The 19-mg rate gave control equal to the benomyl standard on Rome Beauty in a test where the untreated trees had 49% of the terminal leaves infected (Table 7, test 1).

Fenapanil. Mildew infection on Rome Beauty leaves ranged from 1.0 to 8.0% in three field tests on trees treated with fenapanil 2E at 600 mg a.i./L (Table 7, test 2; Table 8, tests 1 and 2). The disease level on the untreated trees was moderate in severity, ranging from 24 to 38%. No significant difference was found between the rates of 300 and 600 mg a.i./L, which were equal to the benomyl standard but not as effective as the combination of bitertanol 21% EC at 150 mg a.i. plus AL 411 F spreader (Table 8, test 1). The combination of fenapanil at 300 mg a.i./L plus superior spray oil at 1.25 or 2.5 ml/L gave control equal to the 600-mg rate alone or bitertanol at 75 mg a.i. (Table 7, test 2; Table 8, test 2). The 300-mg rate used in combination with dinocap at 72 mg a.i./L gave control equal to the Dikar standard, triforine at 140 mg a.i., CGA 64251 at 19 mg a.i., and prochloraz at 180 and 360 mg a.i. (Table 5, test 2).

Prochloraz. Both wettable powdery and emulsifiable concentrate formulations were effective against mildew on Rome Beauty apple, but the level of control was somewhat lower than with other sterol-

Table 5. Incidence of powdery mildew on Rome Beauty apple trees treated with dilute sprays of sterol-inhibiting fungicides, pyrazophos, and dinocap

Fungicide	Rate (mg a.i./L)	Leaves infected (%)	
		Test 1[v]	Test 2[w]
None	0	26.6 e[x]	42.2 d
Prochloraz 25W	190	16.7 d	17.7 c
Prochloraz 25W	380	11.5 c	12.8 bc
Prochloraz 40% EC	180	...[y]	13.7 bc
Prochloraz 40% EC	360	...	8.4 b
CGA 64251 21.5W	11	1.7 a	...
CGA 64251 21.5W	17	0.4 a	...
CGA 64251 21.5W	34	0.3 a	...
CGA 64251 10W	19	...	7.6 ab
CGA 64251 10W	19[z]	...	8.7 ab
Triforine 18.2% EC	85	...	13.9 bc
Triforine 18.2% EC	140	...	8.7 ab
Fenapanil 2E +	300		
dinocap 48% EC	72	...	3.8 a
Fenarimol 1E	38	2.7 a	...
Pyrazophos 30% EC	48	8.4 b	...
Pyrazophos 30% EC	95	5.4 b	...
Dikar 76.7W			
(dinocap 4.7%)	110	...	6.6 ab

[v] Fungicide applied on 11, 18, and 26 April; 12 and 27 May; and 13 and 27 June 1977.
[w] Fungicide applied on 25 April; 4, 18, and 30 May; 12 and 27 June; and 10 July 1978.
[x] Small letters indicate Duncan's multiple-range groupings of means, which do not differ significantly at the 5% level.
[y] ... = Not tested.
[z] Treatment applied only on 18 and 30 May and 27 June 1978.

Table 6. Incidence of powdery mildew on leaves of Jonathan apple trees treated with dilute sprays of triadimefon, fenarimol, and standard fungicides

Fungicide	Rate (mg a.i./L)	Test 1[w]		Test 2[x]	
		Leaves infected (%)	Leaf area affected (%)	Leaves infected (%)	Leaf area affected (%)
None	0	82.2 d[y]	82.5 c	71.9 d	72.1 c
Triadimefon 25W	75	9.2 a	1.9 a	...[z]	...
Triadimefon 50W	300	...	...	5.8 a	1.3 a
Triadimefon 50W +	37				
superior spray oil 7E	2.5 ml	...	...	6.5 a	1.6 a
Fenarimol 12.5% EC	28	19.0 b	4.0 a	...	...
Fenarimol 12.5% EC	19	...	...	7.0 ab	1.9 a
Fenarimol 12.5% EC +	28				
superior spray oil 7E	2.5 ml	21.0 b	4.1 a	...	...
Fenarimol 12.5% EC +	19				
glyodin 30% sol.	0.4 ml	...	...	12.6 ab	3.2 ab
Dikar 76.7W (standard;					
dinocap 4.7%)	100	44.0 c	17.5 b	21.7 c	5.9 b

[w] Fungicide applied on 22 April; 1, 8, and 15 May; 2 and 16 June; and 2 July 1975.
[x] Fungicide applied on 6, 13, 20, and 30 April; 13 and 27 May; 10 and 24 June; and 9 July 1976.
[y] Small letters indicate Duncan's multiple-range groupings of means, which do not differ significantly at the 5% level.
[z] ... = Not tested.

inhibiting fungicides. Although the emulsifiable concentrate formulation provided significantly better control, the difference in disease level was not of commercial importance when used at 360–380 mg a.i./L. At these rates, under moderate disease conditions, prochloraz gave control equal to CGA 64251 10W at 19 mg a.i., triforine at 85 and 140 mg a.i., and the Dikar standard (Table 5, test 2). Its performance was similar under moderate disease levels in three additional field trials (*data not shown*).

CGA 64251. This experimental fungicide provided control of mildew equal to or better than that of the other sterol-inhibiting fungicides. Under moderate disease conditions on Rome Beauty, CGA 64251 10W at 19 mg a.i./L gave control equal to prochloraz 40% EC at 180 mg a.i., triforine 18.2% EC at 85 mg a.i., fenapanil 2E at 300 mg a.i. plus dinocap 48% EC at 72 mg a.i., and the Dikar standard (Table 5, test 2). In this test, three applications of the 19-mg rate applied on 18 and 30 May and 27 June were equal to the seasonal spray programs consisting of seven applications of triforine 18.2% EC at 140 mg a.i., prochloraz 40% at 180 mg a.i., or the same rate of CGA 64251. In a test with light disease conditions (26.6% of leaves infected), 0.4 and 1.7% of leaves were infected on trees sprayed with CGA 64251 21.5W at 11 and 17 mg a.i./L, respectively. Mildew control was significantly better than that provided with either prochloraz 25W at 380 mg a.i. or pyrazophos 30% EC at 95 mg a.i./L (Table 5, test 1).

Bitertanol. A high level of activity against mildew was found for all formulations of bitertanol evaluated. Under moderate disease pressure, the 21% EC formulation was significantly better than the 25W evaluated at 150 mg a.i. Both gave control equal to or better than benomyl at 150 mg a.i. or fenapanil at 600 mg a.i./L (Table 8, test 1). The 50W formulation at rates of 75–300 mg a.i./L provided significantly better control than the Dikar standard (Table 8, test 3). The efficacy level of bitertanol under moderate disease conditions was similar to that of fenapanil (Table 8, test 2).

DISCUSSION

The sterol-inhibiting fungicides evaluated in 18 field tests reported in this paper showed high fungicidal activity against *P. leucotricha*. Additional results have confirmed these observations under equal or more severe disease conditions. The amount of active ingredient required to produce a level of mildew control equal to or better than that obtained with the dinocap standard varied from 10 to 180 mg/L.

The eight fungicides tested may be separated into four subgroups based on the amount of active ingredient needed for commercial control: CGA 64251 and fenarimol, 10–20 mg/L; triarimol and triadimefon, 25–75 mg/L; bitertanol and triforine, 75–120 mg/L; and prochloraz and fenapanil, 180–300 mg/L. The level of disease in commercial orchards generally considered acceptable is 20% or less of the terminal leaves infected for the entire season. In most of the tests reported here, the level was below 15% and often ranged from 1.0 to 10% with the more effective treatments.

The results obtained with triarimol (Table 2) and triforine (CME 74770) (Table 4, test 3) when applied with airblast sprayers suggest that the sterol-inhibiting fungicides will provide acceptable mildew control when used in commercial orchards. Their effectiveness against other major apple diseases, such as apple scab and apple rusts, makes them very desirable as broad-spectrum orchard fungicides.

There is a great need in commercial apple orchards for fungicides that have a curative mode of action against established infections of several apple pathogens. Fungicides used before now have either prevented infection or provided post-infection control for a limited number of hours. The task of keeping major diseases at or below economic thresholds with

Table 7. Incidence of powdery mildew on Rome Beauty apple trees treated with dilute sprays of sterol-inhibiting fungicides

Fungicide	Rate (mg a.i./L)	Leaves infected (%)	
		Test 1[w]	Test 2[x]
None	0	48.5 d[y]	23.9 c
Fenarimol 12.5% EC	19	11.8 bc	...[z]
Fenarimol 12.5% EC	37	5.7 a	...
Triadimefon 50W	37	13.6 c	...
Triadimefon 50W	75	8.3 ab	...
Fenapanil 2E	600	...	1.4 a
Fenapanil 2E +	300		
superior spray oil 7E	2.5 ml	...	2.6 ab
Bitertanol 25W	300	...	3.8 ab
Benomyl 50W	150	13.9 c	...
Benomyl 50W +	80		
glyodin 30% sol.+	380		
sulfur 95W	2,250	...	1.2 a

[w] Fungicide applied on 14, 21, and 28 April; 10 and 25 May; 8 and 22 June; and 7 July 1977.
[x] Fungicide applied on 11, 18, and 26 April; 12 and 27 May; 13 and 27 June; and 12 July 1977.
[y] Small letters indicate Duncan's multiple-range groupings of means, which do not differ significantly at the 5% level.
[z] ... = Not tested.

Table 8. Incidence of powdery mildew on Rome Beauty apple trees treated with dilute sprays of bitertanol, fenapanil, and standard fungicides

Fungicide	Rate (mg a.i./L)	Leaves infected (%)		
		Test 1[v]	Test 2[w]	Test 3[x]
None	0	38.1 e[y]	36.8 d	23.0 d
Bitertanol 25W	150	6.5 c	...[z]	...
Bitertanol 25W +	150			
AL 411 F Spreader	0.6 ml	3.2 b	...	...
Bitertanol 21% EC +	150			
AL 411 F Spreader	0.6 ml	1.3 ab	...	...
Bitertanol 12% EC +	300			
AL 411 F Spreader	0.6 ml	0.4 a	...	...
Bitertanol 50W	375	...	...	16.2 abcd
Bitertanol 50W	75	...	1.5 abc	8.4 ab
Bitertanol 50W	150	...	0.0 a	10.0 abc
Bitertanol 50W	300	...	...	6.9 a
Bitertanol 50W +	75			
Triadimefon 50W	19	...	0.7 ab	...
Bitertanol 50 W+	150			
Triadimefon 50 W	38	...	0.5 ab	...
Fenapanil 2E	300	12.4 d	...	...
Fenapanil 2E	600	7.9 cd	3.5 abc	...
Fenapanil 2E +	300			
superior spray oil 7E	1.25 ml	...	1.4 abc	...
Benomyl 50	150	10.9 cd	...	...
Dikar 76.7W (standard;				
dinocap 4.7%)	110	...	6.4 c	18.4 bcd

[v] Fungicide applied on 1, 11, 19, and 31 May; 13 and 27 June; and 12 and 25 July 1978.
[w] Fungicide applied on 30 April, 7 and 18 May, 4 and 20 June, and 5 July 1979.
[x] Fungicide applied on 22 and 29 April; 6, 13, and 27 May; 10 and 24 June; and 8 July 1980.
[y] Small letters indicate Duncan's multiple-range groupings of means, which do not differ significantly at the 5% level.
[z] ... = Not tested.

present fungicides and application methods (7) has been most difficult when the fungicides are applied after lesions are present. The major loss from apple powdery mildew is the reduction in yield associated with leaf infections or loss of fruit buds from overwintering infections.

Losses in fruit quality are minor except on highly susceptible cultivars such as Jonathan, where fruit russet can spoil fresh fruit appearance.

The sterol-inhibiting fungicides have provided excellent preventive action and, in limited tests not reported here, have been effective in reducing sporulation and mycelial growth on infected leaves. Further detailed studies are under way to determine the extent of curative action and effects of varying numbers of spray applications timed at specific phenological stages of tree growth. Results from such studies will enable more precise recommendations on rates and timing of the sterol-inhibiting fungicides in efforts to increase control and prevent development of tolerant strains of the mildew fungus. This same group of fungicides has shown high activity against other major apple diseases, such as scab, cedar-apple rust, and several fruit decay pathogens (11). Their efficacy against a broad range of important plant pathogens and their high rate of activity at relatively low concentrations make them highly desirable fungicides.

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