Field Evaluations of Flint and Sovran for Controlling Apple Diseases

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Sovran and Flint are very effective fungicides against apple scab and flyspeck. These new fungicides represent powerful tools for managing apple diseases, but they can be used to best advantage if we also recognize their limitations.

Two powerful new fungicides became available to New York apple growers just in time for the 2000 growing season. "Flint" and "Sovran" are broad-spectrum fungicides from the new chemistry class commonly known as strobilurins. The strobilurins are active against a wide array of plant pathogens at rates of only one to three ounces of active ingredient per acre. They have very low toxicity to birds, earthworms, beneficial insects, predaceous mites, and mammals (including humans). They break down quickly in soil but have good residual activity on foliage and fruit. Because of their broad spectra of activity and favorable environmental profiles, they are the most significant new group of fungicides to be developed since the sterol inhibitors (SIs).

The labels for Flint and Sovran restrict applications to no more than two back-to-back sprays and no more than four or five sprays per season. These restrictions are designed to limit selection pressure for development of fungicide-resistant pathogens. Resistance management with the SI fungicides (Nova, Procure, Rubigan) was based on using SIs in combinations with a contact fungicide such as captan or mancozeb. Flint and Sovran have been marketed as stand-alone products that do not need to be used in combinations. Instead, resistance management is based on applying one or two Flint or Sovran sprays, then switching to a fungicide with a different mode of action.

When different fungicides are used in alternating schedules, it is difficult to discern how much each individual product contributes to disease control. This paper reports results of two field trials conducted in the Hudson Valley during the 2000 growing season to evaluate the activity of Flint and Sovran for controlling apple scab, powdery mildew, rust diseases, and summer diseases. Results from a single year must always be interpreted with caution because weather-related variables have a significant impact on fungicide performance. Nevertheless, the data collected during the summer of 2000 provide insights concerning the best uses for Flint and Sovran in apple spray programs.

How do Flint and Sovran compare to SI fungicides for controlling scab, mildew, and rust?

Activity of Flint and Sovran was evaluated in an orchard of Jerseymac and Ginger Gold trees that was left unsprayed for an extended period before treatments were initiated. Trees were at petal fall on 10 May, and test treatments were initiated on 22 May, just a day or two before visible scab symptoms erupted on terminal

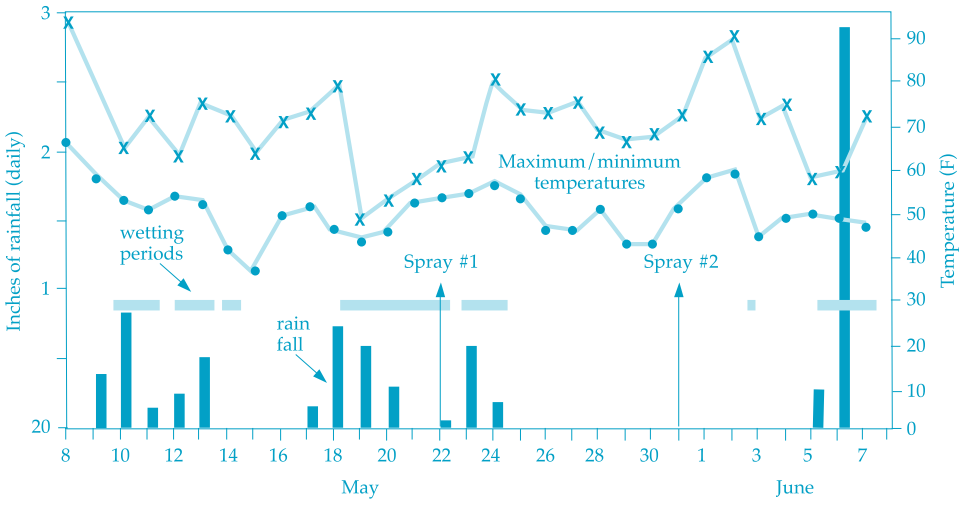

Figure 1. Daily temperatures, wetting periods, and rainfall during the time that post-infection and protectant activities of Nova+Dithane, Sovran, and Flint were being evaluated in 2000.

Figure 2. Jerseymac shoot one day after fungicides were applied, showing tag (white arrow) on the internode above the last leaf that was expanded at the time of the fungicide applications. Leaves below this mark are designated as leaf positions –1 (closest to the tag) through –5, whereas leaves developing above the tag are designated +1 through +5.

leaves. This spray was timed to allow evaluation of post-infection or "pre-symptom" activity of the fungicides. For each fungicide treatment, four replicates were sprayed with test fungicides on 22 May and again on 31 May. Four additional replicates were sprayed with test fungicides on 22 May but received only mancozeb (Dithane 75DF, 1 lb/100 gal) on 31 May. No fungicides were applied to any plots after 31 May.

In previous years, Sovran and Flint provided the same levels of scab control when the rate of Sovran was two times the rate of Flint. Therefore, all of our tests in 2000 were designed to compare Sovran and Flint with rates adjusted to this 2:1 ratio.

The first major infection period of the year occurred 9-11 May with 36 hr of wetting and a mean temperature of 57° F (Fig.1). Additional scab infection periods occurred 12-14 May (45 hr, 57° F), 18-22 May (89 hr, 51° F). Another 50 hrs of intermittent wetting with a mean temperature of 58° F occurred 22-25 May. Fifteen secondary scab infection periods occurred between 1 June and 15 August.

Twenty-four hours after the first application, fifteen terminal shoots per tree were marked by placing a red tag on the node above the last leaf that had expanded to at least 50% of full size (Fig. 2). The tagged shoots were harvested from Jerseymac trees on 15 June and from Ginger Gold trees on 5 July. The 10 longest of the tagged shoots were evaluated for disease on a leaf-by-leaf basis. Leaves were counted as infected even if the scab lesions showed some evidence of being inactivated. However, leaves with chlorotic spots only (i.e., completely inactivated) were not counted as infected. Incidence of scab was evaluated again on 3 July and 16 August by observing terminal leaves on untagged shoots of Jerseymac trees. These later assessments, along with fruit evaluations completed in late July, measured the effectiveness of treatments for limiting secondary spread by reducing inoculum levels within the test trees.

Field evaluations of scab on terminal leaves and fruit showed that Flint and Sovran controlled scab as well as or better than the standard Nova+Dithane treatment (Table 1). By 16 August, the incidence of scab on leaves was significantly higher in plots sprayed with Nova+Dithane than in plots receiving either rate of Flint or the high rate of Sovran.

Flint and Sovran were ineffective against rust diseases. Nova+Dithane provided nearly complete control of cedar apple rust and suppressed quince rust on both apple cultivars (Table 2). Nova+Dithane used in a full-season program usually provide complete control of quince rust, but in this experiment control was incomplete because many quince rust infections occurred April 21-23, almost 30 days before treatments were applied. Quince rust was much more severe on Jerseymac than on Ginger Gold, probably because of differences in bud stages on the two cultivars at the time of the infection period.

To further elucidate differences in treatments, the incidence of disease was compared for each leaf position above and below the tags that had been placed on shoots. Leaf positions were numbered from –1 to –5 counting down the shoot from the tag and +1 to +5 counting outward from the tag. Leaves in the –5 position were therefore the oldest and would have emerged at or shortly after petal fall on May 9. Leaves in the +5 position were the youngest and emerged after the first spray had been applied.

The fungi that cause apple scab, powdery mildew and cedar apple rust attack newly emerged leaves to a greater degree than older leaves on a shoot. Therefore, the incidence of disease at the various leaf positions in this experiment provided some indication of post-infection activity of the fungicides, although many leaves may have been susceptible to infection during more than one infection period. Leaves in positions –1 and–2 probably incurred infections both before and after the first fungicide application on 22 May, so scab control for those leaf positions may reflect a combination of protectant activity and post-infection activity. Disease control for leaf positions –3 through –5 represents post-infection activity against infections that occurred 9-14 May, or 8-13 days before the first treatment was ap

TABLE 1

Incidence of apple scab on Jerseymac leaves and fruit from trees that were sprayed with fungicides on 22 and 31 May, then left unsprayed through the remainder of the season.

Material and rate of formulated product per 100 gal	% terminal leaves with scab			% fruit with scab
	15 June	3 July	16 Aug	18 July
Control[1]	**39**	**64**	**95**	**71**
Effects of fungicide treatments[2]				
Flint 50WG 0.67 oz	1 a	9 ab	64 ab	10 a
Sovran 50W 1.33 oz	1 a	11 bc	70 bc	3 a
Flint 50WG 1 oz	1 a	6 a	59 a	4 a
Sovran 50W 2 oz	1 a	7 a	63 ab	8 a
Effects of number of sprays				
One spray (22 May) followed by Dithane	2 A	11 B	72 B	9 B
Two sprays (22 & 31 May)	1 A	8 A	60 A	4 A

[1] Controls were not included in the statistical analyses of treatments.
[2] A 2 X 6 factorial analysis was used to determine effects of fungicide treatments and effects of one spray versus two sprays of the test fungicides. Means for fungicide treatments followed by the same letter are not significantly different (P≤0.05).

TABLE 2

Incidence of cedar apple rust and quince rust on trees that were sprayed on 22 and 31 May, then left unsprayed through the remainder of the season.

Material and rate of formulated product per 100 gal	% Ginger Gold leaves with cedar apple rust	% fruit with quince rust	
		Jerseymac 18 Jul	Ginger Gold 8 Aug
Control[1]	**29**	**30**	**1.6**
Effects of fungicide treatments[2]			
Nova 40W 1.5 oz + Dithane 75DF 1 lb	1 a	14 a	0.3 a
Flint 50WG 0.67 oz	29 b	30 bc	1.7 b
Sovran 50W 1.33 oz	34 b	26 abc	1.9 b
Flint 50WG 1 oz	41 b	34 c	2.6 b
Sovran 50W 2 oz	40 b	17 ab	0.2 a
Effects of number of sprays			
One spray (22 May) followed by Dithane	27 A	27 A	1.0 A
Two sprays (22 & 31 May)	24 A	23 A	0.9 A

[1] Controls were not included in the statistical analyses of treatments.
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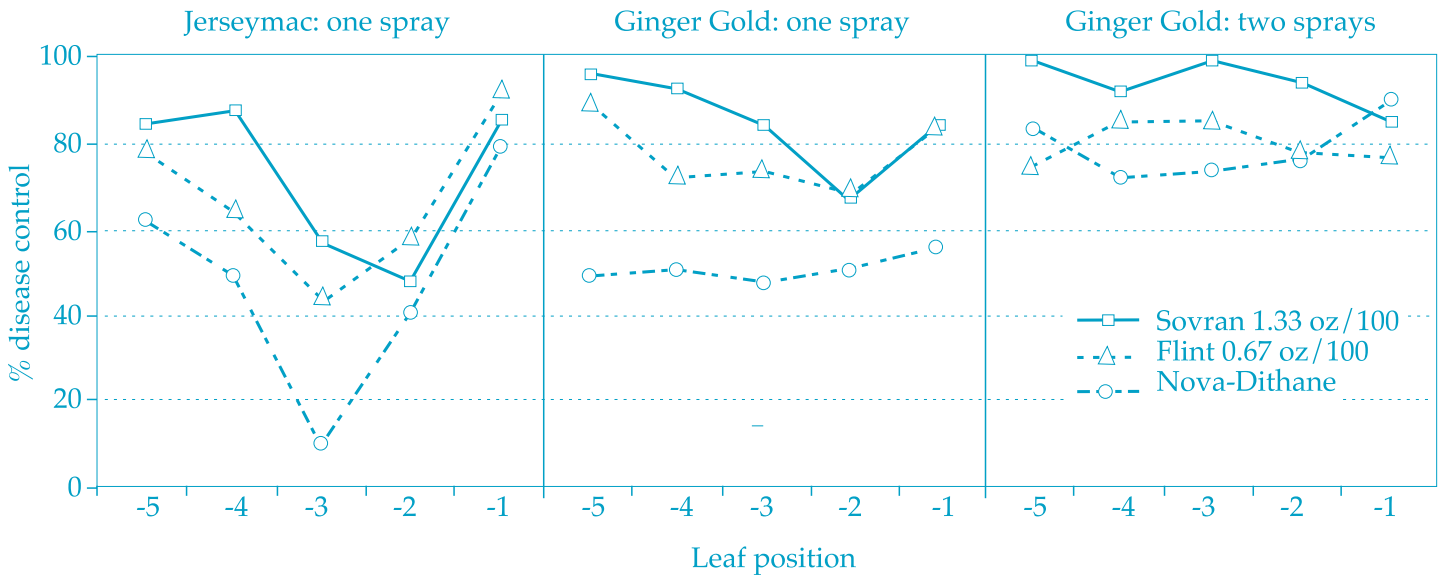

Figure 3. Post-infection control of apple scab on Jerseymac and Ginger Gold, with results presented as percent disease control by leaf position for the five youngest leaves that developed prior to the first fungicide application. Disease incidence for the same leaf positions on unsprayed controls ranged from 38 to 75% of leaves infected for Jerseymacs and 63 to 96% for Ginger Gold.

plied.

Analysis of scab control on Jerseymac shoots harvested June 15 showed the Flint and Sovran treatments were superior to the Nova+Dithane treatment when compared across leaf positions –5 to –1. Thus, Flint and Sovran provided better post-infection activity than Nova (Table 3). The level of post-infection activity was the same for plots receiving one spray as for those with two sprays of the test products (p=0.85), but disease control varied significantly by leaf position. The best control occurred on the oldest leaves where scab erupted through the leaf surface shortly after the first spray and on the youngest leaves where infections presumably occurred not more than 96 hours prior to the first application (Fig. 3).

In a similar leaf-by-leaf analysis of post-infection activity on Ginger Gold, differences among treatments were very similar to those observed for Jerseymac. The high rate of Flint and both rates of Sovran again provided significantly better control of scab on leaf positions –5 to –1 than did Nova+Dithane (data not shown). Differences in scab control among leaf positions –5 to –1 were smaller than on Jerseymac, but here two applications of the test products provided better control than a single application. The benefit of two back-to-back applications was particularly evident for the Nova+Dithane treatment and verified the validity of the long-standing recommendation that back-to-back applications of SI sprays are essential for effective post-infection control of apple scab (Fig. 3).

Fungicide treatments were also compared for "protectant" activity by analyzing scab control on leaf positions +1 to +5. Leaves in positions +1 and +2 were partially formed when the first spray was applied (Fig. 1), but leaves in positions +3 to +5 developed after the first spray was applied. Scab control on leaves +3 to +5 represents the combined effects of fungicide redistribution from the older sprayed leaves, post-infection activity from the second spray application, and reduced inoculum within the tree due to antisporulant effects of the fungicides.

All of the fungicides provided similar levels of scab control for leaves in positions +1 to +5. There were no significant differences among treatments for either cultivar. However, two applications of the

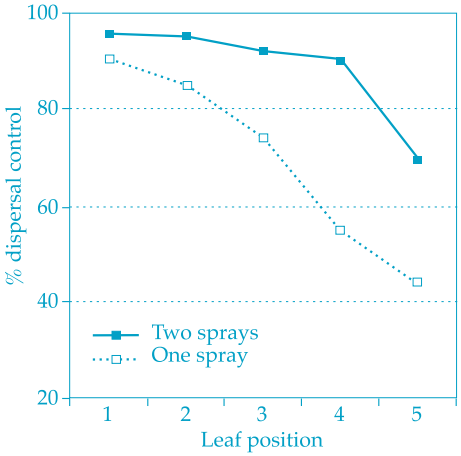

Figure 4. Apple scab control following either one or two applications of fungicides, with results presented as percent disease control by leaf position. Disease incidence in unsprayed controls ranged from 90 to 95% of leaves infected.

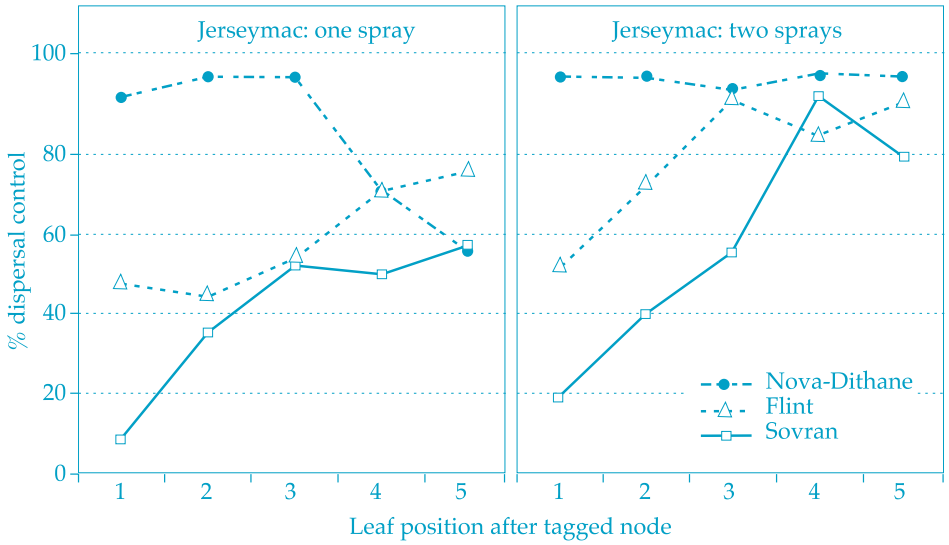

Figure 5. Powdery mildew control following either one or two applications of fungicides, with results presented as percent disease control by leaf position for the first five leaves that expanded after the day of the first fungicide application. Disease incidence in unsprayed controls ranged from 62 to 90% of leaves infected.

test products were more effective than a single application followed by Dithane (Fig. 4). The benefit of two applications was still evident when Jerseymac terminal leaves were evaluated in August (Table 1).

Activity of fungicides for controlling powdery mildew on Jerseymac was evaluated by leaf position as described above for apple scab. Unsprayed Ginger Gold trees adjacent to each plot provided abundant mildew inoculum. Leaves were counted as infected with mildew if they had visible white colonies, "burned out" or reddish-yellow lesions, or large yellowed areas where leaf tissue had been compromised by the early stages of mildew infection.

None of the treatments provided adequate post-infection control of mildew on leaf positions –5 to –1 (data not shown). For leaf positions +1 to +5, Nova was the most effective mildewcide. Differences among treatments were most obvious for leaf positions +1 and +2 where Nova was clearly superior to Flint or Sovran (Fig. 5). Leaves in positions +1 and +2 may have been partially unfolded prior to the first spray and therefore might have been infected before the first spray was applied. Mildew control from a single spray of Nova dropped off sharply for leaf positions +4 and+5, suggesting that Flint and Sovran had greater residual activity against mildew than did Nova. However, two applications of Nova provided almost perfect protection against mildew on tagged leaves, and the second application significantly improved the protectant activity of Flint and Sovran (Fig. 5).

How do Flint and Sovran compare to benzimidazoles for controlling flyspeck?

Flint and Sovran were applied to Liberty trees on M.9 rootstock at various times throughout the summer to determine their capabilities for controlling flyspeck and sooty blotch (Table 4). Treatments were initiated 9 May (petal fall), were replicated four times in 6-tree plots, and were sprayed to runoff using a handgun. Hours of wetting were determined using a DeWit Leaf Wetness Meter. The cumulative hours of wetting (Fig. 6) include dew periods that registered on the wetness recorder. Fungicide programs were evaluated by harvesting 50 apples per plot at intervals from 13 Jun to 20 Sep. For all harvests, fruit were evaluated immediately after harvest and again after two weeks of incubation in plastic bags at 70 F and 100% relative humidity. The incubation period allowed

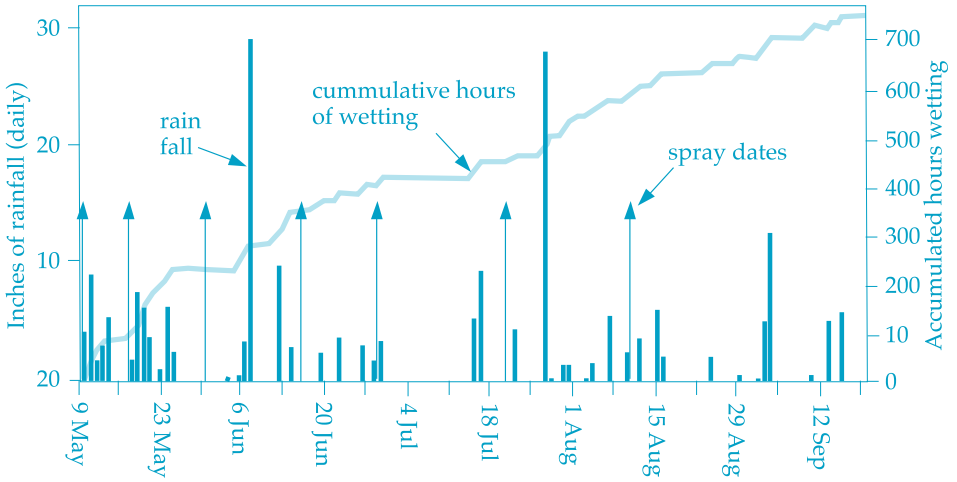

Figure 6. Spray dates, rainfall, and accumulated hours of leaf wetting related to the fungicide experiment for control of flyspeck on Liberty apples.

development of infections that were not visible at harvest.

Flyspeck symptoms developed in control plots between 20 July and 7 August, a timing that coincided with availability of secondary inoculum in the adjacent wood lots. Omitting sprays during June in treatment 3 did not compromise flyspeck control, but flyspeck developed rapidly in treatments 6 and 7 where no sprays were applied after June. Rainfall totaled 4.6 inches between the 30 July and 10 August sprays. Three lines of evidence, all of them from incubated fruit from the 8 August harvest, showed that Sovran provided better residual protection than either Flint or Topsin+Captan during the interval from 30 July to 8 August (Table 4): Sovran in treatment 4 had less flyspeck than Flint in treatment 5; Sovran in treatment 6 was more effective than Flint in treatment 7; and Sovran in treatments 3 & 4 was more effective Topsin-Captan in treatment 2. However, Topsin+Captan as applied to treatments 2, 4, & 5 on 10 August had enough eradicant activity to reduce disease incidence and neutralize differences between Flint and Sovran (trts. 4 and 5) by the time of the next evaluation. The incidence of flyspeck in incubated fruit increased again after the 28 Aug harvest as a result of additional infections during early September after the residual activity from the 10 August application was depleted. By 28 August, new infections had obliterated differences between treatments 6 & 7 that were evident after the previous harvest. Treatments 2, 3, 4 & 5 all provided acceptable control of flyspeck and sooty blotch as judged by percent

TABLE 3

Post-infection control of apple scab on Jerseymac terminal leaves that were unfolded prior to the first fungicide application as determined from tagged shoots harvested 15 June.

Material and rate of formulated product per 100 gal	% control of apple scab by leaf position[1]					Grand mean for leaf positions
	-5	-4	-3	-2	-1	–1 to -5
Nova 40W 1.5 oz +Dithane 75DF 1 lb	63 a[2]	50 a	10 a	41 a	80 a	49 a
Flint 50WG 0.67 oz	79 ab	65 abc	45 b	59 abc	93 a	68 b
Sovran 50W 1.33 oz	84 ab	88 c	58 b	48 ab	86 a	73 b
Flint 50WG 1 oz	67 ab	59 ab	44 b	85 c	89 a	69 b
Sovran 50W 2 oz	92 b	84 bc	56 b	74 bc	92 a	80 b
Grand mean for all treatments	**77 C[3]**	**69 BC**	**43 A**	**61 B**	**88 D**	

[1] Leaf position indicated as "-5" was the fifth leaf down from the tag placed above the last expanded leaf at the time of the application. Therefore, leaf position –5 represents the oldest leaf and position –1 represents the youngest full leaf exposed at the time of application. Disease incidence in the unsprayed control trees for leaf positions –5 to –1 was 38, 55, 63, 65 and 72% of leaves infected, respectively.

[2] High numbers indicate better disease control since the means show percent disease control. Numbers within columns followed by the same letter are not significantly different (Fisher's Protected LSD, P≤0.05).

[3] Grand means across the row followed by the same capital letter are not significantly different (Fisher's Protected LSD, P≤0.05).

TABLE 4

Effectiveness of Flint and Sovran in summer spray programs for controlling flyspeck on Liberty apples.

Material and rate of formulated product per 100 gal	Spray schedule[1] cover sprays							% fruit with flyspeck after incubation following harvest on				% fruit with sooty blotch after incubation	% fruit out of grade at harvest[2]
	PF	1	2	3	4	5	6	19 Jul	8 Aug	28 Aug	8 Sep	18 Sep	18 Sep
1. Control	-	-	-	-	-	-	-	8 b	100 d	100 c	100 c	98 e	95 d
2. Topsin M + Captan[3]	X	X	X	X	X	X	X	1 a	72 b	49 b	71 b	12 ab	5 b
3. Dithane 75DF 1 lb Sovran 50W 1.33 oz	X	X	X	-	-	X	X	2 ab	39 a	29 a	46 a	22 b	3 ab
4. Topsin M + Captan[3] Sovran 50W 1.33 oz	X	X	X	X	X	X	X	0 a	40 a	30 a	60 ab	6 a	1 ab
5. Topsin M + Captan[3] Flint 50WG 0.67 oz	X	X	X	X	X	X	X	1 a	59 b	27 a	59 ab	6 a	1 a
6. Captan 50W 1 lb Sovran 50W 1.33 oz	X	X	X	X	X	-	-	1 a	73 b	99 c	100 c	9 d	44 c
7. Captan 50 W 1 lb Flint 50WG 0.67 oz	X	X	X	X	X	-	-	0 a	91 c	98 c	100 c	36 c	34 c

[1] Application dates were 9 May (petal fall); 17 May (1st cover); 30 May (2C); 15 Jun (3C); 28 Jun (4C); 20 Jul (5C); 10 Aug (6C).
[2] Percent fruit that did not meet USDA standards for a Fancy/Extra Fancy combination pack because of sooty blotch or flyspeck.
[3] Topsin M 70W 3 oz + Captan 50W 1 lb
[3] Means separations: Fisher's Protected LSD, P≤0.05. The angular transformation was used for statistical analyses.

fruit out of grade at harvest (Table 4). This was a severe test considering the exceptionally wet season and the high susceptibility of Liberty fruit. All of the treatments would have provided better control under more moderate conditions.

Although Sovran provided better control of flyspeck than Topsin+Captan, the latter was more effective against sooty blotch during the interval prior to harvest. Treatments 4 and 5 were sprayed with Topsin+Captan on 10 August whereas treatment 3 received Sovran. By 18 September, the incidence of sooty blotch was three times greater in treatment 3 than in treatments 4 or 5. Flint also suppressed sooty blotch better than Sovran when treatments were terminated in mid-summer (trts. 6 vs. 7).

Results from this experiment demonstrate that both Flint and Sovran can be used effectively to flyspeck. Sovran had better mid-summer residual activity against flyspeck than either Flint or Topsin+Captan, but Flint and Topsin+Captan had better activity against sooty blotch at the end of the season. Some of these minor differences might disappear if the products were compared at different rates. However, given Sovran's apparent weakness against sooty blotch, it would seem inadvisable to use Sovran in the last spray of the season when activity against sooty blotch is most essential. This may be a moot point because Sovran's 30-day preharvest interval limits provides a legal limit on late summer uses.

Conclusions

In work reported here, Flint and Sovran were slightly more effective than Nova+Dithane for post-infection control of apple scab, and they were just as good as Nova+Dithane for protecting leaves and fruit. Against apple scab, Flint used at 1 oz/100 gal provided the same level of control as Sovran used at 2 oz/100 gal. Nova provided better control of mildew than either Flint or Sovran. Flint and Sovran were ineffective against rust diseases. Where apple growers previously used three or four applications of an SI fungicide to control scab and mildew, they should now change one or two of those applications to Flint or Sovran so as to reduce selection pressure for SI-resistant pathogens. Where rust diseases are severe, strobilurin fungicides applied between tight cluster and second cover may need to be supplemented with a low rate of mancozeb to prevent damage from rust diseases. Both Flint and Sovran were effective against flyspeck. Sovran showed the best residual activity against flyspeck but was less effective against sooty blotch. Thus, Sovran should not be used as the last spray of the season where extended residual activity against sooty blotch is essential.

Flint and Sovran should not be used alone against running epidemics of apple scab where lesions are already visible on leaves because doing so could quickly select for fungicide-resistant strains of the pathogen. When Flint and Sovran are used to "shut down" a running epidemic, they should be used in combinations with captan or mancozeb. Intelligent use of Flint and Sovran in apple disease control programs should extend the useful life of the SI fungicides for scab and mildew by delaying SI resistance. Sovran and Flint may also help to improve control of summer diseases in wet years.

Acknowledgments

Funding for some of the work reported here was provided by Novartis, BASF, and Rohm & Haas. The author thanks Wayne Wilcox for reviewing the manuscript and Fritz Meyer, Catherine Ahlers, Albert Woelfersheim, and Keri Van Camp for technical assistance.

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ERRATA: Rosenberger article, *New York Fruit Quarterly*, Volume 8, Number 4, 2000 (Winter Issue)

Please substitute these two figures on pages 6 and 9 of David Rosenberger's article in the *New York Fruit Quarterly*, Volume 8, Number 4, 2000 (Winter Issue)

Page 6.

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2. Topsin M + Captan[3]	X	X	X	X	X	X	X	1 a	72 b	49 b	71 b	12 ab	5 b
3. Dithane 75DF 1 lb	X	X	X	-	-	-	-						
Sovran 50W 1.33 oz	-	-	-	-	-	X	X	2 ab	39 a	29 a	46 a	22 b	3 ab
4. Topsin M + Captan[3]	X	-	X	-	X	-	X						
Sovran 50W 1.33 oz	-	X	-	X	-	X	-	0 a	40 a	30 a	60 ab	6 a	1 ab
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Flint 50WG 0.67 oz	-	X	-	X	-	X	-	1 a	59 b	27 a	59 ab	6 a	1 a
6. Captan 50W 1 lb	X	X	X	-	-	-	-						
Sovran 50W 1.33 oz	-	-	-	X	X	-	-	1 a	73 b	99 c	100 c	79 d	44 c
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