SCAB CONTROL STRATEGIES FOR 2001

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Introduction

Two powerful new fungicides recently became available to New York apple growers. "Flint" and "Sovran" are broad-spectrum fungicides from the new chemistry class commonly known as strobilurins. The strobilurins are active against many 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 three 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 that were 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?

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 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, Flint and Sovran 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 Flint and Sovran with rates adjusted to this 2:1 ratio.

The first major infection period of the year occurred 9-11 May with 36 hours of wetting and a mean temperature of 57/ F (Fig.1). Additional scab infection periods occurred 12-14 May (45 hr, 57/ F), and 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, the ends of 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.

Results of the 2000 Field Trial with Flint and Sovran

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 provides 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 applied.

Analysis of scab control on Jerseymac shoots harvested June 15 showed that 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 did 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 anti-sporulant 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 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). The poor control of mildew by Flint and Sovran for leaf positions +1 and +2 suggests that these fungicides did not provide quick protectant activity. Instead, these products may have provided control of mildew by arresting spore production, a process that evolved more slowly and contributed to the improved mildew control observed with Sovran and Flint for leaves in positions +3 through +5. Mildew control from a single spray of Nova dropped off sharply for leaf positions +4 and+5. Thus, Nova provided a more rapid suppression of mildew following the first spray than did Flint or Sovran, but suppressive effects of a single spray persisted longer with Sovran and Flint (Fig. 5). Two applications of Nova provided almost perfect protection against mildew on tagged leaves in all positions.

Other Considerations for Scab Control

Understanding the advantages and limitations of new fungicides is essential, but many other factors are also important in scab control. Following is a check list of items to consider:

1. Calibrate sprayers carefully to ensure that fungicides are being applied at the intended rates and with appropriate distribution throughout the tree canopy. Strobilurin fungicides applied alone may not redistribute as well as the old contact fungicides.

2. Consider both pesticide costs and disease risk factors in deciding which fungicides to apply at various times of year. Mancozeb at 3 lb of formulated product per acre can provide excellent scab control from green tip until at least the pink bud stage if applications are timed to precede predicted infection periods. However, mancozeb programs are "unforgiving" because they offer no post-infection activity to arrest development of missed infections. It makes sense

to begin every season with mancozeb as the primary prebloom fungicide and to continue using mancozeb alone until the point in the season where some infections may have been missed. Infections can be missed either due to poor fungicide timing or because a fungicide was applied under windy conditions that precluded good coverage. Sovran, Flint, or a SI+contact mixture should be applied within 10 days after one suspects that infections may have been missed in a mancozeb program. Delaying longer than 10 days may allow missed infections to sporulate, and that will complicate scab control for the rest of the season. In dry years, it may be possible to use mancozeb alone for disease control until petal fall whereas in other years stronger fungicides may be needed as early as tight cluster.

3. Be cautious about depending too heavily on mancozeb alone: if primary scab lesions are visible in trees before the first application of Sovran, Flint, or an SI fungicide, then scab control for the remainder of the season may become very difficult and expensive, especially if it is a cool wet season. Furthermore, applying Sovran, Flint, or SI fungicides to running epidemics will result in rapid selection for fungicide-resistant strains of apple scab.

4. Use at least two "power sprays" of Sovran, Flint, or SI fungicides every year to minimize risks of secondary scab and mildew infections. In dry years, the best timing for these two "power sprays" might be petal fall and first cover whereas in other years stronger protection may be needed at tight cluster and pink or at pink and bloom stages. In wet years, four or five applications of these "power" fungicides may be the only way to achieve complete disease control. Petal fall and first cover sprays are probably the most critical spray timings for controlling powdery mildew in the northeast. If three or four "power sprays" are used in a season, the longer one can wait to initiate these sprays, the better the mildew control is likely to be. Thus, using power sprays at tight cluster, pink, bloom, and petal fall will provide much less mildew control than if power sprays are applied at bloom, petal fall, and first and second cover, but the reverse is usually true for scab control.

5. Growers who have used just two or three SI fungicides for many years should consider using Sovran or Flint at petal fall and first cover one year followed by an SI fungicide at those timings the next year so as to reduce selection pressure for fungicide-resistant strains of powdery mildew. Growers who use four or five "power sprays" per year should be using SI fungicides for two or three of those sprays and either Sovran or Flint for the other two or three sprays each season as part of a resistance management strategy.

6. In a seasonal program involving four or five power sprays, there is no definitive reason for preferring Sovran or Flint followed by SI sprays as compared to SI sprays followed by Sovran or Flint. Both scenarios have advantages and disadvantages.

7. Sovran and Flint will not provide acceptable control of rust diseases under high disease pressure. Rust infections on fruit are usually initiated between tight cluster and petal fall whereas cedar apple rust usually causes the most leaf damage between petal fall and second cover. Where rust is a problem, a low rate of mancozeb, perhaps 1.5 lb/A, could be added to Sovran or Flint sprays to suppress rust.

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.

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.

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.

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 15 June	3 July	16 Aug	% fruit with scab 18 July
Control[1]	39	64	95	71
Effects of fungicide treatments[2]				
Nova 40W 1.5 oz + Dithane 75DF 1 lb	2 a	16 c	74 c	8 a
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 5 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			
Nova 40W 1.5 oz + Dithane 75DF 1 lb	1 a[2]	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.
[2] Means for fungicide treatments followed by the same letter are not significantly different (P#0.05).

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] -5	-4	-3	-2	-1	Grand mean for all leaf positions
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: 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).

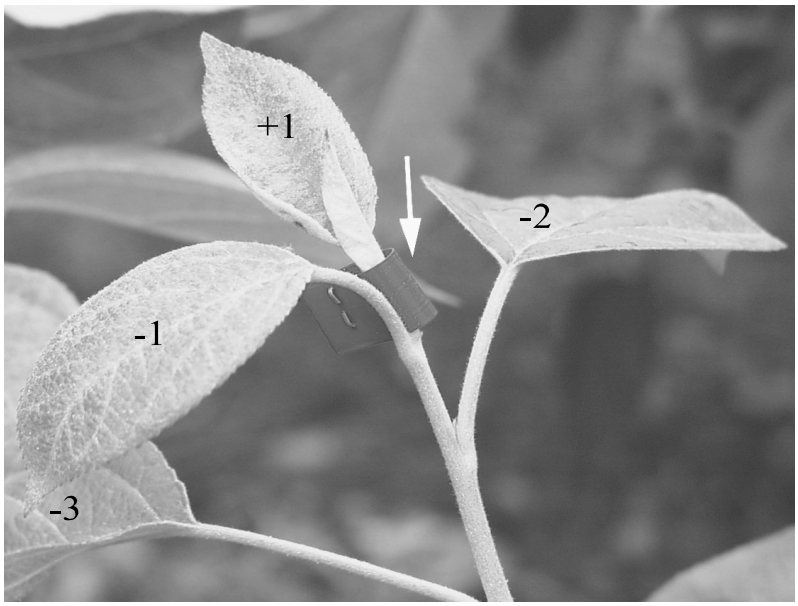

Fig. 1. Jerseymac shoot one day after fungicides were applied, showing tag (white arrow) on the internode above the last leaf that was expanded at the time of the fungicide applications. Leaves below this mark are designated as leaf positions –1 (closest to the tag) through –5, whereas leaves developing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

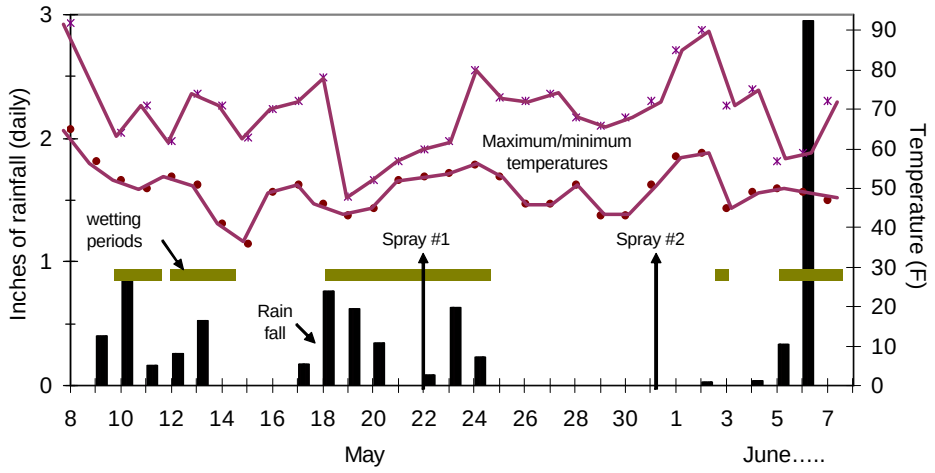

Fig. 2. Daily temperatures, wetting periods, and rainfall during the time that post-infection and protectant activities of Nova+Dithane, Sovran, and Flint were being evaluated in 2000.

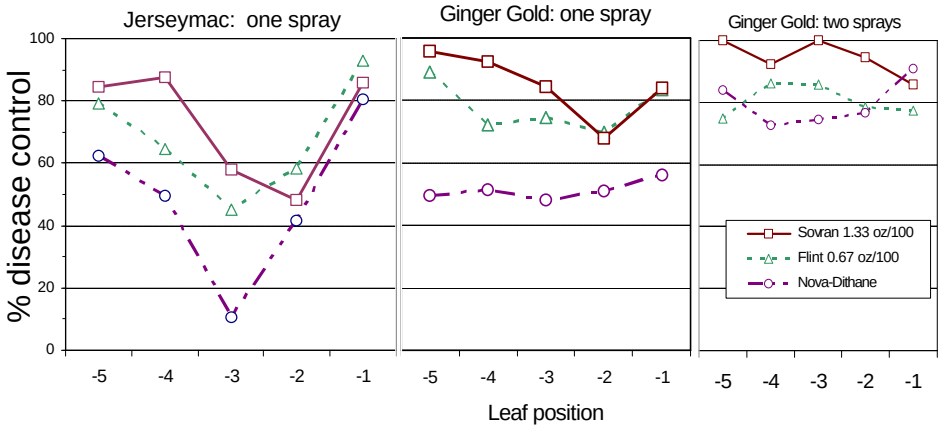

Fig. 3. Post-infection control of apple scab on Jerseymac and Ginger Gold, with results presented as percent disease control by leaf position for the five youngest leaves that developed prior to the first fungicide application. Disease incidence for the same leaf positions on unsprayed controls ranged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

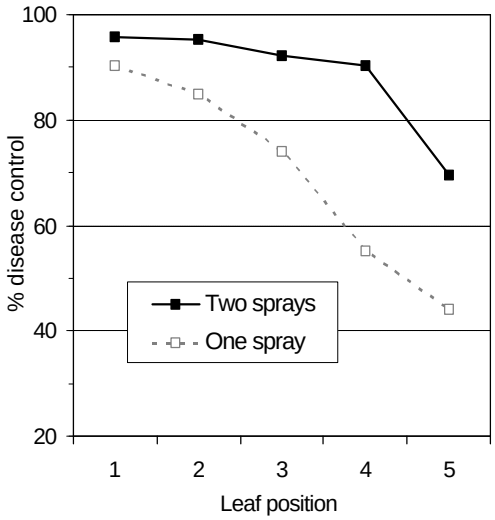

Fig. 4. Apple scab control following either one or two applications of fungicides, with results presented as percent disease control by leaf position. Disease incidence in unsprayed controls ranged from 90 to 95% of leaves infected.

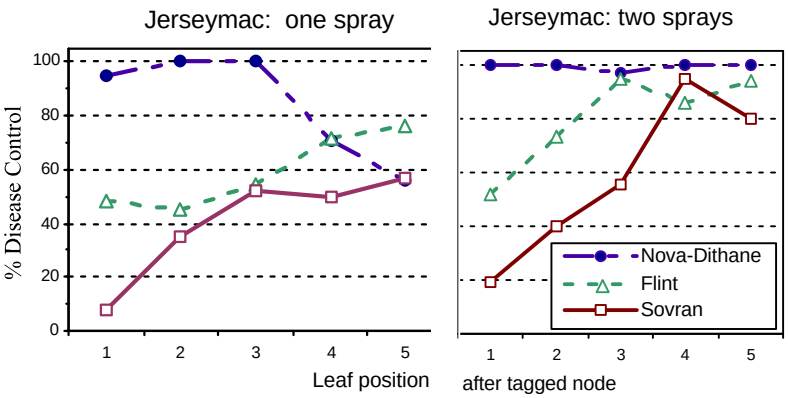

Fig. 5. Powdery mildew control following either one or two applications of fungicides, with results presented as percent disease control by leaf position for the first five leaves that expanded after the day of the first fungicide application. Disease incidence in unsprayed controls ranged from 62 to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