N E W Y O R K
FRUIT QUARTERLY

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Editorial

The Future of the New York Berry Industry

The future of the New York berry industry is very bright. In fact, berries should be considered the fruit for the new millennium! They are nutritious and have special nutriceutical value. Berries are not only beautiful to behold but versatile and easy to use. People of all ages enjoy berries. They are truly mouth poppers.

God definitely put blueberries on earth for the new millennium. They are certainly environmentally friendly to grow, process, and use. They are the ultimate convenience fruit. They wait on the bush until it is convenient for them to be used. In the process of waiting to be used, people walking by pop them in their mouth. This same disappearing act occurs when frozen blueberries are left on the counter on their way into muffins or pancakes. They have their unique growing requirements and cannot be grown in all soils in the state, but they can be a profitable crop where grown well. (An article by Dr. Marvin Pritts on page 14 details the unique mineral nutrition requirement of blueberries.)

It is no wonder then that the demand for berries continues to increase. Berry growers have a number of things going for them. Most of the crop in New York State is sold via direct market through u-pick or farm markets to affluent consumers. Since berry crops are grown in most counties of the state they are truly locally grown. Consumers can see and talk to the farmer, and have a farm experience in getting their berries. The value-added benefits of berries in jams, jellies, and wines have great potential.

Our industry continues to have challenges. Perhaps the most important include a short harvest season combined with the short shelf life of picked strawberries and raspberries; vexing disease problems such as black root rot of strawberries; and continuing severe wildlife damage caused by deer, turkeys, and song birds. The greatest societal change affecting our industry is that fewer people are opting for u-pick berries and prefer that berries be picked for them. Therefore, the most important management skill of tomorrow's New York berry grower must include the talent to recruit and manage labor to harvest our quality crop of great tasting berries, the fruit for the new millennium!

Frank Wiles
Board Member, NYS Horticultural Society
Former President, NYS Berry Growers

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This publication is a joint effort of the New York State Horticultural Society, Cornell University's New York State Agricultural Experiment Station at Geneva, and the New York State Apple Research and Development Program.

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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

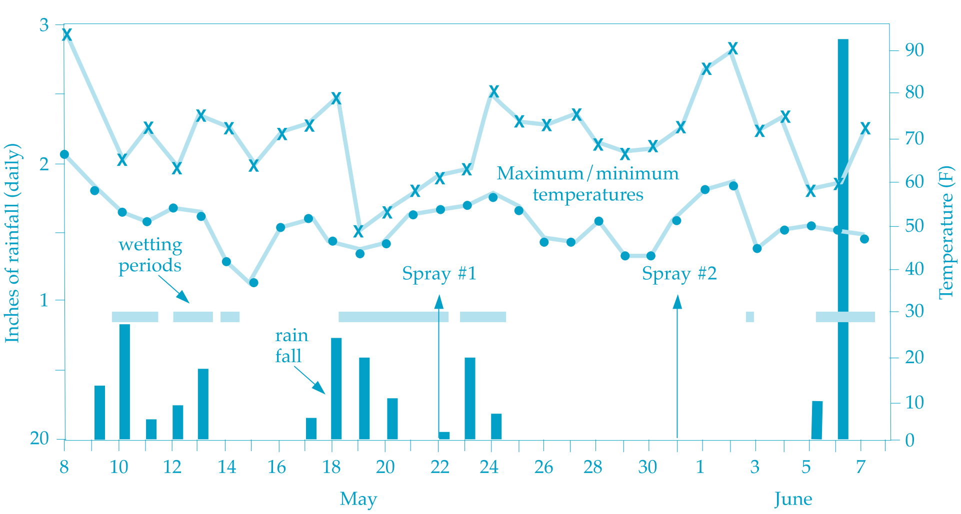

Figure 1. Daily temperatures, wetting periods, and rainfall during the time that post-infection and protectant activities of Nova+Dithane, Sovran, and Flint were being evaluated in 2000.

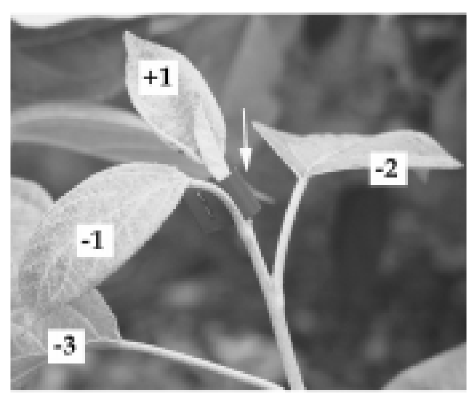

Figure 2. Jerseymac shoot one day after fungicides were applied, showing tag (white arrow) on the internode above the last leaf that was expanded at the time of the fungicide applications. Leaves below this mark are designated as leaf positions –1 (closest to the tag) through –5, whereas leaves developing 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 15 June	3 July	16 Aug	% fruit with scab 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 ($P \leq 0.05$).

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.
[2] Means for fungicide treatments followed by the same letter are not significantly different ($P \leq 0.05$).

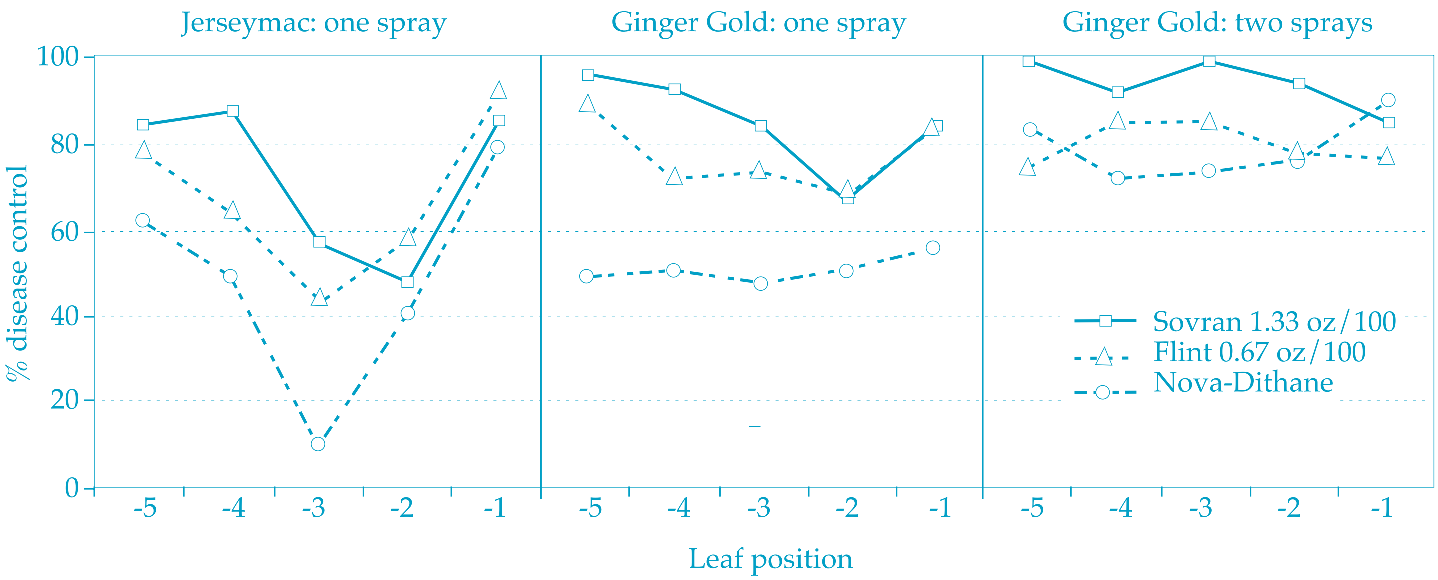

Figure 3. Post-infection control of apple scab on Jerseymac and Ginger Gold, with results presented as percent disease control by leaf position for the five youngest leaves that developed prior to the first fungicide application. Disease incidence for the same leaf positions on unsprayed controls ranged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

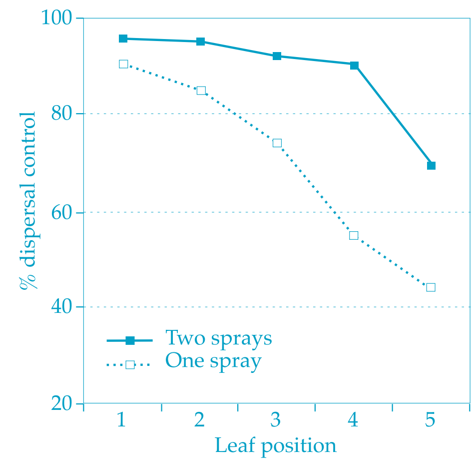

Figure 4. Apple scab control following either one or two applications of fungicides, with results presented as percent disease control by leaf position. Disease incidence in unsprayed controls ranged from 90 to 95% of leaves infected.

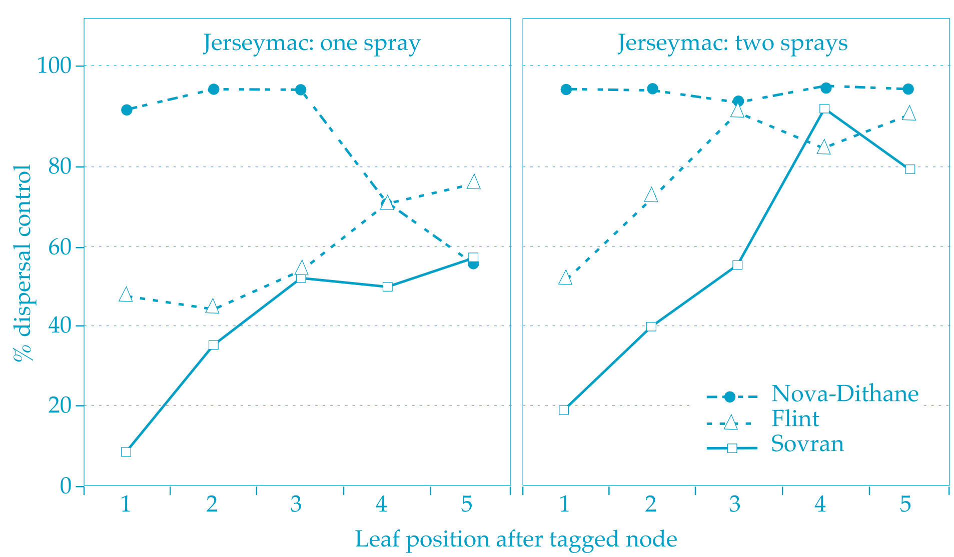

Figure 5. Powdery mildew control following either one or two applications of fungicides, with results presented as percent disease control by leaf position for the first five leaves that expanded after the day of the first fungicide application. Disease incidence in unsprayed controls ranged from 62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

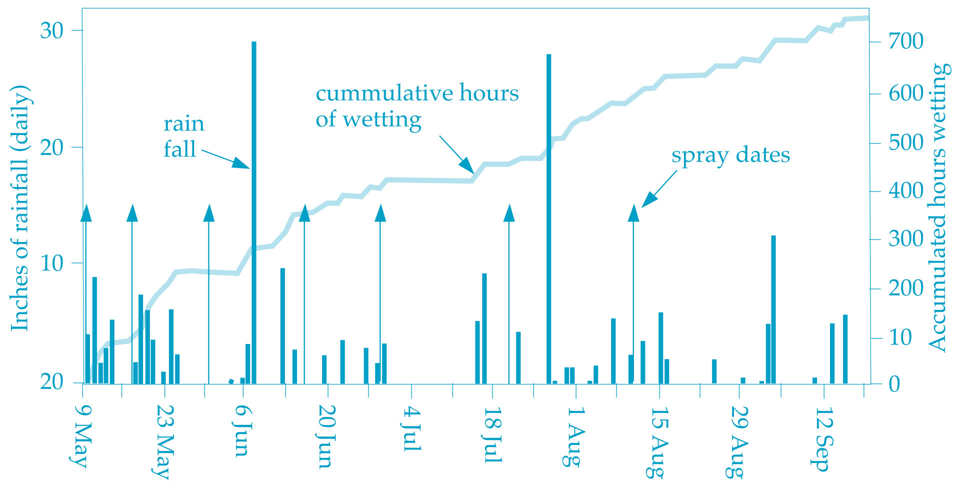

Figure 6. Spray dates, rainfall, and accumulated hours of leaf wetting related to the fungicide experiment for control of flyspeck on Liberty apples.

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] -5	-4	-3	-2	-1	Grand mean for leaf positions –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, $P \leq 0.05$. 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.

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Marketing Apple Products

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Apple growers know that change is needed to remain competitive in today's worldwide market. The processing sector of the apple industry is particularly strained. Low apple prices and the recent closures of some Eastern apple processors have been cause for a negative outlook among many growers in the region. This article summarizes the marketing research aspects of a large project being done at Cornell to help the processing sector meet its current challenges.

Across the country, apple growers know that change is needed. Economic stress is readily apparent in today's apple industry. At most gatherings of apple growers, discussion frequently turns to marketing issues. Growers are concerned about their future in an industry characterized by low prices for apples, competition from low priced foreign apple juice concentrate, and the pressures of industry consolidation throughout the supply chain.

The processing sector of the apple industry is particularly strained. Low apple prices and the recent closures of Eastern apple processors have been cause for a negative outlook among many growers in the region. Among consumers, apple product consumption has generally been stagnant in recent years.

In the Northeast, apple processors provide an important outlet for the apple industry. In New York over half of the annual apple harvest is sold in processing markets. New York apples are processed into apple juice, cider, sauce, pie slices, hard cider, dried apples, and several other apple products by processors in the state and throughout the eastern U.S. Facing the economic pressures of a changing market, apple growers and processors need to make strategic adaptations to enhance their competitiveness. A current research project at Cornell University aims to provide direct assistance to the processing sector in meeting its current challenges.

Two years ago, Cornell University received an anonymous grant to support a project focused on the Northeastern apple processing industry entitled "Development of an Environmentally Sound, More Profitable System for Production and Marketing of Value Added Processing Apple Products in the Northeastern United States." The purpose of this project is to assist growers and processors in the industry to face the challenges of the changing market and to take advantage of opportunities offered by new information and technologies related to production, pest control, product development, and marketing.

This project is interdisciplinary in its approach. The project includes faculty and staff from six Cornell Departments: Entomology, Plant Pathology, Horticulture, Food Science, Cornell Cooperative Extension, and Agricultural, Resource, and Managerial Economics. By involving a broad range of experts, the project aims to address a number of research questions for the industry. The goals of the project are:

- To develop a more environmentally sound, cost-effective apple production and integrated pest management system,
- To stimulate growth of apple processing industry with new technologies that support commercial production of diversified, high value apple products, and
- To assess economic impacts, marketing potential, and consumer reactions to new products.

Marketing research is just one component of this research, but an important step in addressing industry concerns. This article summarizes the on-going marketing research component of this project. This research will be completed in 2001. Final

New apple processed products such as sparklilng cider may offer value added opportunities for fruit growers.

project reports and related articles that report results will be available at that time.

Market Trends

As the global supply of apples is growing, the per capita supply is also growing. In 1998, the global apple supply was approximately 20.1 pounds per person. This level reflects 15% growth in the global supply of apples per capita over the past ten years. With expectations for continued growth in the global supply of apples, the industry faces substantial concern about future demand levels.

Figure 1 shows the average consumption levels for apples and apple products in the U.S. in 1997-98. Each year, the average American consumes 18.82 pounds of apples in juice and cider, 5.70 pounds of apples in canned apple products, 1.30 pounds in frozen apple products, 0.97 pounds of apple in dried apple products, and 0.67 pounds of apples in other apple products.

Over the past 20 years in the U.S., total apple consumption has risen by 34% to over 46 pounds per person annually (see Figure 2). Most of this increase can be attributed to a 108% increase in the consumption of apple juice and cider during this period (see Figure 3). Consumption of frozen apples increased over the same period by about 53%. Other processed apple products did not have discernable consumption trends during this time. Fresh apple consumption fluctuated, but increased overall by about 9% during the 20-year period.

At the current level of consumption, the average American consumes only about one fresh apple per person each week. In 1998, the average American consumed about 288 pounds of fruit, both fresh and processed. By weight, about 16% of that fruit were apples and apple products. For comparison, Americans consumed almost 100 pounds of oranges and processed orange products per person that year. Oranges account for about 35% of all fruit consumed in the U.S. Among fruits, apples rank 3rd in per capita consumption in the U.S., behind oranges and grapes.

Despite the increase in apple consumption over the past 20 years, U.S. consumption of apples and apple products has generally been flat for the past several years. The market for processed apple products shows signs of stagnation. Products are generally mature, and consumers have well-established patterns of purchasing and using these products. Investment in consumer advertising is low, and product innovation is infrequent.

In a mature industry, marketing strategies should focus on expanding existing markets and developing new markets. Existing markets may be expanded by volume consumed by existing consumers. Markets may also be expanded by promoting new product uses. New markets may be developed with new products and by reaching consumers that previously did use the product. Developing new products is a particularly important strategy in a mature market. Existing products are always vulnerable to changes in the market environment, and consumers' needs, tastes, and interests change over time. New products can be used to adapt to these changing market conditions.

The marketing research in this project is focused on market expansion through the identification of new markets and the development of new products. The project has initiated a number of marketing research activities to collect information about processed apple products and markets that can be useful to the industry in developing marketing strategies. This research aims to provide a first step in advancing innovation and market expansion in the industry.

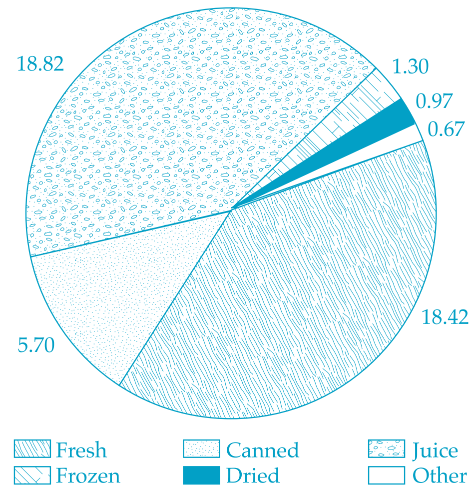


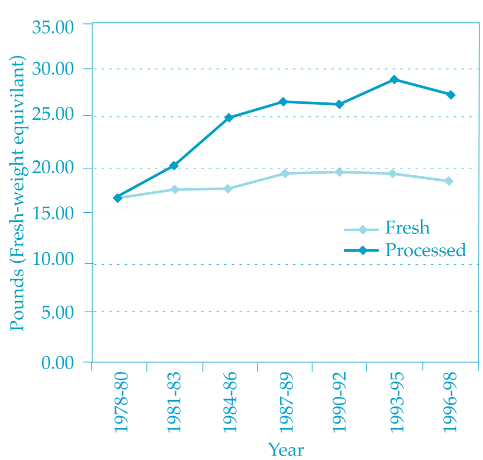
Figure 1.Average annual U.S. apple consumption, per capita (in pounds): 1997-1998

Marketing Research

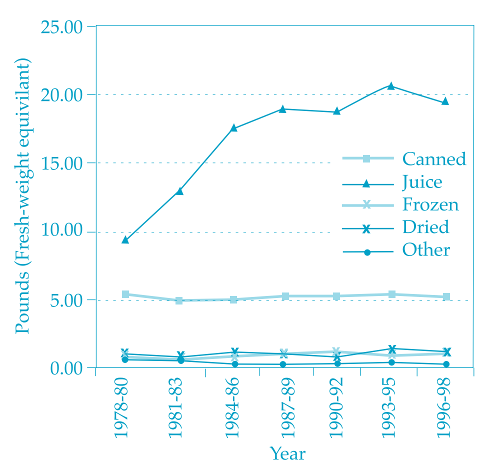
The marketing component of this project was designed to analyze processing apple markets, to develop new product concepts, and to identify new market opportunities for apple products. The agricultural economists on the project work closely with the food scientists to consider new product ideas from both a marketing and a production perspective. However, the marketing research is not limited to consideration of products that are available for sampling from the Food Science laboratories. Instead, market research is aimed broadly at identifying market opportunities by considering product concepts as well as product prototypes.

The first steps in the marketing research process included an industry overview, the development of a project advisory council, and an apple processor survey. These steps were taken to collect background information and to support the development of a marketing research plan.

The advisory council was created to involve a diversity of opinions in discussion about the industry and its markets and products. This group meets twice annually to provide input and guidance on research plans. It also serves as a sounding board and idea generator for the project. Members of the advisory council



Figuer 2. U.S. apple consumption of fresh and processed apples over the past 20 years.



Figuer 3. U.S. consumption trends of processed apple products over the last 20 years.

TABLE 1

Consumer Motivators in Today's Market

- **Convenience: Consumers' need for more time drives the purchase of on-the-go foods, meal solutions, and functional packaging.**
- **Wellness: Fears about aging, declining health, and medical costs drive consumers to prevent and self-treat health problems with food and beverage products that offer health benefits.**
- **Food quality and safety: Consumers are drawn to products that offer quality assurance and reliable food safety.**
- **Gratification: Disposable income levels have been rising in the current strong economy, and consumers are seeking indulgence for themselves and their kids. They are drawn to buy gratifying products that taste good and offer the feeling, "I'm worth it."**

TABLE 2

Apple Product Concepts from New Product Development Workshop

- **Applesauce in Squeeze-Tube Package for Kids**
- **Pre-Sliced Apples for Baking**
- **Snack Pack with Pre-Sliced Apples, Cheese, and Crackers**
- **Waldorf Salad Kit with Pre-Sliced Apples**
- **Ready-to-Microwave Baked Apples**
- **Apple Spritzer with Sparkling Cider and Mineral Water**
- **Stir-fry Sauce with Apple Chunks and Savory Spices**
- **Fresh Pressed Chilled Apple Juice**
- **Apple Cider Syrup for Pancakes and Desserts**
- **Apple Cider Salad Dressing**
- **Apple Cider Fortified with Vitamins or Herbs**
- **Pourable Chunky Apple Topping**
- **Apple Juice and Spring Water Beverage for Young Children**
- **Microwaveable Apple and Cheese Turnover**
- **Apple Slaw**
- **Apple and Green Tea Beverage**
- **Fresh Apple Cobbler or Apple Crisp Baking Kits**
- **Apple Cider Ice Cream**

represent growers and processors, but also an agricultural financial institution, a retail grocery chain, and industry associations.

The survey of regional apple processors was completed in 1999. The purpose of the survey was to assess processor outlook for the industry and to identify marketing challenges and opportunities. In this survey, 21 apple processors in New York, New England, Pennsylvania, and Virginia were interviewed. The interviewees represented processors that purchase almost 35 million bushels of apples annually, including about 12.5 million bushels from New York State. The processors interviewed in the survey produce a wide range of apple products including juice, cider, applesauce, frozen apples, pie filling, dried apples, cider vinegar, hard cider, and baby food.

Using the information collected from the industry overview, the advisory council, and the processor survey, a marketing plan was developed. The objectives of the plan are to:

- **Conduct forward-looking research:** Focus on opportunity identification rather than assessment of current market conditions and trends.
- **Explore how to make apple products relevant in today's market:** Identify the motivators that are driving consumers and how to make apple products relevant in that context.
- **Identify new product and new marketing opportunities:** Use the research to assess consumer reactions to new product ideas and to identify new demographic markets that are possible areas for market expansion.
- **Identify foodservice opportunities:** Explore how to adapt apple products for greater use in foodservice markets, which are experiencing rapid growth as American consumers increase their consumption of meals away from home.

The research plan includes several major activities. The purpose and status of each activity is presented below.

1. New Product Development Workshop

New York processing apple industry leaders attended a workshop in June 2000 focused on new product development. The workshop was facilitated by marketing consultants with extensive experience in new product development, and the meeting was held at a facility that serves as a new products showcase. The facility houses a library of 65,000 consumer products collected over the past 30 years. The products in the collection offered many stories of market successes and failures, and these surroundings provided a rich environment for stimulating creative thoughts about apple products.

The workshop emphasized the importance of innovation as a key to success. New products must stimulate a consumer to take the risk of purchasing them. To do so, new products must appeal to basic consumer motivators (see Table 1). The workshop discussion was focused developing concepts for products that are relevant to today's consumer motivators. The final product of the meeting was a list of apple product ideas for further consideration. A sampling of these ideas is listed in Table 2.

2. National Consumer Survey

A national survey of apple product consumers was conducted in September 2000. The survey had two main objectives. First, the survey sought to identify demographic trends in apple and apple product consumption. This information was collected in order to identify potential opportunities for market expansion to new demographic targets. Second, the survey was used to assess several of the new product concepts discussed at the workshop and presented in Table 2. Results from the survey are currently being tabulated and analyzed.

3. Consumer Focus Groups

Following the survey, six focus group meetings were held with consumers in the New York City metropolitan area in October 2000. All of the groups were held with women that shop for their households. Two groups were held with each of three demographic targets: women with children under 6, women between 50 and 69 years old, and women between 25 and 49 that consume wine. The last group was used in part to evaluate markets for hard cider and apple wine. Overall, the purpose of the focus groups was to explore how these consumer groups use and view apples and apple products. The participants discussed what qualities they like and dislike in apples and apple products, how they would change apples and apple products, if they could. Participants also sampled and evaluated some prototype apple products. The discussions were facilitated by a professional moderator who is currently preparing a summary of the discussions. Preliminary findings indicate broad support for fresh apple slices as a retail food product and interest in baked apple chips as a snack product.

4.School Foodservice Survey

The New York State School Foodservice Association has a task force committed to increasing the use of New York State agricultural products in the state's school foodservice programs. This committee has estimated that New York schools buy the equivalent of six million bushels worth of apples in the form of apple juice each year. This estimate reflects the importance of this market to the apple industry.

School foodservice has traditionally been an important market for apple products, including apple juice, applesauce, and canned apple products. Like other markets for apple products, this market is changing. A survey of school foodservice directors has been developed with the assistance of members of the task force mentioned above. The purpose of the survey is to explore the use of apple products in New York school foodservice programs, to examine the important factors in purchasing decisions, and to assess the relevance of apple products in today's school foodservice market. The survey will be distributed in early November.

5. Foodservice Managers Focus Groups

Recently, much attention has been given to the growing role of foodservice in food and beverage distribution in the U.S. With U.S. consumers currently spending almost half of their income on meals away from home, the foodservice sector is an important market. In November, four focus groups will be held with foodservice managers from family restaurants and institutional foodservice operations. These groups will examine the use of apples and apple products in foodservice and explore opportunities to develop and improve apple products for the foodservice sector. Participants will also sample and evaluate some apple product prototypes.

In addition to these major research activities, the project will includes several other related initiatives, including:

- Marketing research assistance to commercial partners in the research project
- Case studies of successful marketing strategies from other food and beverage industries
- Review of eco-labeling literature and programs
- Publication of short "how-to" marketing articles

Final project reports are expected to be available in 2001, and interim project reports are available now.

While this marketing research can help, it alone will not improve markets for processing apples and apple products. This information gathering effort is only a preliminary step that can provide support and resources for future innovation and strategy development. Stepping beyond this information requires risk-taking and investment on which the future of industry hinges.

Kristin Rowles is a Research Associate in the Dept. of Applied Economics and Management who is heading the marketing research project on processed apple products.

Blueberry Nutrition on Upland Soils

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Proper site selection, coupled with attention to preplant modification, is the major hurdle for blueberry nutrition management. If plants are established properly, they will require little supplemental nutrition, except for nitrogen.

The native peoples of North America have long gathered blueberries (called "star berries" in several Indian languages because of the shape of the calyx) for fresh eating, drying, and flavoring meat, pudding, cake, and bread. Europeans were unfamiliar with this delicious fruit when they arrived in the New World, but were fascinated with it. Anne Pollard, a 12-year-old girl who was the first Puritan ashore in North America in 1630, wrote about Boston's Beacon Hill being covered with flavorful, blue-colored berries.

Europeans first gathered the fruit from woods and stream banks, but as villages were established and forests cleared, people desired the convenience of blueberries in their gardens. The first recorded blueberries brought into cultivation were in northeastern Florida in 1887. The story goes that Moses Sapp, a logging contractor "who liked to fish but was forced by his wife to pick blueberries instead," decided to transplant some blueberries into his yard so she could pick the blueberries and he could go fishing. Although this attempt was somewhat successful, many others who transplanted blueberries into their home gardens observed their blueberry plants turn yellow and die. It was as late as 1910 when Fred Coville (Cornell Class of 1888) discovered that the optimal pH for blueberries is 4.3-4.8, much lower than that of most home gardens. Once this discovery was made, growers made the appropriate modifications, and now blueberries are widely grown in North America.

Blueberries have unique nutritional requirements compared to most other crops. They evolved in acidic soils where fertility is usually quite low. In addition, in such soils, the predominant form of available nitrogen (ammonium) is usually present at levels that would be toxic to many plants. However, blueberries have evolved mechanisms to cope with these acidic, ammonium-rich, nutrient-poor conditions. First, a symbiotic relationship has developed with endomycorrhizal fungi. These fungi derive carbohydrates from the inner portions of the root system, and in return, help extract nutrients (especially phosphorus and nitrogen) from the soil for the blueberry plant. So, in comparison with other crop plants, blueberries have very low nutritional requirements. In fact, blueberries are sensitive to high levels of some nutrients, and a heavy fertilizer application will injure them.

Eric Hanson, Michigan State University

Figure 1. Interveinal reddening is caused by magnesium deficiency.

Blueberries also have the unique ability to directly absorb ammonium ion. Most plants absorb nitrate, which is then converted to ammonium by nitrate reductase, before incorporation into proteins. However, nitrate fertilizers can be detrimental to the blueberry (Fig. 1). For this reason, ammonium forms of fertilizer are recommended, such as ammonium sulfate or urea. Ammonium sulfate is particularly good because it acidifies the soil, and most New York soils tend to have a pH higher than 4.5. Our soils are often underlain with limestone, or the irrigation water source is neutral to basic. Furthermore, soils with clay slowly release potassium, a basic ion. These conditions tend to increase the pH over time, so even if the soil pH was reduced to 4.5 at planting, it can rise to unacceptable levels by the third or fourth year.

Most nutrient problems in blueberries can be avoided by simply maintaining the soil pH between 4.0 and 5.0. Sulfur is the material of choice for acidifying soil, with the amount dependent on texture and current pH. The higher the pH

TABLE 1

Approximate amount of sulfur (lb/A) required to lower soil pH to a value of 4.5.

	Soil Type		
Current pH	Sand	Loam	Clay
5.0	**175**	**530**	**800**
5.5	**350**	**1050**	**1600**
6.0	**530**	**1540**	**2310**
6.5	**660**	**2020**	**3030**
7.0	**840**	**2550**	**3830**

Figure 2. Iron chlorosis is induced by a high pH soil environment.

and the finer the soil texture, the more sulfur will be required (Table 1). In general, soils with more than 40 percent clay plus silt, or a cation exchange capacity greater than 18, will not support blueberry plants. However, a high soil organic matter content is desirable for blueberry production, especially when they will be grown on upland (mineral) soils. Levels of >6.0 percent are preferred. In some areas, blueberries are grown on muck soils.

Approximately 1 year is required for supplemental sulfur to oxidize and reduce the soil pH. Powdered sulfur is faster acting than prills, but is also more expensive and somewhat unpleasant to spread. Oxidized sulfur is available in the form of aluminum sulfate or iron (ferrous) sulfate, but these materials are required in much larger amounts (6-fold and 8-fold, respectively) than elemental sulfur, and they can be toxic to the blueberry plant. Blueberry growers must also be concerned about toxic levels of aluminum and manganese that are present naturally in the soil, since these become very available when the pH is lowered below 5.0.

One of the first signs that the soil pH is too high is interveinal yellowing of leaves (Fig. 2). Symptoms usually appear first on the youngest leaves toward shoot tips, and plants exhibit reduced shoot growth and leaf size. The yellow coloration is caused by the lack of chlorophyll production in the leaves, brought on by the plant's inability to use iron. Although the plant may exhibit iron deficiency symptoms, the cause of the symptom is high soil pH. To correct this problem, growers can apply a foliar spray of iron chelate, but the permanent solution is to apply 200 lb/A elemental sulfur, twice a year, to the soil under the plants until the problem disappears.

Leaf analysis is a valuable and often underutilized tool in blueberry nutrition programs. It provides a means of accurately identifying nutritional problems that are difficult to diagnose by soil testing or by observing bush appearance. More importantly, growers can identify and correct potential nutrient shortages before growth or yield is affected. Plants can be nutrient deficient without showing external symptoms.

In New York, leaf analysis results over many years suggest that nitrogen (N) is among the most commonly deficient nutrients. Ideally, levels should fall between 1.7 and 2.0 percent. Inadequate N causes a general reduction in bush growth. New shoot growth and leaf size are reduced, and few new canes are initiated. Deficient leaves are pale green (chlorotic) in color, as opposed to the lush, dark

Figure 3. Blueberry root systems grown in solutions of nitrate and ammonium ions.

Eric Hanson, Michigan State University

Figure 4 . These leaves come from plants exhibiting a range of solution boron levels.

leaf, with no mottling or pattern. The older or lower leaves usually develop a pale color before younger leaves at the top of shoots. Severely deficient bushes seldom produce more than one flush of growth per season. Leaves of deficient plants often develop fall colors and abscise early. N-deficient plants produce short shoots, usually with fewer flower buds, so yield is reduced.

In mineral soils with low organic matter, applications of an ammonium-based fertilizer will relieve these symptoms. The rule of thumb is to apply 10 lb/A of actual nitrogen for each year old the plant is, up to age 7, then continue with 70 lb/A for the life of the planting. The applications should be split, with the first half being applied at bloom, and the second half 6 weeks later. If fresh mulch was recently applied, rates may have to be increased. Soils high in organic matter rarely need supplemental nitrogen.

Magnesium (Mg) deficiency is common on naturally-acid soils where many of the cations (Ca, Mg, and K) have leached away. Symptoms of Mg deficiency include a distinctive pattern of chlorosis between the main veins of leaves. These regions may turn yellow to bright red while tissue adjacent to the main veins remains green (Fig. 3). This produces a Christmas tree-shaped green area in the middle of reddish leaves. Leaves at the base of young shoots are likely to show symptoms first. Young leaves at the tips of shoots are seldom affected. To treat these symptoms, growers fertilize with epsom salts or sul-po-mag (potassium magnesium sulfate); usually 500 lb/A will correct the imbalance.

Potassium levels are rarely low, except on sandy soils. If soil tests or leaf analyses indicate a need for K, use potassium sulfate, or sul-po-mag if Mg is also needed. Potassium chloride (muriate of potash) is used by some growers because it is less expensive, but blueberries are sensitive to the chloride in this material. If high rates are used or the material is applied to young plants or not spread uniformly, damage can occur. Rates of 50-100 lb K_2O/acre will correct most shortages. Apply K at any time of the year. Excess K can interfere with Mg uptake, so it should not be applied unless a foliar analysis indicates a deficiency.

Phosphorus deficiencies have never been reported for blueberries in the field. Blueberries are good scavengers of P, and when soil P is low, the infection rate from mycorrhizal fungi increases, thereby increasing P uptake.

Boron, zinc, and copper levels appear to be relatively low in plantings throughout the Northeast and Midwest. However, foliar sufficiency levels are only best guesses based on greenhouse experiments. Although 88 percent of samples from New York are below 5 ppm Cu, we are unsure if productivity and plant growth are limited by Cu, and we are unsure how to increase levels in plants. Excessive boron levels cause foliar marginal reddening and necrosis. (Fig. 4) Much more work needs to be done with micronutrients in blueberries, and methods to economically increase their availability in soils.

Proper site selection, coupled with attention to preplant modification, is the major hurdle for blueberry nutrition management. If plants are established properly, they will require little supplemental nutrition, except for nitrogen. So, plant some blueberries; then grab the fishing pole. Important work awaits!

Marvin Pritts is a professor in the Department of Horticulture at Cornell University, Ithaca, NY. He specializes in berry crop culture and leads Cornell's research and extension program in berry crops.

Effects of Multiple Pyrethroid Insecticide Applications on Secondary Mite Outbreaks

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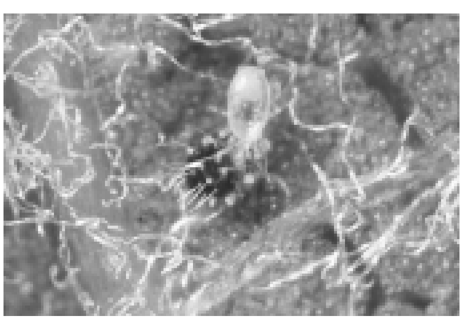
This work supported in part by the New York Apple Research and Development Program and the USDA Northeast Pesticide Impact Assessment Program.

Organophosphate(OP) insecticides have long been essential to northeastern apple growers for the management of many insects, primarily for plum curculio and apple maggot. Because these two pests oviposit directly into the fruit, protection by insecticides is provided by toxicity to the adult prior to or during oviposition. The OP's have been well suited and popular for this purpose because they generally act quickly, yet have good persistence, and are effective against both Coleoptera and Diptera. Implementation of the Food Quality Protection Act (FQPA), and the resulting restrictions on OP usage, has affected apple pest management programs in the Northeast. At the onset of the FQPA, we were concerned that all OP usage would be eliminated, and therefore thought it likely that this pest control void would be filled by pyrethroids. For the purposes of this research, we chose the worst-case hypothesis that all OP uses would be revoked.

It is commonly thought that because of detrimental effects on phytosied predators, applications of pyrethroid insecticides contribute to secondary outbreaks of European red mite (ERM), *Panonychus ulmi* (Koch) and to two-spotted mite (TSM), *Tetranychus urticae* Koch. It was undetermined however, the extent to which such outbreaks might be mediated by the residues of three currently registered efficacious miticides, ie. Apollo, Savey and AgriMek. Within the context of a larger project, one of our objectives was to assess the relationship of multiple pyrethroid applications to secondary mite outbreaks.



A *T. pyri* predator mite attacking a European red mite.

Twospotted spider mite, a sporadic but potentially serious pest in New York orchards.

Pyrethroid insecticides are known to cause or contribute to mite problems in certain situations. Our results showed that flaring of mite populations by Asana was greatly dependent upon the degree of early-season mite control. Asana and Guthion applications suppressed *Typhlodromus pyri* in some trials, but this effect alone did not cause significant flaring - suggesting that other factors contribute to the phenomena.

Within three commercial orchards (one each in Eastern NY[ENY] and two each in Western NY[WNY]) during 1998 and 1999, we established the following treatments in a split-plot design to assess the relationships among miticides, multiple Asana and Guthion sprays and the seasonal buildup of phytophagous mites:

1) prebloom Apollo + multiple Guthion
2) prebloom Apollo + multiple Asana
3) petal fall AgriMek + multiple Guthion
4) petal fall AgriMek + multiple Asana
5) either no miticide or prebloom oil + multiple Asana
6) either no miticide or prebloom oil + multiple Guthion
7) various untreated situations

Treatments were replicated 4 times. Insecticide applications started at petal fall and continued as regular covers through the apple maggot oviposition period (≈Aug 15). Prebloom and petal fall miticide treatments were prophylactic; summer miticide treatments, where necessary, were applied at the NY IPM threshold. Phytophagous and predacious (*Typhlodromus pyri*) mite populations were assessed by standard methodology. Cumulative mite days per leaf (CMD's) were calculated by: $[0.5(mpl_1 + mpl_2]*d_{1-2}$, where mpl_1 is the number of mites per leaf at time 1, mpl_2 is the number of mites per leaf at time 2, and

d_{1-2} is the number of days elapsed between the two counts. Simply described, the CMD model utilizes frequent assessment of mite numbers to measure the accumulative effects over time, rather than at a single point in time. For the purposes of these experiments, treatments allowing greater than 100 CMD's are considered to be poor from the perspective of mite management.

1998 Experiments

Western NY: Identical trials were performed in two commercial orchards. Moderate to high mite (ERM) populations were present at these sites. These trials included oil treatments applied at the same timing as Apollo (tight cluster). Pyramite alone was applied at IPM threshold and is considered as the untreated control. Results of these experiments, which are presented in Table 1, show the following:

- In the untreated plots at both sites, ERM populations developed early and Pyramite rescue treatments were necessary before the trial ended.
- In the tight cluster oil treatment at both sites, populations exceeded threshold by mid-June, regardless of the insecticide used.
- At both sites, the tight cluster Apollo treatments yielded very acceptable CMD's regardless of the insecticide used.
- Between sites, AgriMek applied at petal fall provided inconsistent results – Asana yielded high CMD's at site #1; while conversely, Guthion yielded high CMD's at site #2.

Eastern NY: Low mite populations (ERM+ TSM) were present at this site. Leaf condition was compromised by severe apple scab infections. Results of this experiment, which are also presented in Table 1, show the following:

- Significant flaring of mites did not occur regardless of the miticide used or the insecticide schedule.
- Based on CMD's, the Asana schedules tended to produce more mites, but in no instance did the effects approach seriousness.

1999 Experiments

Western NY: Identical trials were performed in two commercial orchards, representing two distinct mite (ERM) pressure situations. Results of these experiments, which are presented in Table 2, show the following:

- Infestation pressure at site #1was initially low and all miticides, regardless of seasonal insecticide program, allowed low CMD's throughout the season.
- By early July however, populations at site #1 were significantly over threshold in both tight cluster oil treatments, regardless of insecticide used.
- Infestation pressure was considerably higher at site #2. Both tight cluster oil treatments needed rescue miticide applications after the trial was concluded.
- Within the tight cluster Apollo treatments, rescue treatments were required regardless of the seasonal insecticide schedule employed.
- AgriMek treatments maintained ERM well below threshold for the entire season, regardless of the seasonal insecticide schedule employed.
- Generally, Asana reduced *T. pyri* predator numbers to a greater extent than did Guthion. Relative to the untreated trees however, all treatment combinations reduced *T. pyri* CMD's.

Eastern NY: High mite (ERM+TSM) populations were present at this site. Results of this experiment, which are presented in Table 2, show the following:

- Treatments that utilized Asana or Guthion but no miticide, yielded very high CMD's, without an apparent relationship to the insecticide used.
- Similar to WNY-site #2, tight cluster Apollo applications allowed high CMD's, with no relationship to the insecticide used.
- AgriMek allowed very low CMD's, regardless of the seasonal insecticide

TABLE 1

Effects seasonal insecticide applications on phytophagous mite pests of apple in Western and Eastern New York orchards, 1998.

Treatment	Miticide timing	Cumulative mite days per leaf WNY[1]site 1	WNY[1]site 2	ENY[2]
Oil + Guthion	TC	176.3[a]	247.5[b]	-
Oil + Asana	TC	164.9[a]	181.1[b]	-
Apollo + Guthion	TC	34.9	39.9	18.3
Apollo + Asana	TC	47.9[a]	23.3	49.8
AgriMek + Guthion	PF	38.1	132.0	58.7
AgriMek + Asana	PF	125.4	28.5	72.2
Pyramite check		291.9[a]	283.5[c]	-
No miticide + Guthion	-	-	-	93.3
No miticide +Asana	-	-	-	34.6

[1] ERM only; Guthion applied 5 times, starting at PF; Asana applied 6 times, starting at pink. Numbers in bold represent a significant degree of flaring of mite populations by Asana.

[2] ERM + TSM; Guthion applied 4 times, starting at PF; Asana applied 5 times, starting at pink. Note: severe apple scab infection affected leaf quality and subsequent mite infestations.

[a] Rescue treatments applied after data completed.

[b] Rescue treatments applied on 1 July before data completed.

[c] Rescue treatment applied 10 June before data completed.

TABLE 2

Effects seasonal insecticide applications on phytophagous mite pests of apple and a predator in Western and Eastern New York orchards, 1999.

		Cumulative mite days per leaf				
	Miticide	WNY[2] site 1		WNY[2] site 2		ENY[3]
Treatment[1]	timing	pest	predators	pest	predators	pest
Oil + Guthion[4]	TC	61[6/28]	1.3	104[6/28]	3.6	398[7/22]
Oil + Asana[4]	TC	131[7/13]	0.7	327[8/6]	3.7	277[7/22]
Apollo + Guthion	TC	25	4.3	171[8/15]	4.7	342
Apollo + Asana	TC	51	1.4	358[8/15]	1.5	313
AgriMek + Guthion	PF	4	4.2	42	1.6	88
AgriMek + Asana	PF	6	1	3	2.3	54
Untreated	-	26	12.6	386	10.4	473

[1] At all locations, Guthion applied 5 times, starting at PF; Asana applied 6 times, starting at pink.

[2] ERM only; predator primarily *Typhlodromus pyri.* Numbers in bold represent a significant degree of flaring of mite populations by Asana. Dates in brackets are threshold or rescue treatments with Pyramite.

[3] ERM + TSM; dates in brackets are threshold or rescue treatments with Pyramite.

[4] Dormant oil applications in WNY only; ENY received insecticide only.

schedule employed.

Our results show that either Asana or Guthion can cause flaring of mite populations. Within only four of twenty-one total paired comparisons (19 percent) between Asana and Guthion did the pyrethroid promote higher mite populations. Moreover, if effective and persistent miticides (AgriMek in particular) were employed against early-season mite populations, CMD's were not exacerbated by the use of either insecticide. It was apparent that flaring of mites was more likely to happen with either insecticide when early-season mite populations were high, or were not adequately controlled by an early miticide application. Our evidence suggests that Asana could be substituted for an OP without causing outbreaks of phytophagous mites, provided that current (and future miticides) remain efficacious and are applied early in the season. Analyses of predatory mite populations within Asana and Guthion treatment scenarios showed that both insecticides had suppressive effects on *T. pyri* , but this effect alone did not cause significant flaring of phytophagous mites.

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Effects of ReTain, Nitrogen Fertilization, and Mid-summer Trunk Scoring on Fruit Color and Quality of 'Jonagold' Apples

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Fruit coloring can be improved in poorly coloring blocks of 'Jonagold' by limiting or eliminating N fertilizer applications on trees with leaf N levels above 2.0% or by mid-summer trunk scoring. Red color intensity can also be improved by trunk scoring.

'Jonagold' is a high quality apple that has steadily increased in popularity since its release by the Cornell/ Geneva apple-breeding program in 1968. However, the fruit of most 'Jonagold' strains in many orchards do not develop sufficient red blush - even when firmness, starch index, and other maturity indices suggest the fruit is ready for harvest. To make matters worse, if growers delay harvest waiting for better red color, 'Jonagold' often becomes greasy and vulnerable to rapid breakdown during subsequent cold storage. The success and profitability of 'Jonagold' for the NY apple industry has been limited by these problems. We initiated an experiment to test and develop practical management strategies that improve fruit color, firmness, and storage quality of 'Jonagold' apples in New York.

Our strategy over the last two years examined: 1) The use of ReTain™ (50 g AVG/acre) to slow ethylene synthesis and ripening and delay harvest for better color development; 2) Nitrogen management schemes including, i) elimination of nitrogen applications, ii) a single low nitrogen (N) fertilization (30 lb. N/acre, soil applied in May), and iii) spring and postharvest urea spray applications (two 1% sprays post petal fall, and one 5% spray postharvest); and 3) Mid-summer trunk scoring (first week of August) to decrease N uptake and increase the carbohydrate to N ratio in the tree canopy, thereby improving fruit color. Fruit were collected and analyzed weekly on four dates, beginning in late September and ending the middle of October during 1998 and 1999. This allowed us to determine the treatment effects on color and maturity over time.

Results from 1998 and 1999

ReTain: Maturity indices showed that ReTain delayed maturity of 'Jonagold' by 7 to10 days in both years of the study. This was evidenced by lower starch index scores, increased firmness, lower internal ethylene production, reduced red blush, and greener background color when treated fruit were compared to controls on the same harvest date. Harvest of ReTain treated fruit had to be delayed approximately one week to obtain equivalent percent blush color as untreated fruit (Fig. 1A). In the 1998, ReTain reduced blush development more when sprayed on N fertilized trees compared to unfertilized controls (Fig. 3D). ReTain had no direct effect on fruit size, but size increased linearly over the three week harvest period (Fig. 1C). Therefore, delayed harvest of ReTain treated fruit could be expected to increase average fruit weight, just as early harvest of Ethrel treated fruit will result in smaller fruit size. Since 'Jonagold' is a large fruited variety, the increase in fruit size is not an advantage, but small-fruited varieties may benefit from delayed harvest with ReTain. ReTain treated fruit were firmer than untreated fruit at harvest and after storage when picked at the same time (Fig. 1B). ReTain also delayed the onset of greasiness at harvest and after storage (Fig. 1D). The delay in firmness loss and greasiness development was a function of delayed maturity since these benefits were lost when ReTain fruit were harvested at similar levels of maturity one week later. After that period of time, ReTain treated fruit had equivalent, but not higher flesh firmness compared to untreated fruit harvested earlier. The same was true for greasiness. Therefore, ReTain appeared to be an effective harvest management tool, maintaining fruit quality for a period of 7 to 10 days beyond that of untreated fruit. Harvest timing of ReTain treated fruit should

Figure 1. Jonagold fruit color following treatment with AVG (ReTain) (top left), trunk scoring (bottom left), 30 lbs/acre N fertilizer (bottom right) or untreated (top right).

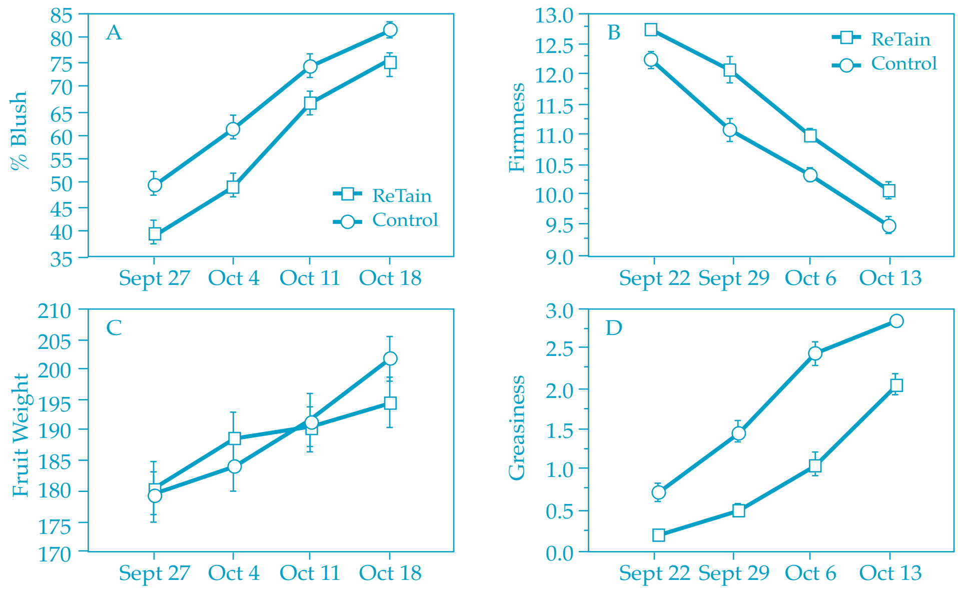

Figure 1. Effect of ReTain on percent blush (A), and average fruit weight (C) at harvest in 1999, and firmness (B) and skin greasiness (D) after two months in cold storage and seven days at room temperature (?) in 1998.

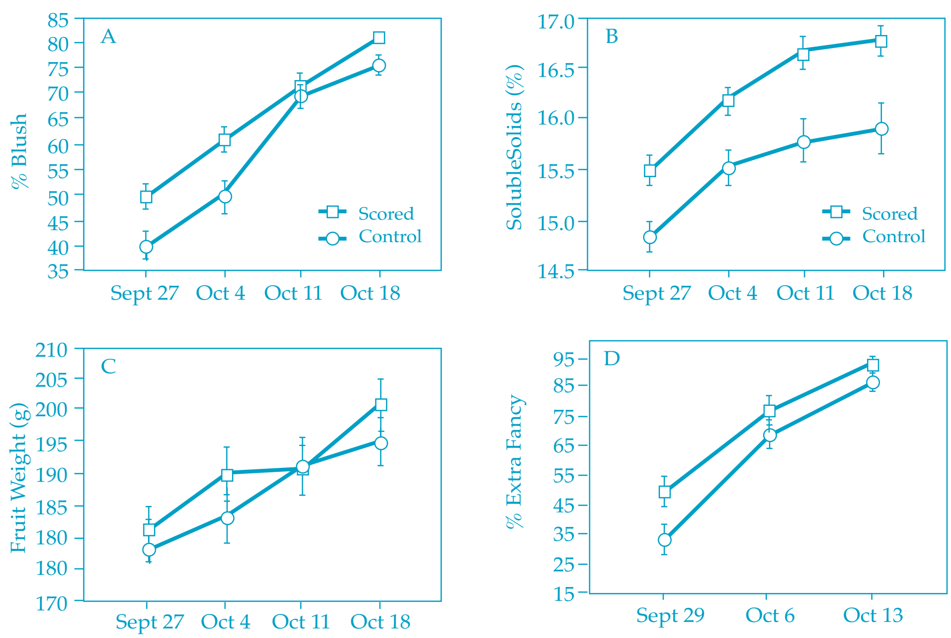

Figure 2. Effect of mid-summer scoring on blush development (A), soluble solids (B), and average fruit weight (C) in 1999, and precent extra fancy fruit (D) in 1998.

be based on the grower's objective. If the growers goal is to have harder fruit that are not greasy out of storage, treated fruit should be harvested around the same time as untreated fruit, but color will be sacrificed. If the goal is to delay maturity of 'Jonagold' in order to harvest larger crops of earlier ripening varieties, then ReTain can be used to extend the harvest window without substantial loss in fruit quality. Using ReTain to let fruit hang on the tree longer to improve red color does not seem to be a viable strategy for 'Jonagold' since ReTain actually delays color development. Furthermore, one should consider the potential for ReTain to interact with other orchard factors that may reduce color development such as N fertilization. Color may be further delayed if ReTain is applied to heavily cropped or overly vigorous trees.

Trunk Scoring: Mid-summer scoring increased blush development in both years of the study (Fig. 2A). Fruit from scored trees had 7 to10% more blush than control trees resulting in 10 to 20% more fruit in the extra fancy grade compared to non-scored trees (Fig. 2D). Red color intensity was brighter and background color was less green on fruit from scored trees. The effect of scoring on fruit color was more pronounced at the earlier harvest dates. This was not attributed to advanced maturity of scored trees since there was no difference in ethylene or starch index. The only observation that indicated advanced maturity of scored trees was the slight increase in skin greasiness at harvest which did not persist after storage. Scoring increased soluble solids concentration of fruit at harvest and after storage, giving fruit a noticeably sweeter taste (Fig. 2B). Scoring had no direct effect on fruit weight (Fig 2C), but size appeared to be reduced only when low N status trees were scored. Timing of scoring seems to be a significant factor involved in fruit color improvement. In other studies, scoring performed in the spring to reduce vegetative growth or enhance fruit set and flowering advanced fruit maturity without improving fruit color. In contrast, we found that scoring in mid-summer enhanced fruit color development without advancing maturity. Hastening the advent of color development with mid-summer scoring has the benefit of allowing growers to harvest a greater percentage of fruit earlier in the harvest window when storage quality is best.

Mid-summer scoring may be an effective method for improving blush of poorly coloring 'Jonagold' strains, especially since it can be performed at the same time as summer pruning. However, this technique needs further investigation before it can be recommended commercially. Data from this experiment were only collected for two years, and therefore, long term effects on tree health and yield could not be assessed. In any case, growers with poorly coloring blocks of 'Jonagold' may want to consider experimenting with this technique on some of their own trees.

Nitrogen Fertilization: The effect of N fertilization on 'Jonagold' color and quality varied in each year of the study. Under the more normal growing conditions in 1998, both the urea sprays and 30 lb. N/acre caused a 10 to 16% reduction in blush (Fig. 3A). The percentage of fruit graded extra fancy was 11 to 13% lower than control trees. Blush intensity was reduced, and background color was greener with foliar or ground N applications. Fruit size was greater on N fertilized trees, but only if ReTain was not applied (Fig. 3C). For some unknown reason, ReTain appeared to negate the size increase associated with both forms of N application.

Nitrogen treated fruit were softer at harvest (Fig. 3B), but there was no difference in flesh firmness between foliar and ground N treatments when ReTain was also applied. In 1999, N fertilization increased fruit breakdown after storage. We believe that the drought during the summer of 1999 may have interfered with N uptake and utilization.

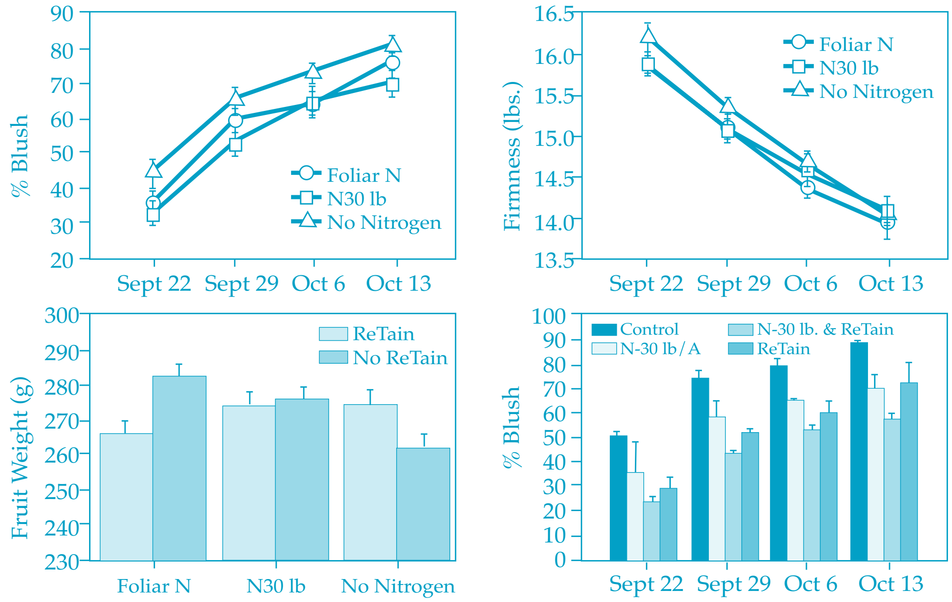

Figure 3. Effect of nitrogen fertilization on blush development (A), and fruit firmness (B) at harvest in 1998. Figure 3-C shows interaction between ReTain and N on fruit weight in 1998, and Figure 3-D dhows the effect on N and ReTain alone in combination on blush development in 1998.

Nitrogen application had no effect on fruit maturity or yield in either year even with leaf N levels of the control trees averaging 2.0%. Our results showed that N fertilization of mature 'Jonagold' trees had no economic benefit and even the low rate of ground applied N (30 lb./A), or the two spring urea sprays (1%) lowered packout in one year. One important negative consequence of Nitrogen fertilization is that growers may delay harvest due to poor color development in N fertilized trees, during which time fruit quality could decline. Our data indicates that the leaf N status of mature 'Jonagold' trees should be kept close to 2.0% in order to produce a larger quantity of extra fancy grade fruit. Further experimentation is needed to verify this, and also to determine the lower threshold at which point yield or fruit size are reduced, and biennial bearing becomes a concern. Reducing or eliminating N fertilizers on poorly coloring mature blocks of 'Jonagold' may be one of the most simple and effective ways to overcome problems with poor color development. Leaf analysis should be used to determine tree N status so that fertilization programs can be adjusted accordingly.

Conclusion

Based on results from this study, we conclude that fruit color can be improved in poorly coloring blocks of 'Jonagold' by limiting or eliminating N fertilizer applications on trees with leaf N levels above 2.0%. Scoring tree trunks in mid-summer at the time of summer pruning may also be an effective tactic for improving blush intensity and coverage. Since mid-summer scoring is not an established practice, we recommend it only be tried on a limited scale commercially. ReTain can maintain fruit firmness and delay development of greasiness on 'Jonagold' for a period of 7 to 10 days, after which time, fruit quality will be equivalent but not superior to non-treated fruit harvested earlier. We found interactions between ReTain and N on fruit size, firmness, and color development. It is possible that ReTain may interact with other orchard factors to either enhance or reduce its effects on fruit maturity and quality. Growers should be aware of the potential for such interactions, and apply ReTain only to uniform blocks where color development is generally good, and a 7 to 10 day delay in harvest is desired.

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