

NEW YORK FRUIT QUARTERLY

VOLUME 9 • NUMBER 4 • WINTER 2001

Editorial

Giving Credit to the Experiment Station

I should have known! The fruit growers of New York have ready and easy access to the finest fruit research and extension facility in the world! Even I didn't understand its importance to agriculture until I spent the summer working in and around the New York State Agricultural Experiment Station in Geneva, N.Y. Only after working closely with the people at the Station on a one-to-one basis did I grasp how totally dedicated they are to you, the New York agricultural producer, and your concerns. If it is of concern to you, there is someone probably working on it at the Experiment Station. If there is no one actually working on the problem, then someone is certainly thinking about how to find the time and resources to solve that problem for you. I am extremely proud just to be associated with this program.

The one thing that became crystal clear to me as I worked with Terence Robinson, Bob Andersen, and Susan Brown is how hard they work on behalf of the fruit industry. Finding funds and running successful research programs are extremely difficult things to do. And it has recently become even more difficult. A significant portion of their programs are unselfishly run on a shoestring budget to satisfy the practical wants and needs of our industry. This can truthfully be said of every faculty member within Horticultural Sciences and, indeed, within all the departments at the Experiment Station.

The Station's faculty are supported by people whom we can never credit enough—the many dedicated people working behind the scenes, including the technicians, farm crew, communication services, and Station and departmental administrators who somehow put it all together and make it work.

I would strongly disagree with anyone who would argue we do not need this resource. The many visitors from around the world attest to the reputation of the New York State Agricultural Experiment Station and the quality of its work. The Station's record of achievement is unparalleled, and the need for further technological development is even more important for agriculture in the future.

I wanted to take this opportunity to thank the New York fruit industry for allowing me to spend the last six months on "sabbatical" at the New York State Experiment Station in Geneva. I really enjoyed learning new things and working on in-depth projects that would be impossible to do under normal circumstances. Hopefully, the fruits of my labor will translate into new ways for our industry to remain strong and profitable.

*Steve Hoying
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FRONT COVER: Bird damage to crops has always been a problem. Bird control was practiced by Native Americans in 1853 to protect their crops. Today scare-eye balloons and netting are used to limit bird predation. PHOTOS: J. Ogrodnick/NYSAES/Cornell. ILLUSTRATION: Courtesy The Granger Collection.

BACK COVER: Large numbers of apples are tested using an electronic pressure tester (EPT) to accurately determine differences in firmness among 1-mcp treated fruit. See the "Grow New York" article on page 21 for complete results. Inset: A gas chromatograph is used to determine internal ethylene. CREDIT: J. Ogrodnick/NYSAES/Cornell.

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Bye-Bye Birdie: Repelling Birds from Fruit Plantings

Marvin P. Pritts

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Birds are wonderful creatures that fill the morning air with song, eat many insects that affect our crops and our health, and usually enhance our quality of life. But, for growers of cherries, blueberries, grapes, gooseberries, and even apples, birds can be major pests. In one survey, blueberry growers in the Northeastern United States estimated that nearly 30 percent of their crop is lost to bird depredation each year. Across the country, 10 percent of the blueberry crop is probably lost—at a cost of \$10 million. Recently, fresh food handlers have been concerned about the possibility of birds introducing *Salmonella* and other pathogens into the food supply. Since the loss of Mesurool more than a decade ago, no effective chemical repellent has been available to keep birds off fruit in the field. Netting is expensive and difficult to install, so most growers would like to avoid using it if possible.

With the cooperation of Paul Curtis,

wildlife management specialist in Cornell's Department of Natural Resources, and Ian Merwin, Department of Horticulture, we have been examining the effectiveness of various techniques for repelling birds in blueberries, grapes and cherries for the past several years. Most of the techniques have had limited effectiveness, but others have worked reasonably well.

Grape Expectations

Perhaps the most desirable approach to controlling bird populations is to spray something onto the plants that will repel birds during the season. Scientists have known for many years that certain chemicals are distasteful to birds. Unfortunately, most chemicals used in the past had toxicological effects (i.e. Mesurool was an insecticide), so the search began for a non-toxic chemical that was distasteful to birds, but not detectable to humans at

Depredation by birds is a difficult and costly problem for agricultural producers. A combination of visual and audio scare devices, coupled with taste deterrents, is the most effective approach to reducing bird damage in orchards, vineyards and berry plantings.

harvest. Researchers found that methyl anthranilate, a major flavor component of Concord grapes, was distasteful to birds. It is the reason why birds tend to avoid Concord but feast on other varieties. Methyl anthranilate is manufactured in large quantities by food processors and is added to chewing gum, candy, juice, and soft drinks.

When sprayed onto cherry trees or blueberry plants, pure methyl anthranilate converts into an acid that severely burns leaves. Over several years, companies have formulated products that encapsulate the methyl anthranilate and make it safe to use in fruit plantings. The product is now registered for use in fruit plantings as Bird-Shield and Rejex-It. However, we have found several problems with this material. First, it is a vola



Photo 1. Bird damage to tart cherries.



Photo 1. Bird damage to blueberries.

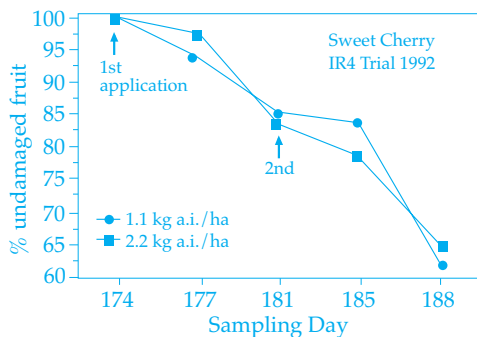


Figure 1. Percentage of undamaged sweet cherry fruits in response to treatment with methyl anthranilate (two rates).

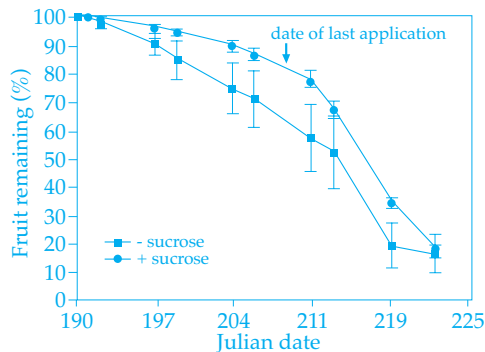


Figure 2. Fruit loss due to birds in blueberry plantings treated and not treated with sucrose syrup.

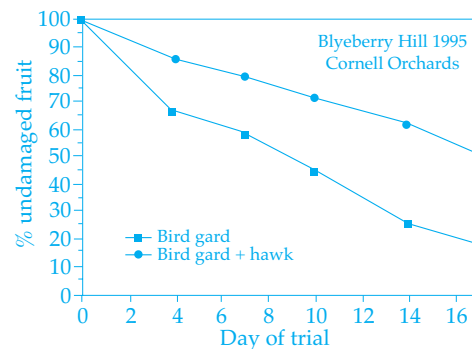


Figure 3. Fruit loss due to birds in a planting with Bird-Gard, and in a planting with Bird-Gard plus hawk models.

tile compound that has a short residual on exposed fruit. We have found good repellency for about three days, but the material loses its effectiveness later (Figure 1). Similar results have been reported from Oregon and Florida. Secondly, to repel birds, a large amount must be consumed in one bite. It is less effective when applied uniformly as it would be with an air blast sprayer. Thirdly, it must be reapplied after rainfall. Although methyl anthranilate works well in some situations (e.g. as a goose repellent in turf), we have not found it to be a reliable deterrent in fruit crops, particularly in rainy climates and in blueberries that ripen over long periods of time.

How Sweet It Is

In nature, most bird-dispersed fruits contain only simple, monosaccharide sugars (i.e. fructose, glucose) rather than disaccharides (i.e. sucrose that contains two sugar molecules). Certain bird species do not have the necessary stomach enzymes to digest disaccharides, so it is not surprising that smaller, bird-dispersed fruits contain only monosaccharides. Blueberries, a

bird-dispersed fruit, contain mostly fructose and glucose for sweetening, whereas apples, a mammal-dispersed fruit, contain sucrose. Humans cannot distinguish between these different sugars, but birds can. When birds are force-fed sucrose, they become ill.

We applied sucrose syrup to blueberry plantings just when the fruits were beginning to turn blue. The syrup was made by dissolving 230 lbs of table (cane) sugar in 21 gallons of hot water, yielding 40 gallons of syrup. Olympic Spreader Sticker was added at 310 ppm. This made a sufficient amount of syrup to treat one acre of blueberries. The syrup solution was reapplied after periods of heavy rainfall.

In our first test with sugar, birds damage was 50 percent less where sucrose was applied, compared to an adjacent field that did not receive treatment (Figure 2). The number of birds visiting the planting in the early morning also was greatly reduced, from 70 bird visits per hour to 2. Although our results have been promising, we have not conducted large-scale trials where entire orchards have been treated. In our tests,

birds have always had a choice between treated and untreated fruit. In a situation where all fruit in a large area is treated, birds may feed despite the sugar.

Drawbacks to using the sugar are: re-application is necessary after a rain, an increase occurs in the number of yellow jackets on the fruit in late summer, and the sugar crystallizes on the berries. The sugar washes off easily, but its presence will require an explanation for pickers, especially at pick-your-own farms. Although each treatment cost \$50-\$60 per acre, and we applied sugar four times during the season, the total expense (\$200-\$240) was far less than the losses to birds that the adjacent field experienced.

A Distressing Situation

Audio tapes, cannons, shotguns, firecrackers and other types of noises have been used for years to scare birds from agricultural plantings. Unfortunately, birds rapidly acclimate to these devices, particularly if they are not moved every few days. The use of these devices alone requires constant vigilance.



Photo 3. Propane powered "cannons" are common bird deterrents.

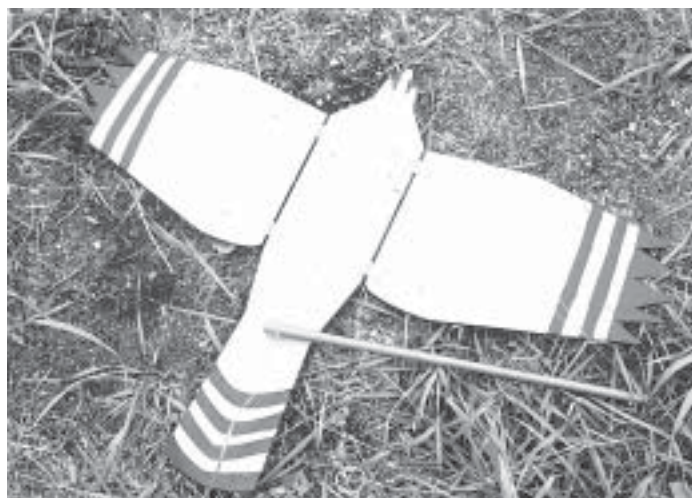


Photo 4. Hawk model made of wood and hung by fishing line.

Some farmers have argued that capturing real birds in a trap for a few days will help repel birds since the captured birds will warn others of the danger. The challenge, of course, is capturing wild birds in enclosures. Several attempts have been made to develop a bird-capturing device, but none are very effective.

Recently, a new electronic device named "Bird-Gard" has been developed that emits digitized, species-specific bird distress calls. The device we tested emitted distress calls of crows, robins and starlings every minute during daylight hours. We tested the device in two blueberry fields with high bird pressure, and found it to be effective for about 7 to 10 days. In one field, we added hawk models after a couple of weeks and observed a further reduction in feeding (Figure 3). When the device was turned off, feeding increased dramatically. Newer versions of the Bird-Gard include a shriek of a hawk prior to the distress calls, a photosensitive cell, and a random calling pattern.

Even though feeding by certain bird species was reduced, many birds still fed in the plantings, especially ground-feeders like sparrows and finches. Because blueberries ripen over such a long period of time,

the birds have ample opportunity to habituate to the sounds. Furthermore, species composition changes over time, so sounds that work early in the harvest may not work at the end of the season. However, the Bird-Gard easily paid for itself and was one of our more effective tools.

One blueberry grower reported that an owl model was very effective for him. The owl mounts on a bearing on top of a post, allowing the owl to swivel in the slightest breeze. In addition, the owl emits a loud shriek at intervals, powered by a solar cell. The combination of sound and visual scare device works much better than either by itself.

We have tried several other strategies for scaring birds, most of which have failed to reduce bird damage. We have surrounded a blueberry planting with strobe lights, but found they were not effective for repelling birds. We also tested a device from Japan that looks like a bird, but contains a powerful magnet purported to disrupt the natural sense of direction of birds for distances up to 70 ft. After hanging many of these magnets over a blueberry field, we found them to be ineffective at repelling birds from the planting. In addition, we tested a special machine that laid

out a sprayable "biodegradable" netting over a blueberry planting. The application was too slow and uneconomical to use.

Summary

To summarize, plastic netting is highly effective at keeping birds away from fruit plantings, but its application is very labor-intensive and costs are high. Birds have difficulty acclimating to their own distress call, so a device such as Bird-Gard can be effective for reasonable periods of time, particularly when supplemented with visual scare devices such as hawk kites and eye balloons. Sugar can be an effective repellent as well, particularly in a dry year when bird pressure tends to be greater anyway. A combination of visual and audio scare devices, coupled with taste deterrents, is the most effective approach to reducing bird damage in orchards, vineyards and berry plantings.

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

Status of Borers Infesting Apple Burrknobs and Their Management in New York Orchards

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Seventy percent of dwarf and semidwarf trees have burrknots susceptible to borer infestation. Prebloom or petalfall applications of Lorsban will control both dogwood borer and American plum borer season-long.

The dogwood borer, *Synanthedon scitula* (Harris), was first recognized as a pecan pest during the early 1940s, but was not an economic pest of apple until the introduction of clonal apple rootstocks. Such rootstocks tend to produce burrknots, which are attractive oviposition and entry sites for dogwood borer (Figure 2). Because size-controlling rootstocks have become so prevalent in modern apple culture, the consequential incidence of dogwood borer infestations has also risen. Earlier work in New York (Riedl et al. 1985) highlighted this borer as a prevalent and important pest of apple. Their examinations of apple orchards in western New York and the Hudson Valley revealed that 70 percent of trees on dwarfing or semi-dwarfing rootstocks had burrknots and that an average of 40 percent of the burrknots in any particular orchard were infested by dogwood borers.

Dogwood borer is in the family *Sesiidae*, commonly known as clearwing moths. This family also contains peachtree borer, lesser peachtree borer and a number of borers that

infest forest trees and shrubs. Dogwood borer larvae are creamy white with a yellowish-brown head capsule and the last instar is about half an inch long (Figure 1).

Results of tree trunk surveys of tart cherry and peach, performed during 1994 and 1995 in western New York, the Hudson Valley and on Long Island determined that American plum borer, *Euzophera semifuneralis* (Walker), is the predominant tree-boring insect pest in tart cherry in western New York, but not in the other two regions (Kain and Agnello, 1999). More recently, a number of apple orchards in western New York with rootstocks expressing burrknots were infested almost exclusively with plum borer. It is likely that tart cherries are reservoirs of plum borer, from which other susceptible crops (i.e., apples with burrknots) may become infested. Plum borer is in the family *Pyralidae*, which contains many pest species—most notably the European corn borer. Plum borer adults are obscurely colored grayish moths with a wingspread of slightly under one-inch. The

larvae range from blackish-green to blackish-purple with a yellowish-brown to dark brown head capsule and are about three-quarter to one inch long in the final instar. Plum borers also have long hairs projecting from the body at right angles and are often found inside white, silken cocoons (Figure 3).

In apple, borers gain entry through burrknots that form on the above-ground part of dwarfing rootstocks. They initially feed on tissues within the burrknot, which is thought to be the least harmful type of feeding. They may move outward from there to feed on the surrounding inner bark and can eventually girdle the tree. While dogwood borer infestations can greatly affect plantings on dwarfing rootstocks, plum borer infestations are probably a greater cause for concern because the larvae are larger and more voracious, are usually more abundant within a particular wound, and feed in a more girdling fashion. Researchers in California have noted that plum borer infestations of young pecan trees has led to outright death of the young trees or crotch splitting later in the lives of the trees.

Past recommendations for dogwood borer management have called for one trunk spray of Lorsban in mid-July to mid-

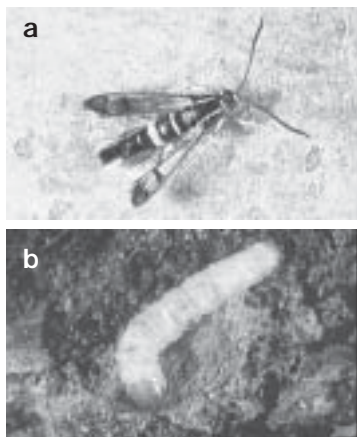


Figure 1. Dogwood borer (a.) adult (b.) larva



Figure 2. Burrknobs

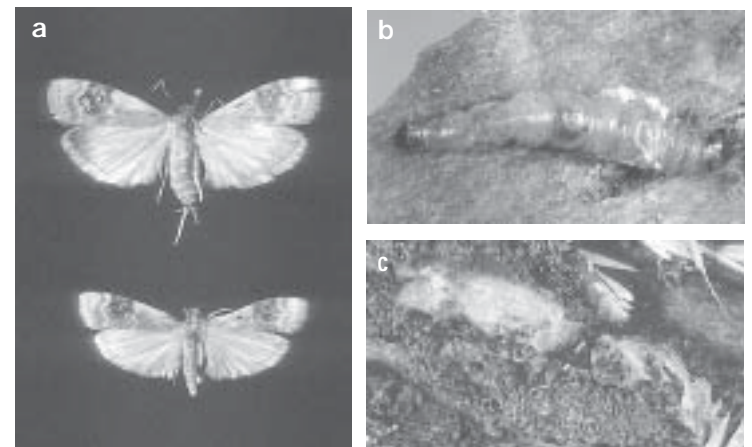


Figure 3. American plum borer. (a.) adult (b.) larva (c.) cocoon

August, or two applications of endosulfan—one in early July and one in early August. However, because the peak of the first flight of plum borer occurs at about the end of May, these summer treatments for dogwood borer miss the first generation of this pest (Figure 3).

During 2000, in accordance with the Food Quality Protection Act, the EPA established a 'zero' tolerance for Lorsban on fruit and consequently limited its use on apple to prebloom applications only. While awaiting results of additional analyses of residues on fruit, the EPA and NYSDEC have granted a temporary amendment to the Lorsban label that allows a maximum of two postbloom trunk sprays for the control of these borers. For a number of reasons, Lorsban has long been the standard treatment for borers infesting pome and stone fruits. Because the continued prebloom or postbloom usage of this insecticide is by no means assured, we are compelled to seek alternatives.

Research Objectives

Because testimonials by growers, agents and nurserymen suggest that the incidence of borer infestations are increasing throughout the Northeastern and Mid-Atlantic apple production states, our objectives were to: a) determine the prevalence and species distribution of borers in apple, b) determine which of the two pests are present in any given production region, because the flight periods of dogwood borer and plum borer do not coincide, and c) devise new or altered control strategies for borers of apple.

Results

Preliminary surveys (Table 1) provided evidence that plum borer is prevalent near infested tart cherry and peach orchards, old stumps of these trees, and wild cherry trees. In orchards more isolated from stone fruits, such as the Hudson and Champlain valleys, dogwood borer is more likely to be the predominant pest. Both borers were more likely to be found in orchards with mouseguards.

We performed efficacy trials on apple during 2000 and determined that Lorsban, applied as a coarse trunk spray at petal fall, provided season-long control of both plum borer and dogwood borer (Table 2). In addition to preventing infestation by larvae hatching after application, the insecticide penetrated the burrknot and controlled overwintering larvae within.

These data suggest that Lorsban applied much earlier than previously recommended would control borers. During 2001, we evaluated prebloom applications at half-

inch green and at pink. We did not find enough American plum borer larvae to evaluate efficacy against them, so results given are from an orchard where only dogwood borers were present (Table 3). Early

sprays were the superior treatments in early (late-June) evaluations because they controlled overwintered larvae before they began spring feeding, as evidenced by decreased production of frass.

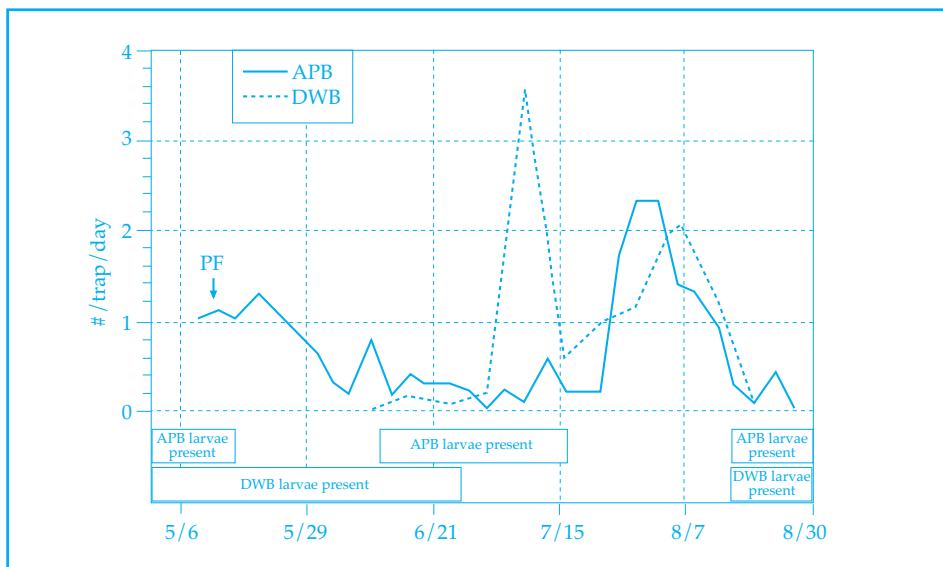


Figure 3. Seasonal occurrence of dogwood borer and American plum borer in New York.

TABLE 1

Incidence of trunk borers in New York apple orchards, 1999-2001.

Location	Block	proportion w/burrknots	proportion infested	Average damage rating	Larvae per 10 infested trees			Stone fruit w/in 0.5 mi.
					DWB	APB	Mouseguards	
Wayne Co.	1	0.66	0.58	0.61	7	0	No	No
Wayne Co.	2	0.68	0.76	1.26	12	0	No	No
Wayne Co.	3	0.94	0.94	2.64	12	12	No	Yes
Wayne Co.	4	0.82	0.46	0.63	0	15	Yes	Yes
Wayne Co.	5	0.98	0.94	2.18	9	7	Yes	Yes
Wayne Co.	6	0.78	0.56	1.56	15	2	Yes	Yes
Wayne Co.	7	0.30	0.00	0.00	0	0	Yes	Yes
Wayne Co.	8	0.52	0.27	0.50	6	0	Yes	No
Wayne Co.	9	0.78	0.62	1.44	17	0	No	Yes
Wayne Co.	10	0.88	0.16	0.43	8	1	No	Yes
Champlain	1	0.52	0.00	0.50	0	0	Yes	No
Champlain	2	0.50	0.15	0.15	1	0	Yes	No
Champlain	3	0.52	0.34	1.18	3	0	Yes	No
Champlain	4	0.28	0.00	0.69	0	0	No	No
Orleans	1	0.60	0.23	1.46	1	7	No	Yes
Orleans	2	0.90	0.05	0.27	2	1	No	No
Orleans	3	0.20	0.12	0.62	3	0	No	No
Orleans	4	0.40	0.02	0.43	1	0	No	No
Orleans	5	0.84	0.00	0.36	0	0	No	Yes
Orleans	6	0.80	0.15	0.65	1	5	No	Yes
HV	1	0.38	0.50	1.35	10	0	No	No
HV	2	0.40	0.23	0.61	8	0	Yes	No
HV	3	0.32	0.42	1.00	6	0	No	No
HV	4	0.40	0.16	0.30	9	0	No	No
HV	5	0.18	0.08	0.12	1	0	No	No
HV	6	0.48	0.18	0.48	9	0	No	No
HV	7	0.62	0.23	0.73	10	0	No	No
HV	8	0.44	0.20	0.45	11	0	No	No
Albany	1	0.80	0.58	1.13	12	0	No	Yes
Albany	2	0.38	0.11	0.26	4	0	Yes (on 1/2)	Yes
Albany	3	0.68	0.35	1.56	13	0	No	No
Albany	4	0.48	0.00	0.38	0	0	No	No

* Damage rating: 0 = none; 1 = burrknot feeding only, < 50% consumed; 2 = burrknot feeding only, > 50% consumed; 3 = feeding outside burrknot, < 25% trunk girdled; 4 = feeding outside burrknot, 25-50% trunk girdled; 5 = feeding outside burrknot, > 50% trunk girdled

TABLE 2

Efficacy of Lorsban trunk sprays against borers infesting apple in two Western NY orchards.

Waffer Orchards - 2000 Treatment (Lorsban 50W timing)*	% trees infested	
	late June (n=50)	October (n=25)
Petal fall	1.3 a	5.3 a
Petal fall + mid-July	4.0 a	2.7 a
Mid-July	24.7 b	1.3 a
Untreated	40.0 c	66.7 b

Fowler Orchards - 2000 Treatment (Lorsban 50W timing)*	% trees infested	
	6/28/00	10/5/00
Petal fall	5.0 a	0 a
Petal fall + mid-July	7.5 a	0 a
Mid-July	32.5 b	5.0 a
Untreated	30.0 b	35.0 b

Means followed by the same letter are not significantly different ($P < 0.001$).

*1.5 lb Lorsban 50W/100 gal

In the late September evaluation (Table 4), the petal fall Lorsban application was equal to, and maybe a little better than the earlier Lorsban applications, indicating that Lorsban applied prebloom may be beginning to lose some of its effectiveness by mid-July, when the dogwood borer flight peaks. However, the addition of paint to Lorsban at half-inch green appears to have extended the duration of Lorsban activity from that early application. All treatments were better than the check, in terms of both the proportion of trees infested and the number of larvae, but Lorsban treatments were better than all others. Efficacy of Avaunt applied at petal fall and again in mid-July was intermediate.

Current Recommendations

- Avoid the development of burrknots in the first place; where there are no burrknots, there are no borers. When establishing a new orchard, plant trees so that the graft union is 2 inches above the soil surface. This will encourage buried burrknots to establish roots and decrease the number of active burrknots. Care must be taken to avoid planting too deeply allowing the development of scion rooting.
- In established orchards, mound the soil up to within a couple of inches of the graft union. Mounds must be wide enough to prevent freezing injury to the buried rootstock.
- Because shade and increased humidity promote the development of burrknots, good weed control around the trunk is essential.

TABLE 3

Efficacy of insecticides and white paint against borers infesting apple in Western NY, 2001. Evaluated late June.

Waffer Orchards - 2001 Treatment	% trees infested	Mean No. DWB larvae/tree
Lorsban 4EC (3 qt/100) @ HIG	6.7 a	0.03 a
Lorsban 4EC (3 qt/100) + paint (1 part paint: 2 parts water) @ HIG	13.3 a	0.17 ab
Lorsban 4EC (3 qt/100) @ Pink	16.7 a	0.03 a
Lorsban 4EC (3 qt/100) @ PF	50.0 b	0.20 ab
Avaunt 30WG (6 oz/100) @ PF	50.0 b	0.40 bc
Avaunt 30WG (6 oz/100) @ PF + July	60.0 bc	0.70 cd
Endosulfan 3EC (1 qt/100) @ PF + July + August	63.3 bc	0.67 cd
Paint alone (1 part paint: 2 parts water) @ HIG	63.3 bc	0.67 cd
Untreated	76.7 c	0.90 d

Means followed by the same letter are not significantly different ($P < 0.001$). n=10

TABLE 4

Efficacy of insecticides and white paint against borers infesting apple in Western NY, 2001. September 11 Evaluation.

Waffer Orchards - 2001 Treatment	% trees infested	Mean No. DWB larvae/tree
Lorsban 4EC (3 qt/100) @ HIG	6.7 ab	0.07 a
Lorsban 4EC (3 qt/100) + paint (1 part paint: 2 parts water) @ HIG	3.3 a	0.03 a
Lorsban 4EC (3 qt/100) @ Pink	13.3 ab	0.13 a
Lorsban 4EC (3 qt/100) @ PF	3.3 a	0.03 a
Avaunt 30WG (6 oz/100) @ PF	40.0 cd	0.50 bc
Avaunt 30WG (6 oz/100) @ PF + July	23.3 bc	0.23 ab
Endosulfan 3EC (1 qt/100) @ PF + July + August	33.3 cd	0.43 bc
Paint alone (1 part paint: 2 parts water) @ HIG	46.7 d	0.53 c
Untreated	76.7 e	0.90 d

Means followed by the same letter are not significantly different ($P < 0.001$). n=10

- Orchards with mouseguards, especially the plastic spiral type, have substantially greater problems with both species of borer.
- Use directed sprays of Lorsban while it is available to reduce the population. We are currently evaluating other materials in the event we ultimately lose the use of Lorsban altogether.

Borers in tree fruits may be thought of as unimportant or secondary by many because the damage they cause is less visible and less immediately threatening than other forms of insect damage. Over the long run however, they can substantially decrease the lives of trees. It is estimated that the lives of tart cherry trees infested by plum borers are shortened by about one-third. We have witnessed situations in which the same is true for dogwood borer. Young trees may be killed outright, or weakened and deformed later in their lives. Although it is harder to quantify, borers may also reduce tree vigor and yield and open the way for increased disease problems. We have established apple plantings to determine the long-term ef-

fects of borer infestations on the growth and performance of size-controlled apple trees.

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Dave Kain is a research support specialist in entomology at the New York State Agricultural Experiment Station in Geneva, with considerable experience in the control of borers in tree fruit. Dick Straub is a professor of entomology at the Hudson Valley Laboratory, specializing in arthropod management in vegetables and tree fruits.

Processing Apple Planting Systems Trials

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Our goal was to evaluate the usefulness of high density planting systems for processing orchards that would allow growers to replant and improve orchard production efficiency.

This work was funded in part by the New York State Apple Research and Development Programs, and the Apple Research Association.

The New York apple industry is an important part of the agricultural economy of New York State, contributing an average farm gate value of \$125 million annually for the past five years (New York Ag. Statistics, 1995-2000). Apples are produced on about 50,000 acres with an average statewide production of 1.1 billion pounds. In an average year, about 50-55 percent of the crop is processed and 45 percent is sold fresh.

The processing market is very important to the economic success of New York apple growers, particularly in Western New York. However, the number of fruit processing businesses has declined in the state and the future of those that remain depends on the ability of New York growers to produce the varieties needed at a competitive price. Fruit growers in New York State have excellent fruit soils and a favorable climate. However, yields per acre are relatively low (500 bu/acre for apples) while production costs have continued to climb and prices for fruit have remained static, especially in the processing market.

A large part of the production problem is due to aging orchards with outdated varieties. Although much higher yields and better fruit quality are possible, they can only be achieved with new orchards where they can utilize the newest varieties, rootstocks and production systems. Growers have been slowly replanting to higher density systems for the last 20 years. The acreage of standard size trees declined 25 percent from 1985-1995 while the acreage of dwarf and semi-dwarf trees increased 200 percent. However, most of this new production is aimed

at the fresh market only. For the processing market to remain viable, growers need to modernize orchards for that market. Most of the new orchards for fresh apple production have been planted to higher-density dwarf trees which begin production in the third or fourth year and reach full production by years 6-8. Typically, these new orchards are trained with the vertical axis system. The value of high density orchards for the processing market has not been studied. Our goal was to evaluate the usefulness of high density planting systems for processing orchards that would allow growers to replant and improve orchard production efficiency. This should strengthen the ability of New

York growers to produce what the processors need at a competitive price and with a reasonable profit for the grower.

The new high density production systems which were compared in this study are based on three principles aimed at increasing the production efficiency and profitability of processing orchards when compared to the traditional production system used in processing orchards in New York. They are: (1) increased tree density, (2) dwarfing rootstocks that promote early production of fruit, (3) tree training systems requiring reduced inputs of labor. Our studies were done with both standard New York processing apple varieties and new varieties of apples recently developed in the apple breeding program at the New York State Agricultural Experiment Station that are either resistant to major apple diseases, or have special properties such as anti-browning characteristics when sliced.



Photo 1. Vertical Axis planting on M.26 rootstock in the Mark Lagoner planting.

Materials and Methods

Two semi-commercial research plots were established on two farms in Wayne County, NY, in 1994 and 1995.

The first block was located at the farm of Mark Lagoner in Williamson, NY, which has a relatively sandy soil that had previously had an apple orchard (Photo 1). The second block was at the

farm of Ned Morgan in Marion, NY, which is on a hillside that has silt loam soil and had never had apples. The Lagoner block was 2.5 acres in size and utilized three well established process

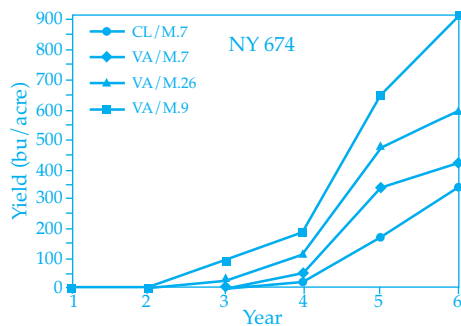


Figure 1. Annual yields of NY674 trained to 4 systems at the Morgan research plot.

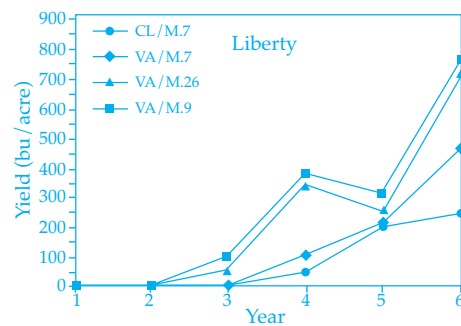


Figure 2. Annual yields of Liberty trained to 4 systems at the Morgan research plot.

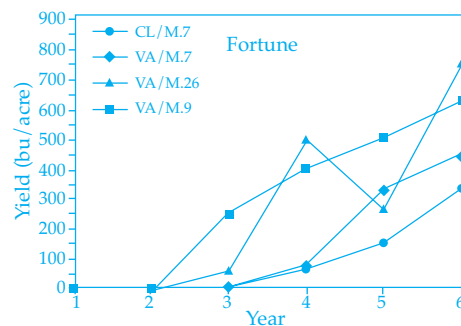


Figure 3. Annual yields of Fortune trained to 4 systems at the Morgan research plot.

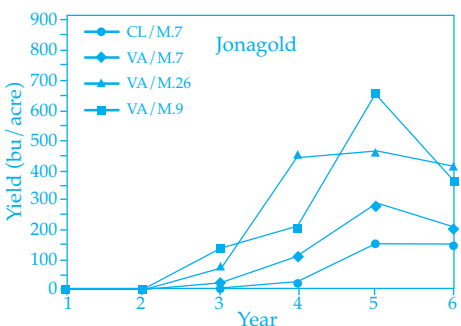


Figure 4. Annual yields of Jonagold trained to 4 systems at the Morgan research plot.

Research Block	Production System	Rootstock	Tree Density (trees/acre)	Tree Spacing
Lagoner	Central Leader	M.7	165	12' X 22'
	Vertical Axis	M.7	303	8' X 18'
	Vertical Axis	M.26	389	7' X 16'
	Vertical Axis	M.26	484	6' X 15'
Morgan	Central Leader	M.7	156	14' X 20'
	Vertical Axis	M.7	340	8' X 16'
	Vertical Axis	M.26	484	6' X 15'
	Vertical Axis	M.9	670	5' X 13'

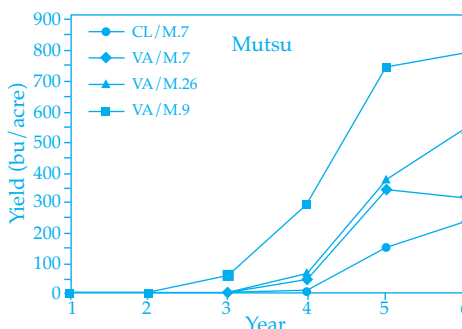


Figure 5. Annual yields of Mutsu trained to 4 systems at the Morgan research plot.

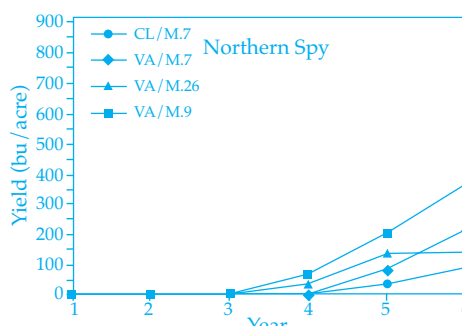


Figure 6. Annual yields of Northern Spy trained to 4 systems at the Morgan research plot.

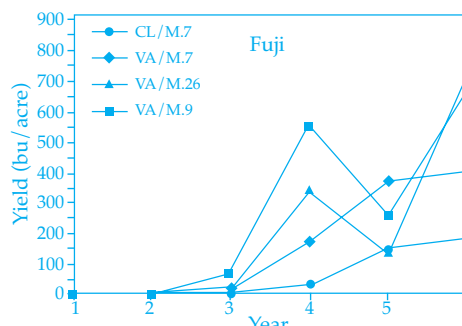


Figure 7. Annual yields of Fuji trained to 4 systems at the Morgan research plot.

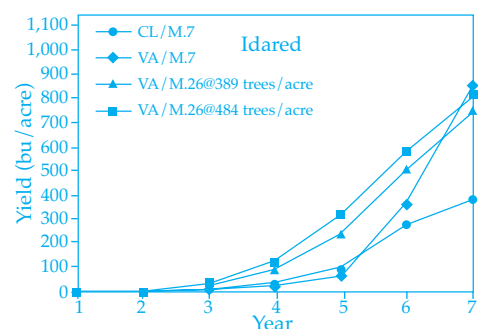


Figure 8. Annual yields of Idared trained to 4 systems at the Lagoner research plot.

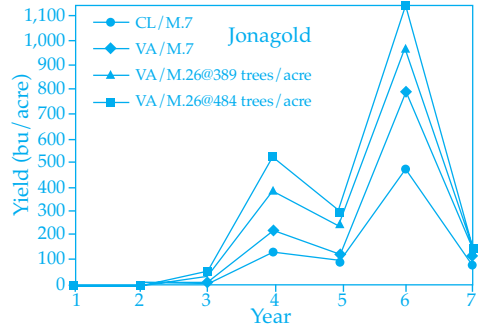


Figure 9. Annual yields of Jonagold trained to 4 systems at the Lagoner research plot.

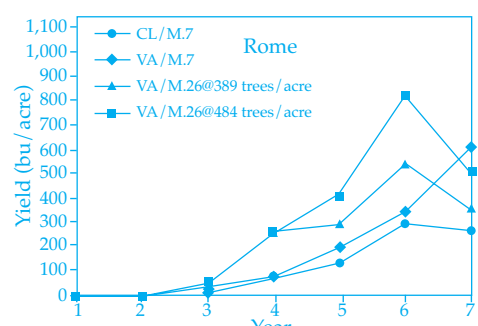


Figure 10. Annual yields of Rome trained to 4 systems at the Lagoner research plot.

ing apple varieties each grown in four production systems of differing planting densities. The Morgan block was 5.5 acres in size and utilized seven varieties of both established and new processing varieties each grown in four production systems of differing planting densities. Both blocks were laid out as randomized complete block experiments with four replicates of 100 feet of row length for each replicate of each variety.

The four systems used in each block are listed in Table 1. The traditional system in both blocks utilized a semi-vigorous rootstock (M.7) and a relatively low tree density of 156 or 165 trees/acre (Photo 2). Tree densities of the new high-density production systems ranged from 303 to 670 trees/acre and utilized the more dwarfing and precocious rootstocks M.26 and M.9.

During the developmental years (1-5), the horticultural inputs of labor and materials of the four production system were minimized and included only those items essential to the success of the system. With each system the inputs of labor and materials were recorded and used in an economic analysis. Fruit production, fruit size and fruit color were recorded each year. A simulated commercial grade-out for the processing market was calculated each year and an economic analysis of gross returns was done.

Results

In the first two years there was no fruit production in any system as the trees developed a large canopy. Begin-

ning in the third year there was a small crop on all systems that utilized either M.26 or M.9 rootstock but not on systems that utilized M.7 rootstock. Yields increased in the fourth year and were

largely a function of tree density. As density increased, yield per acre increased. In the 5-7 years, the trees approached full production with some varieties in the highest density systems

TABLE 2

Cumulative yield of 4 production systems at the Lagoner research orchard (1994-2000).					
Production System	Tree Den. (trees/acre)	Idared (bu./acre)	Jonagold (bu./acre)	Rome (bu./acre)	Average of all Varieties
Central Leader/M.7	165	763 b	779 c	716 b	753 c
Vertical Axis/M.7	303	1301 ab	1267 bc	1175 ab	1248 bc
Vertical Axis/M.26	389	1614 ab	1758 ab	1431 ab	1601 ab
Vertical Axis/M.26	484	1855 a	2181 a	1983 a	2006 a

TABLE 3

Cumulative gross returns of 4 production systems at the Lagoner research orchard (1994-2000).					
Production System	Tree Den. (trees/acre)	Idared (\$/acre)	Jonagold (\$/acre)	Rome (\$/acre)	Average of all Varieties
Central Leader/M.7	165	2566 b	2618 c	2406 b	2530 c
Vertical Axis/M.7	303	4372 ab	4256 bc	3947 ab	4192 bc
Vertical Axis/M.26	389	5422 ab	5907 ab	4808 ab	5379 ab
Vertical Axis/M.26	484	6233 a	7328 a	6664 a	6741 a

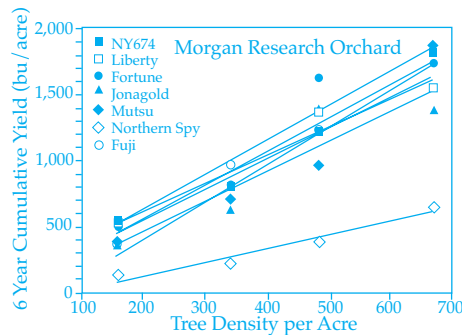


Figure 11. Relationship between tree density and 6-year cumulative yield with 7 varieties at the Morgan Research Orchard.

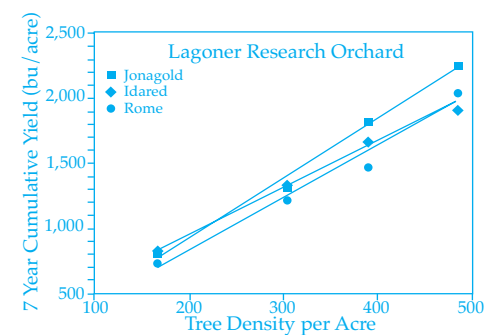


Figure 12. Relationship between tree density and 7-year cumulative yield with 3 varieties at the Lagoner Research Orchard.

TABLE 4

Cumulative yield of 4 production systems at the Morgan research orchard (1995-2000).									
Production System	Tree Den. (trees/acre)	NY674 (trees/acre)	Liberty (bu./acre)	Fortune (bu./acre)	Jonagold (bu./acre)	Mutsu (bu./acre)	N. Spy (bu./acre)	Fuji (bu./acre)	Average of all Varieties
Central Leader/M.7	156	536 b	522 b	519 b	354 b	396 c	125 a	361 b	402 b
Vertical Axis/M.7	340	807 ab	802 ab	817 ab	625 ab	709 bc	231 a	974 ab	697 b
Vertical Axis/M.26	484	1218 ab	1377 ab	1630 ab	1400 a	973 ab	383 a	1231 ab	1173 a
Vertical Axis/M.9	670	1826 a	1553 a	1738 a	1384 ab	1891 a	644 a	1561 a	1513 a

TABLE 5

Cumulative gross returns of 4 production systems at the Morgan research orchard (1995-2000).									
Production System	Tree Den. (trees/acre)	NY674 (\$/acre)	Liberty (\$/acre)	Fortune (\$/acre)	Jonagold (\$/acre)	Mutsu (\$/acre)	N. Spy (\$/acre)	Fuji (\$/acre)	Average of all Varieties
Central Leader/M.7	156	1908 b	1803 b	2080 b	1310 b	1444 c	542 a	1555 b	1520 b
Vertical Axis/M.7	340	2795 ab	2821 ab	3158 ab	2274 ab	2657 bc	1082 a	4006 ab	2656 b
Vertical Axis/M.26	484	4532 ab	4637 ab	6051 ab	5015 a	3647 ab	1761 a	5414 ab	4437 a
Vertical Axis/M.9	670	6451 a	5212 a	6213 a	4818 ab	6682 a	2850 a	6543 a	5538 a



Photo 2. Vertical Axis planting on M7 rootstock were tall at the Ned Morgan planting. Cropload finally bent over trees in year 7 for this rootstock.

reaching 1,000 bushels per acre (Figs. 1-10).

At the end of 2000, the Lagoner block had completed seven years and the Morgan block had completed six years. In both cases, the trees have essentially filled their allotted space and the development period of the block is complete. Cumulative yields were largely a function of tree density with systems on dwarfing rootstocks (M.9 and M.26) giving the highest yields (Tables 2 and 4). There was considerable variation among the productivity of varieties. At the Lagoner plot the most productive variety was Jonagold but it suffered from extreme biennial bearing with low crops in 1998 and in 2000. Rome and Idared were much more annual but slightly lower yielding. Averaged over all varieties, the highest density system produced almost three times that produced by the traditional low density system over the

first seven years (Table 2). At the Morgan block, Mutsu, NY674 and Fortune were the most productive varieties when grown in the highest density system. Liberty, Fuji and Jonagold were intermediate and Northern Spy was very unproductive regardless of the training system. Averaged over all varieties, the highest density system produced almost four times that produced by the traditional low density system over the first six years (Table 4).

Estimates of gross returns over the first seven years using a price of \$0.08 per pound showed at the Lagoner block that Jonagold was the most profitable variety followed by Rome and then Idared (Table 3). On average the highest density system had

2.7 times the level of gross returns after 7 years as did the low density conventional system. For the Morgan block the most profitable varieties were Mutsu, Fuji, NY674 and Fortune (Table 5). The least profitable variety was Northern Spy while Liberty and Jonagold were intermediate. On average the highest density system had 3.6 times the level of gross returns after six years as did the low density conventional system.

Discussion

For both research blocks, yields were largely a function of tree density (Fig 11 and 12). It is noteworthy that with the highest tree density and with high yielding varieties such as Jonagold, Mutsu or NY674 yields of 1000 bushels per acre were achieved in the sixth or

seventh year after planting. In contrast, the traditional system of Central leader on M.7 rootstock achieved less than one-third of the high density system. This increase in production will likely translate into improved profitability. A complete economic analysis of the production systems in these blocks with the 2001 yield data and assumed future yields is currently being conducted. These analyses will determine the annual expenses and returns over the life of the orchard including, the Net Present Value (NPV) the Internal Rate of Return (IRR), and the annualized cost per pound of apple produced. These figures will be useful in determining the optimum tree density for processing orchards of the future as well as the break-even fruit price required to allow growers to replant older less productive processing orchards.

If the higher density production systems prove to be more profitable, they should be used to replace older conventional orchards that are currently relatively unprofitable because of low yields, poor fruit quality, relatively low processing prices and the continuing need for high horticultural inputs to maintain production.

Acknowledgements

This project was made possible through grants from the New York Apple Research and Development Program, the Apple Research Association (the processor funding group) and an anonymous, private foundation which sponsors economic development in New York state. We thank Mark Lagoner and Ned Morgan for their cooperation, providing land and cultural management. We also thank Bob Norris and Matt Wells of Cadbury Beverages for their invaluable assistance.

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The Grow New York Project: 1-MCP Effects on Apples (The 2000 Harvest Season)

The Grow New York Grant Program allowed us to fast-track commercial application information for this potentially important and valuable material.

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The inhibitor of ethylene binding, 1-methylcyclopropane (1-MCP), is being researched actively because it maintains fruit quality during storage, and its impact for the marketplace may be huge. At the Ithaca laboratory, we are studying the effects of factors that may influence the effectiveness of 1-MCP, such as variety, temperature of application, and delays between harvest and application. However, these types of experiments cannot replicate many issues that may influence the efficacy of 1-MCP under commercial conditions. Lack of registration for 1-MCP means that any tested fruit must be destroyed and therefore testing of the compound under commercial storage volumes of fruit is prohibitively expensive.

In 2000, the State of New York introduced the Grow New York Grant Program. The aims of this program include funding of projects that involve application of new technologies with the potential for near term commercial application. In conjunction with matching funding from the New York Apple Association and Cornell University, the Grow New York Grant Program has allowed us to develop a unique approach to fast-track the gaining of valuable commercial information.

Objective of the Grow New York Project

To identify the effects of current operating procedures in the New York industry on the efficacy of 1-MCP to con-

trol apple fruit ripening and permit successful exploitation of its potential to maintain and increase industry competitiveness.

Procedures

The project was carried out at four storage sites in New York State, with most emphasis being on Western New York because of its focus on long-term CA storage. Air storage regimens were included to ensure that information obtained in these trials would also be applicable to smaller volume operators who are less focused on CA storage. The cooperators were:

1. Chazy Orchards, Champlain Valley
2. Lake Ontario Fruit, Inc., Orleans County
3. Fowler Brothers Inc., Wayne County
4. K.M. Davies, Wayne County

At each site, fruit were sampled off trucks arriving at the storage facility, or in the case of the Champlain, collected from blocks being harvested on that day. Depending on the storage facility, three to six individual fruit orchards, or orchard blocks within an orchard were used. The varieties used were typical of those being harvested commercially during the experimental period. Each sample consisted of 250 apples. Fruit maturity/quality was assessed immediately on 10 fruit, using firmness and starch. At Lake Ontario, internal ethylene readings were also taken. Of the remaining fruit, 160 were designated for the CA storage, and 80 for regular storage.

Basic Protocols

1-MCP treatment

The trials were designed to determine if it would be necessary to treat fruit warm on the day of harvest, or if fruit could accumulate while storage rooms were filled before treatment, as would occur under commercial conditions. All 1-MCP concentrations were 1ppm and applied in sealed plastic containers either warm or cold for a minimum of 16 hours. There were four comparisons:

1. Warm fruit, no treatment on the day of harvest, and then coolstored.
2. Warm fruit, 1-MCP treated on the day of harvest, and then coolstored.
3. Cooled fruit, coolstored on the day of harvest, and no treatment applied.
4. Cooled fruit, coolstored on the day of harvest, and 1-MCP treated cold according to the timing of the CA storage sealing in the facility used.

For CA storage, 80 were designated for warm treatment. For each 80 fruit sample, 40 were treated with 1-MCP, the others serving as untreated controls. The warm 1-MCP treatment consisted of treating all orchard samples at the end of the day in airtight containers. The remaining 80 apples for the CA treatment were placed in cold storage immediately after arriving at the storage facility. They remained in cold storage until all samples were treated at the same time one-day prior to closing the CA room.

For air storage, 20 fruit were used for warm 1-MCP treatment, and 20 as controls. Fruit were treated at the end of the day, held overnight at ambient temperature and put in air storage the next day. For 1-MCP-treatment of cold samples, fruit were collected as described above on a daily basis and placed in regular air storage. They remained in cold storage until all samples were treated at the same time one-day prior to closing the CA room, but were kept in air storage.

After treatment, control and 1-MCP-

treated fruit were stored in air for four months, or in CA until each room was opened for marketing.

Regional differences

1. Champlain - fruit were treated warm with 1-MCP at ambient temperatures on each day of receipt, or treated cold the day before the CA room was sealed. Fruit stored in air were treated at the same time as the CA-stored fruit. The number of samples that accumulated were a function of the number of days that fruit were harvested to fill a room, and therefore varied from two to four days of harvest.
2. Western New York – fruit were treated with 1-MCP as described for the Champlain except that a standard protocol of fruit collection was followed. Fruit were collected and treated at ambient temperatures daily throughout the week. All cold samples were treated on the Friday of each week. Fruit that were stored under CA conditions were placed in the next CA room to be sealed.

Measurement of fruit quality

Firmness was used as the primary guide of fruit quality. Air stored fruit were kept at room temperature and analyzed after one and seven days. CA-stored fruit were evaluated whenever the rooms are opened and therefore provided a wide range of storage periods ranging from two to seven months. After the room was opened, samples were evaluated at one and seven days at room temperature. The remaining fruit were kept in regular storage for one more month, to replicate marketing periods, and evaluated again at one and seven days.

Results

The results of this project are extensive. To provide an overview of the study, we have presented the Champlain and one of the Western New York sites.

Champlain

Only McIntosh apples were evaluated in the Champlain. The McIntosh types were predominantly old strains on seedling rootstocks, or Rogers on seedling or 111, and to a lesser extent Spur on 111 and RedMax on M26. Six CA storage rooms were used, and fruit were stored from 2 to 8 months, depending on the harvest dates (Table 1). Harvest ranged from September 18 to October 6, fruit from the later harvests being predomi-

nantly ReTain-treated.

The results of storing fruit for four months in air are shown in Table 2. Data for evaluation day, that is day 1 versus day 7 of shelf life period, were often similar, and therefore were combined for ease of presentation. However, in one storage room, fruit treated warm with 1-MCP did

not soften during the shelf-life period, while all other fruit did. Data for each harvest date are also combined as no effects of this factor could be detected.

Overall, the firmness of air-stored McIntosh was maintained about 0.9 to 1.4lb if fruit were treated warm with 1-MCP on the day of harvest. The only ex-

TABLE 1

Flesh firmness and starch indices of McIntosh fruit in orchard blocks at harvest, and CA storage periods, for the Champlain 1-MCP experiments.						
Room number	Harvest dates	Firmness (lb)	Starch (1-8)	CA room sealed (2000)	CA room opened	Storage time (approx. months)
1	9/13 - 9/17	18.0	4.0	9/19	5/14/01	8
2	9/19 - 9/20	17.9	5.4	9/21	4/16/01	7
3	9/21 - 9/22	17.4	4.7	9/23	3/1/01	6
4*	9/24 - 9/26	17.6	4.6	9/27	2/1/01	5
5*	9/27 - 9/30	17.2	4.5	10/1	1/10/01	3
6*	10/1 - 10/5	16.4	5.5	10/6	12/12/00	2

*mostly ReTain-treated fruit

TABLE 2

Firmness (lb) of Champlain-grown McIntosh after removal from air storage after 4 months. Fruit were evaluated after 1 and 7 days at room temperature. The data for all harvest dates and for both shelf life periods have been combined.					
Room number	Harvest dates (2000)	Treatment			
		Warm fruit		Cold fruit	
		Control	1-MCP	Control	1-MCP
1	9/13 - 9/17	11.2	12.6	11.1	11.8
2	9/19 - 9/20	10.6	11.6	10.4	10.9
3	9/21 - 9/22	10.2	11.2	10.2	10.2
4	9/24 - 9/26	10.5	11.4	10.5	10.6
5	9/27 - 9/30	10.7	11.6	10.5	10.4
6	10/1 - 10/5	10.7	10.9	10.7	10.5
Grand mean		10.7	11.6	10.6	10.7

Notes: Effects of treatment significant in all cases except room #4

TABLE 3

Firmness (lb) of Champlain grown McIntosh after removal from CA storage after various periods with and without an additional 1 month in air storage. Fruit were evaluated after 1 and 7 days at room temperature. The data for all harvest dates and for both shelf life periods have been combined.					
CA storage					
Room number	Harvest dates (2000)	Treatment			
		Warm fruit		Cold fruit	
		Control	1-MCP	Control	1-MCP
1	9/13 - 9/17	12.2	15.9	12.1	14.1
2	9/19 - 9/20	13.4	16.4	13.5	15.7
3	9/21 - 9/22	13.3	16.1	13.3	14.3
4	9/24 - 9/26	12.5	15.7	12.8	14.2
5	9/27 - 9/30	12.6	15.8	12.9	14.4
6	10/1 - 10/5	11.7	13.9	12.0	12.2
Grand mean		12.6	15.6	12.8	14.2
CA plus 1 month in air					
1	9/13 - 9/17	12.4	15.6	12.4	14.3
2	9/19 - 9/20	12.6	15.6	12.9	14.5
3	9/21 - 9/22	13.2	15.9	13.1	14.1
4	9/24 - 9/26	12.3	15.7	12.7	14.2
5	9/27 - 9/30	12.4	15.4	13.0	14.1
6	10/1 - 10/5	10.9	12.8	11.1	11.0
Grand mean		12.3	15.2	12.5	13.7

ception occurred in the late harvested fruit in room 6. Fruit from the earliest harvest showed the greatest response to 1-MCP treatment. Treatment of cooled fruit with 1-MCP generally did not slow softening, except in the first two harvests. Greater differences may have been detectable earlier in storage, four months being too long a storage period in air.

CA stored fruit responded dramatically to 1-MCP (Table 3). These responses

were consistent even when fruit were kept in air cold storage for a month after removal from CA storage. Overall, fruit treated warm with 1-MCP were about 3lb firmer than the untreated control fruit. The benefit of 1-MCP on firmness of cold-treated fruit was approximately 50% of that of the warm-treated fruit, although fruit still averaged 14.2lb. The maintenance of firmness in 1-MCP-treated fruit was consistently greater with earlier har-

vest date, even though these fruit were stored for the longer periods. Effects of harvest date within a storage lot of fruit were sometimes significant, but no consistent pattern was detectable. This indicates that time after harvest before treatment was not important, and differences probably resulted from effects of orchard block on fruit storability.

Western New York

In the Western New York storage, six CA rooms were also used (Table 4). The Marshall McIntosh and standard McIntosh (Pioneer, standard, Acey, Rogers, RedMax, Buhr) require different CA regimes. Cortland included Red Cortland as well as the standard Cortland. Empire included Royal as well as the standard strain. The two Empire rooms represented an early harvest destined for eight months storage, and a later harvest for medium term CA storage. Fruit of both Marshall and standard McIntosh strains, the second harvest of Empire, and Delicious, were climacteric at harvest.

In air storage, the responses of both Marshall and standard McIntosh strains (Table 5) were similar to those shown for Champlain-grown fruit. The effect of 1-MCP on firmness of the other varieties was much greater, however, especially for Empire. Cortland and Delicious also responded well, although the untreated control fruit of Delicious maintained good firmness. In all cases, the effect of warm treatment was much greater than cold treatment.

Under CA storage conditions, all varieties responded well to 1-MCP treatment (Table 6). Empire apples exceeded minimum export firmness standards,

TABLE 4

Flesh firmness (lb) and starch indices of fruit varieties at harvest, and CA storage periods, for the Western New York 1-MCP experiments.

Variety	Harvest dates (2000)	Internal ethylene (ppm)	Firmness (lb)	Starch (1-8)	CA room sealed (2000)	CA room opened (2001)	Storage time (approx. months)
McIntosh (Marshall)	9/12 - 9/14	110	15.4	6.4	9/16	2/20	5
McIntosh (standard)	9/18 - 9/21	52	15.2	6.1	9/22	1/22	4
Cortland	9/18 - 9/21	1	16.0	2.3	9/22	1/22	4
Empire	9/25 - 9/28	3	17.8	4.8	9/30	5/30	8
Empire	10/2 - 10/5	14	18.0	5.5	10/7	3/18	5
Delicious	10/9 - 10/12	21	17.4	3.4	10/24	4/3	5

TABLE 5

Firmness (lb) of Western New York-grown varieties after removal from air storage after 4 months. Fruit were evaluated after 1 and 7 days at room temperature.

The data for all harvest dates and for both shelf life periods have been combined.

Variety	Harvest dates (2000)	Treatment			
		Warm fruit		Cold fruit	
		Control	1-MCP	Control	1-MCP
McIntosh (Marshall)	9/12 - 9/14	10.1	11.6	10.3	10.3
McIntosh (standard)	9/18 - 9/21	10.4	12.2	10.5	11.2
Cortland	9/18 - 9/21	10.4	13.2	10.4	11.7
Empire	9/25 - 9/28	12.6	15.3	12.5	13.8
Empire	10/2 - 10/5	12.8	15.6	13.1	13.9
Delicious	10/9 - 10/12	14.1	15.9	14.1	15.4

TABLE 6

Firmness (lb) of Western New York-grown varieties after removal from CA storage after various periods with and without an additional 1 month in air storage.

Fruit were evaluated after 1 and 7 days at room temperature.

The data for all harvest dates and for both shelf life periods have been combined.

CA storage					
Variety	Harvest dates (2000)	Treatment			
		Warm fruit		Cold fruit	
		Control	1-MCP	Control	1-MCP
McIntosh (Marshall)	9/12 - 9/14	10.9	13.4	10.8	12.6
McIntosh (standard)	9/18 - 9/21	11.3	13.5	11.4	12.4
Cortland	9/18 - 9/21	11.0	13.9	11.2	13.4
Empire	9/25 - 9/28	14.6	16.1	14.7	15.3
Empire	10/2 - 10/5	14.7	16.2	14.8	16.0
Delicious	10/9 - 10/12	14.9	16.1	15.0	15.9
CA plus 1 month in air					
McIntosh (Marshall)	9/12 - 9/14	10.8	13.1	10.9	12.1
McIntosh (standard)	9/18 - 9/21	11.4	13.6	11.6	12.3
Cortland	9/18 - 9/21	11.3	14.1	11.0	13.2
Empire	9/25 - 9/28	13.2	15.3	13.3	14.1
Empire	10/2 - 10/5	14.3	16.0	14.3	15.4
Delicious	10/9 - 10/12	14.5	16.0	14.5	15.8

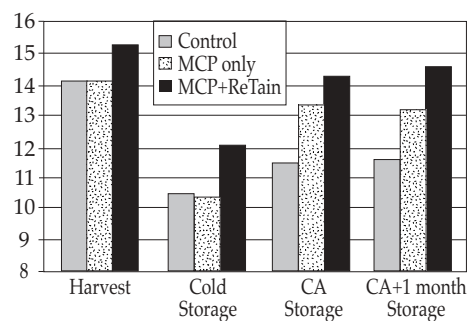


Figure 1. Effect of pre-harvest ReTain on firmness (lb) of control and 1-MCP-treated McIntosh apples. The air and CA storage periods were four and five months respectively. CA stored fruit were either assessed after removal, or after an additional one month in air storage. Apples assessed after one and seven days at room temperature.

even with an additional month in air storage after the CA rooms were opened. The effects of treating cold compared with warm fruit were less evident for Cortland, the second Empire harvest, and Delicious, than for the other varieties.

The effects of harvest date within any storage room were not consistent, suggesting that fruit could be accumulated over at least several days before treatment with 1-MCP and closing of these rooms for application of CA.

Further evaluations

We are still evaluating these data, as collection of information about treated fruit is allowing us to examine the range of management techniques used by the industry. For example, in the Champlain use of ReTain did not seem to prolong the effective application dates for McIntosh. However, in western New York, McIntosh treated with ReTain and 1-MCP were firmer after storage compared to non-ReTain treated fruit with or without 1-MCP (Figure 1). This suggests ReTain has potential to improve the efficacy of 1-MCP by decreasing ethylene production at harvest. Further investigation is warranted on McIntosh as well as other varieties.

Conclusions

1. 1-MCP is a powerful tool to maintain firmness of New York-grown apple varieties, especially under CA storage conditions. The residual effects of 1-MCP on firmness after removal of fruit from CA suggests that 1-MCP will result in improved shelf life, and better quality fruit in the marketplace.
2. 1-MCP is not a substitute for CA storage for some varieties, if air storage is prolonged, e.g. four months, but may be a valuable means of maintaining fruit quality for shorter storage periods.
3. The effectiveness of 1-MCP was affected by fruit temperature when 1-MCP was applied in McIntosh (in air and CA) and Cortland (in CA), and in the first Empire harvest, but to a much lesser extent in the second Empire harvest, and in the case of Delicious. However, in Ithaca-based trials we were not able to find effects of treatment temperature with similar 1-MCP-exposure periods to those used here, and a 16-hour exposure time used in the Grow New York trials may not have been sufficient to get maximal responses.
4. It seems unlikely that the delays between harvest and treatment of fruit

with 1-MCP will be a significant factor if procedures similar to those used for rapid CA storage are followed. No consistent differences among harvest date were detected.

5. The effectiveness of 1-MCP lessens with later harvest date, probably because of increasing rates of ethylene production in these fruit. Low ethylene fruit responded better to 1-MCP treatment than did high ethylene fruit, which suggests fruit should be picked early in the harvest window (pre-climacteric) in order to maximize the benefits of 1-MCP.

The 2001 Trials

We are continuing this research. During the 2001 harvest season fruit in the Hudson Valley have also been treated, as well as in two Champlain locations and in Western New York. In addition to obtaining further information about responses of fruit under CA storage conditions, we are evaluating shorter-term air storage periods.

Acknowledgements

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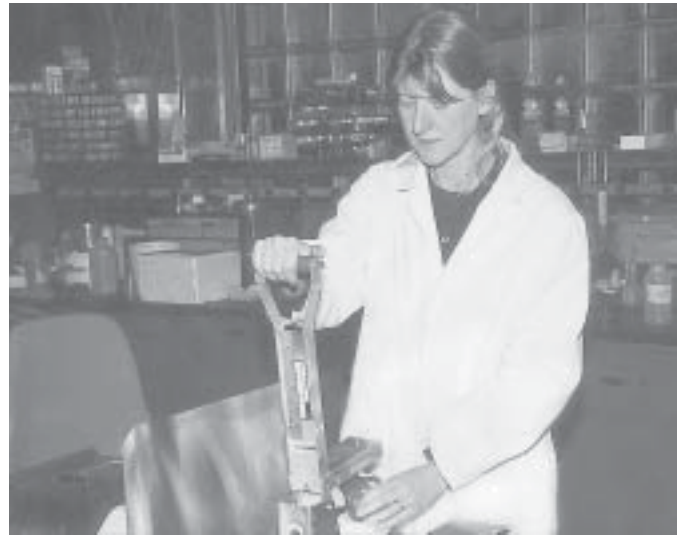


Photo 1. Firmness measurements were made using an Electronic Pressure Tester. (EPT).

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