N E W Y O R K
F R U I T Q U A R T E R L Y

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Editorial

Marketing the New York Apple Crop

Many challenges that face the New York apple industry are out of our control, but fortunately or unfortunately, we have the opportunity to take control and try to solve some of our problems. The biggest challenge is that market trends are changing. Who would think that consumers would spend 47 percent of their food dollar away from the grocery store? This will only rise, and soon will be over 50percent. You wonder why retail chains such as A&P and Grand Union, two old companies, have experienced financial troubles over the years. Once market powerhouses, P&C and the New Jersey-based chain, Pathmark, have both been in and out of Chapter 11. When we see high retail prices, we cannot believe how any grocery store could lose money, but they do, and it is because consumers have unlimited places to spend their dollar. What our industry has to do is to take this information, understand it, and change the way we have always done business, to the way we need to do it.

Successful strategies to address the marketing needs of the fruit industry in New York include both the skills of Cornell and the support of the New York State Department of Agriculture and Markets. In addition, we need the support of our government. We have been very appreciative of their contributions over the last few years. It is very appropriate that your tax dollars find their way back to you, and Albany and Washington continue to offer us the aid that is needed. Our Land Grant University has contributed to this industry for decades, providing New York with the best horticultural tools in the world. To be successful, we must have these same tools for marketing. Articles such as the one by Wen-fei Uva in this issue and the information that has been presented by Dr. Gerry White and Dr. Bruce Anderson to our industry over the last few months (*NY Fruit Quarterly*, Vol. 8, No. 2, p.7) are great examples of these marketing tools. Our New York State Department of Ag & Markets is also an important player in our struggle for success. On the marketing front, Ag & Markets offers us numerous opportunities. Their representation of our industry in the world market is vital. Involvement with the FAS, as well as different Ag Export Showcases, at trade shows gives us the chance to be exposed to the world market. Our Commissioner of Agriculture, Nathan Rudgers, is providing the leadership that all of New York agriculture needs to be competitive. We look to the Commissioner to continue his mission and to implement new and exciting consumer campaigns to focus on increasing the demand by consumers for New York apples. Imagine what the effect would be if every tenth political ad you see over the next four months was, instead, a "Have You Had Your Apple Today?" ad.

Expanding market access and increasing market penetration certainly is one of our goals at the New York Apple Association (NYAA). Last year we embarked on a campaign to expand and increase our Empire apple markets. We were able to penetrate over 21 retailers to perform over 1,000 in-store demos. We also carried out different advertising promotions with retailers in the North, Southeast, Southwest, and as far away as California. In the recent "World Apple Report", results of the annual retailer survey were published. This survey was mailed to produce directors in all major chains in the United States. The results were "The Empire variety, which had received mediocre ratings in previous surveys, came in fifth ahead of Granny Smith." It also states "retailers report that their future stocking plans show that about 25 percent of the retailers plan on stocking 20 percent more Empires next year." In 1995-1998, Empires received a rating of 3.20 (out of 5), in 1999, a 3.40, and last year the highest ever at 4.08. Our attempt to expand and to penetrate worked.

On the export front, expanding markets is almost as important as on the domestic front. In some instances, perhaps more important. The NYAA is deeply involved

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COVER PHOTOS: Kelly Stevens/NYSAES

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through the United States Export Council, with programs that help New York growers in the United Kingdom, Latin America, and recenty in Mexico. Competition is fierce, as we now compete with the Southern Hemisphere and others from around the world. We see the threat of the Chinese ability to flood markets and displace Washington State in the Far East. We continuously fight the French-subsidized crop and have to contend with Chili and New Zealand. Our activities in our foreign markets are a unified effort, working with all major apple-producing states except Washington. To make further progress, the industry needs to build trust and collaborate on marketing. Presently, the United States government provides market access funds (MAP) to Washington State and the United States Apple Export Council with restrictions that keep the programs fragmented.

Finally, we need to strengthen trade associations and cooperatives and encourage strategic alliances and collaboration. I feel that perhaps that this is our biggest challenge. This situation goes far beyond growing areas, districts and states. As we try to market our products, whether it is 90 miles to NYC or 3,000 miles to Los Angeles, there are fewer buyers today than yesterday. As we try to convince the buyers that our apples are bigger, better, sweeter and fresher, it usually only ends up being cheaper. When we only try to influence the buyer, and not the consumer, the result will be, sell cheaper. Imagine what could happen if all parties were willing to work together to achieve a common goal and increase marketing options for all?

Recent data from Cornell on the health benefits of eating apples have given us all hope that we can expand on this information and be in a position to tell the world that "one apple a day can keep you healthy." It will take money and a collaborative effort from the United States apple industry to get this message to the consumer. Imagine increasing apple consumption from one apple a week to one apple a day!! I would vote for that!

James Allen
President
New York Apple Association

MCP: Facts, Speculation, and How Could it Affect the New York Apple Industry?

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This work supported in part by the NY Apple Research & Development Program and the NY Apple Research Association.

A revolution may be occurring in our ability to control ripening of apple fruit. MCP is a compound with great potential for the New York industry and may have the impact equivalent to the development of CA storage on the apple industry. It is not a magic bullet, and as with any new product or technology, we have a lot to learn about this compound.

The dream of every grower, storage operator, and retailer is to have commodities that we put into some type of suspended animation where the fruit do not change from the time of harvest, and then are ripened to reach the consumer in desirable condition. The closest we get to that goal in the modern marketing system is the banana, which is ripened artificially with ethylene after import into the United States and then marketed as it ripens. For the apple industry, however, we are dealing with a perishable product for which "control" of senescence and ripening has been limited to refrigeration and controlled atmosphere (CA) storage in which the oxygen level in the storage atmosphere is lowered while that of carbon dioxide is increased. Cold temperatures and CA storage go part way to slowing down respiration and reducing the production and action of ethylene. Success in applying these technologies to apples is the basis of our industry's reliance on long-term storage of apples. Ethylene, however, continues to be our main "enemy" in preventing us from consistently providing wholesome, fresh apples in the marketplace. None of the technologies available can do more than delay the production and action of ethylene. We are all aware that, despite our best efforts, much fruit arrive in the marketplace in much poorer condition than is ideal. Better control of ethylene production in this fruit would benefit the industry, as firmer and more consistent fruit quality in the marketplace will hopefully encourage growth of apple consumption. Benefits of controlling ethylene may be even greater for the New York industry, with our reliance on varieties such as McIntosh, Cortland, Empire, and Jonagold, which soften readily after harvest.

Kelly Stevens/NYSAES

Apple CA storage technology has allowed high quality apples to be delivered to consumers for 12 months of the year. Neverthless, fruit condition problems persist.

A revolution may be occurring in our ability to control ripening of apple fruit! Many trade magazines have recently carried articles about a compound known as 1-methylcyclopropene (MCP). It is not difficult to get excited about a compound when one is able to show growers McIntosh apples that have been treated at harvest and after two months at room temperature are still 15 lb! However, in this article we aim to do two things. Firstly, to provide an understanding of how MCP works and its present status in the registration process. Secondly, to provide an update on findings from our research at Ithaca, and try to put this compound in perspective. We hope to convince you that MCP is a compound with great potential for the New York industry, but that it is not a magic bullet. We have already identified a number of limitations, and we have a lot more to learn about MCP before the industry can fully exploit new technologies based on the compound.

What is MCP, and How Does it Work?

MCP is an organic compound, which blocks ethylene receptors and prevents ethylene effects in plant tissues for ex

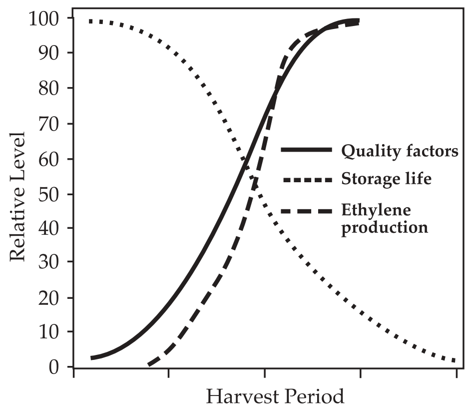

Figure 1. Stylized interpretation of the compromise between increasing fruit quality factors, such as color, sweetness, lower starchiness, aroma and flavor, and decreasing storability of apple fruit. During the time that these factors are moving in opposite directions, ethylene production by the fruit increases markedly in most apple varieties.

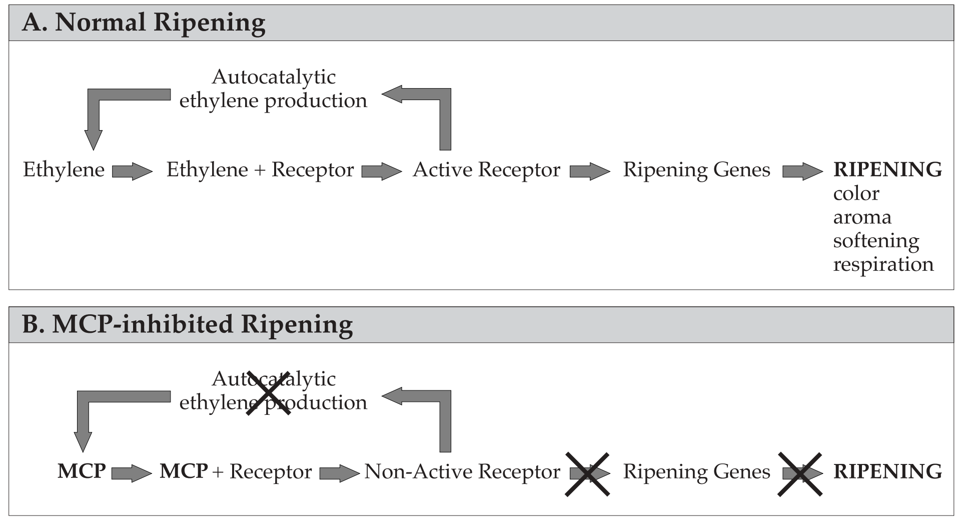

Figure 2. Comparison of normal ripening processes and effects of fruit treated with MCP.

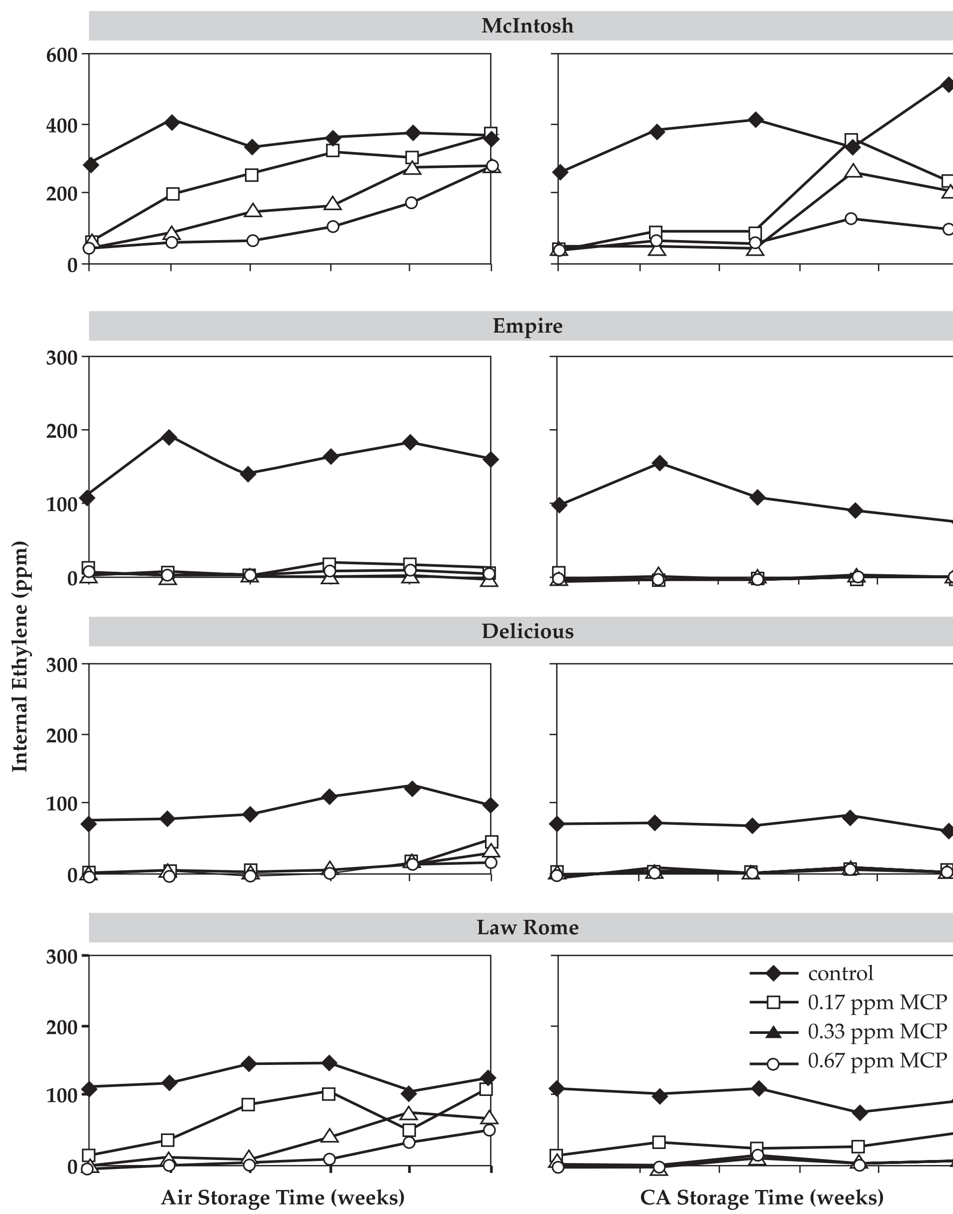

Figure 3. Internal ethylene (ppm) of four apple varieties treated with MCP immediately after harvest and stored in air (left hand column) or CA (right hand column). Fruit were evaluated after removal from storage at the times indicated plus 1 week at 68ºF.

tended periods. To understand the action of MCP, we have to first appreciate the role of ethylene in the apple ripening process. Ethylene is a naturally occurring plant growth hormone that is thought to regulate many aspects of fruit ripening. In the apple, an increase in ethylene production generally occurs during the harvest period. Growers often know when this increase has occurred because the build-up of ethylene is often associated with pre-harvest drop, especially in apples such as McIntosh. Compounds such as ReTain™ are used to delay this ethylene increase and reduce this drop. The natural increase in ethylene is associated with increasing quality attributes (e.g. flavor and aroma development) but also decreasing storability (Fig. 1). Harvest of apples is always a compromise therefore, between early harvest where quality of the ripened fruit is lower but storability is high, and later harvest where ripening quality is higher, but potential storage periods are shorter.

Increased ethylene production by fruit involves two interrelated processes. Firstly, ethylene is produced by the action of several biochemical steps involving enzymes. Secondly, however, the ethylene molecules produced by these reactions have to bind to a receptor for rapid ethylene increase (known as autocatalytic ethylene production) to occur (Fig. 2A). The ethylene production is responsible for many ripening-related events such as color change from green to yellow, aroma development, softening, and increased respiration. MCP binds to the receptor and therefore prevents the ethylene increase (Fig. 2B).

TABLE 1

Toxicology data for MCP

- Acute oral toxicity in rats: LD50 > 5,000 mg/kg (not toxic following acute oral exposure).
- Acute dermal toxicity in rabbits: LD50 > 2000 mg/kg (not toxic following acute dermal exposure).,
- Acute inhalation toxicity in rats: LC50 > 165 ppm active ingredient (highest achievable concentration); no adverse effects observed.
- Dermal irritation in rabbits: LD50 > 2,000 mg/kg Non-irritating.
- Eye irritation in rabbits: Slightly irritating.
- Dermal sensitization in guinea pigs: Not a dermal skin sensitizer.
- Ames assay: Non-mutagenic
- Mouse lymphoma assay: Non-mutagenic.
- In vivo mouse bone marrow micronucleus assay: Non-mutagenic.

What is the Registration Status of MCP?

1-MCP is currently formulated as a 0.14 percent powder under the brand name EthylBloc(TM) for the floral market. Acute toxicity, mutagenicity, and product chemistry studies conducted on the end-use formulation indicate a favorable toxicology profile (Table 1). In addition, 1-MCP has a non-toxic mode of action, is applied at extremely low ppb dose levels, and there is no expectation of measurable residues in food commodities. The EPA has classified 1-MCP as a plant growth regulator and structurally related to plant-containing materials and eligible for a reduced data set requirement. EPA registration was granted in flowers in April 1999 and is expected for postharvest use on fruits and vegetables in 2001.

Research Results So Far

We started working with MCP during the 1998 season. MCP was applied to McIntosh, Delicious, Empire, and Law Rome, and fruit were stored either in air (30 weeks) or CA (32 weeks). During storage, fruit samples were removed and evaluated after 1 or 7 days at 68°F. These evaluations included internal ethylene concentrations, firmness, soluble solids, acidity, and occurrence of any storage disorders that developed during the experiment. Only selected results are shown here to illustrate the main findings.

Figure 3 shows the internal ethylene concentrations for each variety stored in air (left hand set of graphs) or CA (right hand set of graphs). Each time point represents fruit removed from storage at that time and then kept at 68°F for a further week. Two things are apparent:

1. MCP controlled ethylene levels to a much greater extent in Delicious and Empire than in McIntosh and Law Rome in both air and CA storage.
2. The effects of MCP were slightly greater under CA than air storage, although this effect was more evident on the day 1 evaluation.

MCP similarly affected softening of the fruit (Fig. 4), with very pronounced reduction of softening in Delicious and Empire apples compared with McIntosh and Law Rome during air storage. MCP in combination with CA storage was very effective in controlling softening, and for McIntosh and Law Rome the fruit from the combined treatment were much firmer than air-stored fruit alone.

A factor of concern to us, however, was that in a population of MCP-treated McIntosh fruit, a mixture of firm and soft fruit existed, even when stored in CA. This is illustrated in Figure 5, which shows individual internal ethylene and firmness data sets in non-treated and MCP-treated fruit stored under CA conditions for 24 weeks and evaluated after a further 7 days at 68°F. The average internal ethylene concentration was 351±107 ppm in untreated fruit. The average internal ethylene concentration was lower (140 ppm) in the MCP-treated fruit, the variation was high being ±95 ppm. Most importantly, this variation was also evident for fruit firmness, being 12.8±1.1lb for untreated fruit, but 15.4±2.2 lbs in MCP-treated fruit.

It appears that for McIntosh, unlike Delicious and Empire, fruit with high ethylene production at harvest cannot be "switched off." This may be a real problem for use of MCP in areas where fruit are harvested with mixed populations of pre-climacteric (not yet producing ethylene) and post-climacteric (producing ethylene) fruit.

In the 1999 season, we tested McIntosh (Rogers strain) apples in two ways. First, we compared the responses of fruit harvested during the harvest window for CA storage on September 15 (IEC = 0.13 ppm, starch index = 4.9 units, firmness = 17.6 lbs) and 15 days later (IEC = 87 ppm, starch index = 6.2 units, firmness = 16.7 lbs). These fruit were treated with MCP concentrations of 0.3, 1.7 and 17 ppm at harvest. The results showed that:

1. In air storage, the 1.7 and 17 ppm MCP concentrations delayed the increase in the IEC of early harvested fruit for up to four months. For the late harvested fruit, the IEC at harvest was reduced only by the 17 ppm MCP treatment. The inhibition of IEC by MCP was reflected in maintenance of firmness of first harvested fruit, but little effect of MCP was found for late harvested fruit.
2. In CA storage, MCP inhibited the increase of IEC in fruit from both harvests, but the effect was more concentration dependent in the late harvested fruit than the early harvested fruit. Again these effects on IEC were largely mirrored by results of fruit softening.

In a second set of experiments, we separated fruit at harvest into fruit that were pre-climacteric (<1 ppm) and fruit that were post-climacteric (>50 ppm), treated them with 0. 3ppm MCP and kept them at 69°F for a week. Firmness of the pre-climacteric fruit was 16.7 lbs in the MCP-treated fruit compared with 13.1lbs in the control fruit, but firmness differences in fruit responses were negligible.

In 1999, we also compared the effects of treating fruit warm (as in the above experiments) with treatment of fruit cooled overnight using Cortland, Delicious, Empire, Gala, Jonagold, McIntosh, and Red Cort varieties. We observed three types of response, which are illustrated in Figure 6. Delicious (which did not respond as positively to MCP as in the previous year) responded less well to MCP when treated cold than warm. Gala effects were independent of treatment temperature, whereas Jonagold responses were better in cold fruit than warm fruit. Cortland, Empire, and McIntosh responses were similar to that of Delicious. Red Cort was similar to Jonagold.

Another important observation from our experiments over two years is that MCP has prevented or reduced the occur

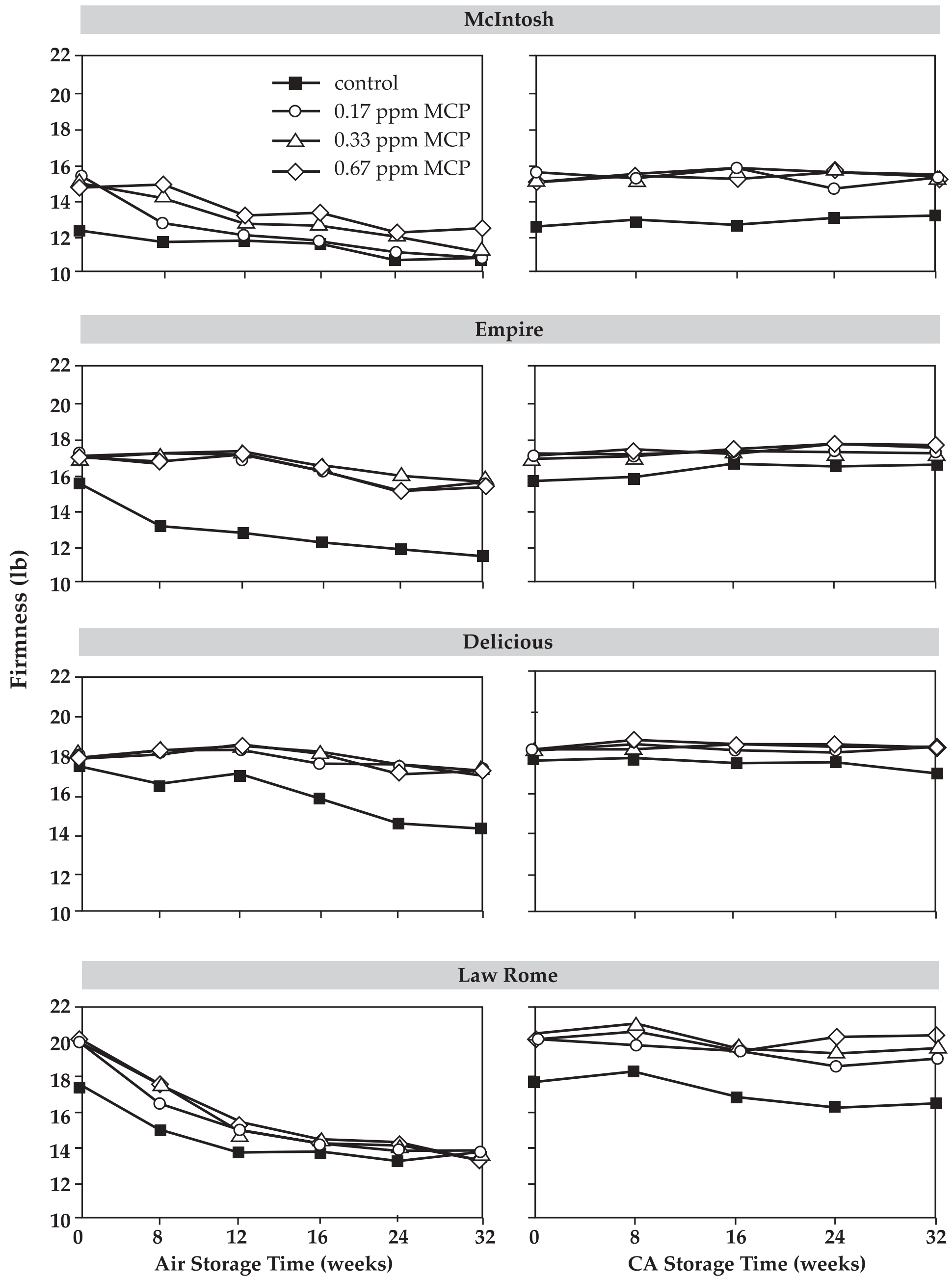

Figure 4. Flesh firmness (lb) of four apple varieties treated with MCP immediately after harvest and stored in air (left hand column) or CA (right hand column). Fruit were evaluated after removal from storage at the times indicated plus 1 week at 68ºF.

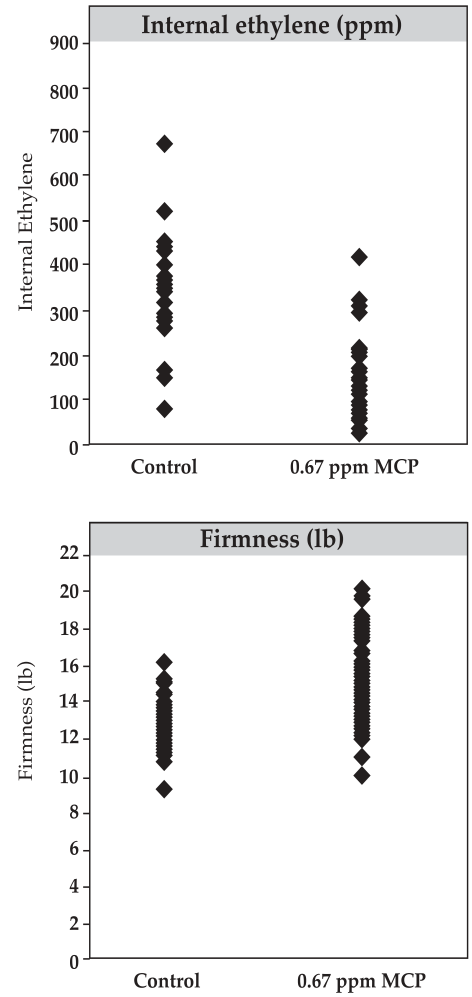

Figure 5. Range of internal ethylene concentrations (ppm) and flesh firmness (lb) found in individual McIntosh fruit stored in CA for 24 weeks and kept for 1 week at 68ºF before evaluation.

rence of superficial scald and a number of other storage-related problems. The possibility that MCP will eliminate reliance of the industry on the scald-inhibitor diphenylamine (DPA) and therefore avoid the need for the accompanying fungicide in the drench is particularly exciting.

Take Home Messages

The conclusions from our studies so far that will impact commercial success of MCP for the New York industry are:

1. Varieties differ greatly in their response to MCP, especially under air storage conditions. Successful use of MCP on varieties such as McIntosh may require a combination of good maturity information, especially internal ethylene concentrations, and CA storage. If permitted by label, higher MCP rates may be required. There is some evidence that results can be variable even within varieties (e.g. Delicious).
2. For some varieties, it is possible that MCP usage could replace CA storage. However, variations between year and harvest dates for varieties suggest that it is unlikely that MCP will become a replacement technology for CA storage. We believe that CA storage may be an essential backup to the use of MCP for seasons where MCP may be less effective. Nevertheless, for some varieties, MCP may permit extension of air storage periods and may be very useful to improve quality of fruit entering the marketplace in December.
3. Treating fruit warm may be more effective than treating fruit cold for some varieties, but this has a huge set of implications to current fruit handling systems.
4. MCP may eliminate the use of DPA.

We still have a lot to learn about this compound! MCP may have the impact equivalent to the development of CA storage on the apple industry. As with any

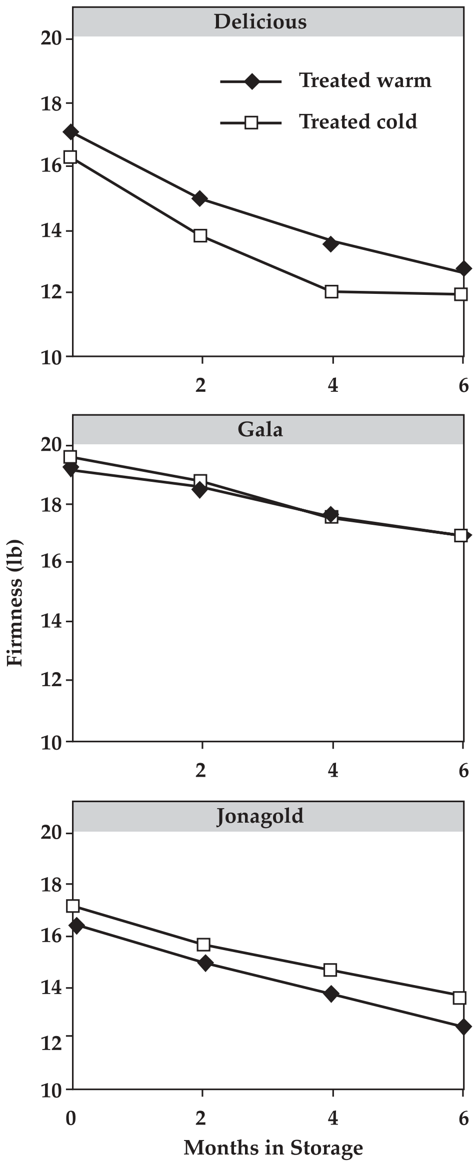

Figure 6. Flesh firmness (lb) of Delicious, Gala and Jonagold apples treated at harvest while warm or after overnight cooling to 32 ºF. Fruit were stored in air for 2, 4, or 6 months and evaluated after 1 week at 68ºF.

new product or technology, there may be downsides to the use of MCP. The cost factor is not yet known, but even if the cost of MCP is in addition to CA, the cost may be recovered by the stimulation of fruit sales if we get consumers to purchase more apples. Another issue of concern is the effect of MCP on volatile production associated with flavor, since inhibited ethylene production in aromatic apple varieties may be less desirable. However, the positive influence of MCP on maintaining the acid/sugar balance of fruit together with excellent texture qualities may more than compensate for lower aroma. As soon as MCP is registered for use, however, it will be essential that sensory analyses be carried out.

We have received funding from the New York Research and Development Program, the Apple Research Association and Rohm and Haas Company for research this coming season. Our primary goals for the coming two years are to focus on McIntosh and Empire. In addition, the New York Apple Association is applying to the Grow New York Program for matching funds to carry out research under commercial conditions. Our primary objective is that a year from now, when we hope that MCP will be registered, is to have enough information to help the New York industry make calculated decisions on how to best begin using the compound. The 2001 Storage Workshop in Ithaca will focus on application of MCP.

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An Analysis of Marketing Needs and Strategies for the Fruit Industry in New York and Marketing Programs at Cornell

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In 1999, United States economic expansion continued at nearly the four percent rate of 1997 and 1998. Strong profits, low interest rates, and profitable business opportunities brought robust growth in spending for business equipment and software. Solid consumer spending growth continued as real wages and stock market returns rose. The gains in domestic spending more than offset the effects of growth in the trade deficit. These are some of the economic reports we hear from the media, but what do these factors mean to the agricultural industry or, more specifically, to the fruit industry in New York? This article analyzes the strategic marketing needs for the fruit industry in New York and provides an overview of the marketing programs at Cornell University that address the needs of the fruit industry.

Marketing Trends and Challenges

Marketing of fruits is more dynamic than that of most agricultural products because it brings you directly in touch with consumption and food distribution trends. Knowledge of these trends will help you win battles in the global marketplace. Ushered by the greatest economic growth in United States history, American consumers are spending money where their mouths are. They are eating more and demanding more varieties, better quality, and greater convenience. According to United States Department of Agriculture reports, in 1999, Americans spent $789 billion for food and another $96 billion for alcoholic beverages, up from $565 billion and $73 billion in 1990, and $308 billion and $45 billion in 1980 for food and alcoholic beverages, respectively. Per capita consumption of fruits reached 320 pounds (fresh farm weight) in 1997, a 25 percent increase from 1970. They are feeling richer in terms of food consumption. The percentage of disposable personal income spent on food declined from 13.8 percent in 1970 to 10.4 percent in 1999. Away-from-home meals and snacks captured 47 percent of the United States food dollar in 1999, up from 39 percent in 1980 and 34 percent in 1970.

> **The New York fruit industry is facing a "crisis" for survival. To resolve the crisis will require building trust among industry members to adopt collaborative actions on marketing and take necessary risks to avoid threats and seize opportunities. This is the time for change at both the farm and industry level in order to revitalize the industry's competitive advantages, capture higher shares of consumer dollars, and improve long-term sustainability.**

Although the United States retail food expenditures increased five-fold in the last two decades, farm receipts have not caught up with the trend (Fig. 1). The cost of providing food processing and marketing services beyond the farm gate is the most persistent source of rising food

Figure 1. Distribution of food expenditures.

Source: United States Department of Agriculture, Economic Research Service, Food Review, September-December 1999

Figure 2. United States dollar spent for food paid for in 1998.

expenditures. While consumer expenditures for domestic farm food grew 3.2 percent in 1998, farm value fell 2.5 percent in the same year, and the marketing bill grew 4.8 percent. Marketing costs accounted for 80 percent of the $585 billion consumers spent for domestic farm foods, not including imported foods, in 1998. Only the remaining 20 percent, or $119 billion, represents the gross return paid to farmers (Fig. 2). While America's desire for convenience foods drives marketing costs, it presents a great value-added opportunity for the fruit industry in New York.

According to the Census of Agriculture, the New York fruit industry ranked sixth among states but accounted for only 1.5 percent of the total value of fruits and nuts produced in the United States in 1997. However, in addition to low farm returns, the New York industry is confronting the challenges of increasing world supplies, growing numbers of fruit varieties in the market, volatile and sometimes depressed prices, changing market demands, and concentration in the retail sector with relatively low market power. When prices are high, who cares about marketing? The New York fruit industry is facing a "crisis" for survival. The Chinese expression for "CRISIS" (pronounced "wei-ji") is a combination of risks ("wei") and opportunities ("ji"). To resolve the crisis will require building trust among industry members to adopt collaborative actions on marketing and take necessary risks to avoid threats and seize opportunities. I would argue that this is the time for change at both the farm and industry level in order to revitalize the industry's competitive advantages, capture higher shares of consumer dollars, and improve long-term sustainability.

Alernative Marketing Strategies for the Fruit Industry in New York

The fruit industry in New York includes commodities that rely heavily on national and international markets to sustain current investments in land, buildings, machinery, equipment, and human resources. These commodities include apples, tart cherries, juice grapes, and wine grapes. The challenge with these commodities is to maintain competitiveness by improving efficiency of production and developing marketing systems that take advantage of consistently high-quality products at a large volume supply to meet competition from other regions and the demands of an increasingly concentrated retail sector. Another group of crops includes those for which there is either a lack of volume produced in New York, or those which are not competitive in national and international markets. These include a long list of niche products such as small fruits, organic fruits, and specialty products, etc. This group can include many of the same commodities that are mentioned in the large volume products in which New York competes in national and international markets but are marketed directly to consumers, e.g. wine produced by small wineries. The challenge for growers and marketers producing these products is to achieve sufficient differentiation so that a higher price can be obtained to offset high costs inherent in producing and marketing these products. There is also the avenue of developing value-added options that allow capturing more of the final users' dollar.

Successful strategies to address the marketing needs of the fruit industry in New York require a balanced blending of programs and skills of the industry, New York State Department of Agriculture and Markets, and the Land-Grant University at Cornell. The marketing strategies should enhance the marketing effectiveness of fruit producers in New York. The following is a list of selected strategies to meet the marketing needs of the fruit industry in New York.

Marketing Strategy 1: Diversification and Differentiation

While the dynamics of the produce market are increasingly commodity-like, with producers maintaining the role of price-takers, product differentiation and diversification, including new product introductions, is still a key strategy for expanding sales in the fruit and vegetable market. For example, the fresh tomato category has been differentiated to more than 10 offerings, and the introduction of specialty fresh fruits and fresh-cut products has opened new opportunities for domestic producers. To exploit such opportunities, it is important to continuously conduct research and disseminate information regarding the benefits of New York produced fruits, develop new fresh fruit varieties and processing products, evaluate economics and market sizes of these new products, and identify marketing trends and alternatives for New York fruits. More importantly, it needs innovative entrepreneurs to join this market arena and take advantage of alternative marketing tools and new information technologies.

Marketing Strategy 2: Expanding Market Access and Increasing Market Penetration

The fruit industry in New York often cites closeness to market as a major advantage. However, closeness to market also has its disadvantages. Because it is feasible for small marketers to reach the market, it tends to promote a fragmented industry, where it is difficult to control quality and coordinate marketing efforts (Anderson 1989). Strategic alliances among industry members is essential to expand market access and increase market penetration for all New York fruit producers in the northeastern markets. With supply and quality commitments, an alliance of producers is well positioned to pursue major wholesale as well as retail buying groups, including restaurants and food service. Collaboratively, producers can strengthen farm-to-market relationships with potential buyers at restaurants and hotels by identifying and promoting the varieties and volume of products available from a group of specialized producers. Promotional efforts developed through trade associations and the New York State Department of Agriculture and Markets targeting northeastern regional markets could increase the awareness of and stimulate demand for New York products in the market.

Marketing Strategy 3: Identify Existing and Emerging International Market Opportunities for Fresh and Processed Fruits

The growing global demand for year-round availability of a broader line of high quality fruits is stimulating the growth of international trade, since no country produces all fruits all year-round. A source of contact should be established for producers to obtain information about exporting, including market information, trade issues, standards, certification, and logistics. Communication should be established with the United States Foreign Agricultural Service representatives in countries that have the strongest potential for export. Joint efforts should be encouraged among the New York State Department of Agriculture and Markets, independent growers, trade associations, and cooperatives to attend domestic and international tradeshows, to connect with international buyers, and to deliver market information to producers.

Marketing Strategy 4: Increase the Volume and Variety of Locally Produced Products Merchandized through Wholesale and Retail Channels in New York

Sales of New York fruits through New York marketing outlets can be promoted by expansion of agri-tourism, agricultural awareness programs, and ag-based economic development initiatives. Raising consumers' awareness of New York agriculture and helping them identify New York products can increase demand for New York fruits. Research has shown that when informed, consumers would prefer to buy a local fruit if it were readily available with acceptable quality and competitive prices (Campbell and Feenstra, 1998). Formation of selling networks would facilitate supply and distribution to New York fruit buyers and support marketing negotiation with large market multipliers. Relationships with retail partners present opportunities to raise consumer awareness of New York fruits. It also means taking advantage of the retail partner's promotion resources. Moreover, direct marketing is one way for New York fruit producers to capture higher shares of consumer dollars and further increase consumer accessibility to New York fruits. State and industry organizations should identify and support educational awareness programs and Ag-in-the-Classroom projects for the creation and delivery of balanced and up-to-date information regarding agricultural issues in New York.

Marketing Strategy 5: Strengthen Trade Associations and Cooperatives and Encourage Strategic Alliances and Collaboration

I would suggest that what gives fruit growers in the western United States and some overseas countries so much power in the market is their collaborative organization. Although members of the fruit industry in New York have successfully worked independently in the past, changes in the world market are sufficient to warrant the industry to take a hard look at collaboration in marketing as well as production and distribution. A unified fruit industry is also the most effective way for fighting trade battles since organized producer commodity groups are most successful at influencing their government officials to defend their trade interests. Collaboration requires the willingness of all parties to work together to achieve a common goal, maximize impacts and increase marketing options for individual members. Strengthening existing organization, including trade associations and cooperatives, and confronting conflicts with mutual interests in mind are the first steps to effective industry collaboration. Although it is not easy, becoming **interdependent** is the key to remaining **independent** for members of the New York fruit industry!


KELLY STEVENS/NYSAES

Peaches may offer an attractive diversification option for NY apple growers.

Unusual fruit, like ribes (gooseberries and currants) may offer niche marketing options for NY fruit growers.

Marketing Program at Cornell

Numerous programs at Cornell work directly with the fruit industry. Here are descriptions of some of the Cornell programs that address marketing needs of the fruit industry by various research and extension activities. Although only campus programs are mentioned in this article, it should be noted that additional marketing programs are initiated by county extension offices throughout the state.

Agricultural Cooperative Enterprises
http://www.cals.cornell.edu/dept/arme/cooperatives/index.htm

The Cornell Cooperative Enterprise Program focuses on cooperative strategies, structure, board / management relations, marketing, and finance. Educational programs are designed to improve decision-making skills, to create a positive corporate culture within organizations, and to increase the economic performance of cooperatives. Several events are co-sponsored with the Northeast Cooperative Council and / or CoBank, ACB. For groups interested in forming new cooperatives, analysis of the economic viability and feasibility of their business concept is encouraged. Prospective new cooperatives are also encouraged to include in their certificate of incorporation all necessary provisions to assure long-term organizational soundness. Its target audience are cooperative directors, management and members; cooperative employees; future cooperative leaders; producers considering cooperation; and extension educators. Outreach activities are coordinated with The Pennsylvania State University and with other Land Grant Universities across the United States, as well as with the National Council of Farmer Cooperatives. The faculty contacts for this program are Brian Henehan and Bruce Anderson in the Department of Agricultural, Resource, and Managerial Economics.

Economic Outlook

Economic outlook for agricultural commodities and the general economy is a major activity in this program area. An Agribusiness Economic Outlook Conference is held annually in December. Outlook news articles are prepared for the Agricultural News Service. Outlook for the Northeast is prepared for the *American Agriculturist*. The program objectives are to increase public understanding of forces affecting supply and demand conditions for agricultural commodities, enhance public understanding of policy alternatives, and improve knowledge of future trends in key economic variables to permit better planning by producers and agribusiness people. The faculty contact for this program is Robert Milligan in the Department of Agricultural, Resource, and Managerial Economics.

Food Industry Management

The focus of the majority of the research in the Food Industry Management Program is the manufacturing and distribution (i.e., wholesaling and retailing) sectors of the food industry. Extension of this research assists food retailers and wholesalers in better managing their firms and understanding the economics of their markets. In addition, consumers and growers learn how the wholesale and retail food sectors impact them. Improved understanding of the activities of these companies is critical to formulating appropriate marketing programs for producers and informed shopping decisions for consumers. Results from this research are communicated with the above clientele groups through various reports, articles in county extension newsletters, numerous state and national workshops and seminars, and several executive education programs for food industry managers. The faculty contacts for this program are Jim Hagen, Ed McLaughlin, and Meg Melloy in the Department of Agricultural, Resource, and Managerial Economics.

Food Industry Management Distance Education Program
http://distance-ed.arme.cornell.edu/

The Food Industry Management Distance Education Program provides educational materials and programs to assist food industry companies in developing managers and associates for the purpose of improving food distribution efficiency. For over 35 years, the program has offered non-credit correspondence courses leading to Certificates of Achievement and workshop and seminar programs for food industry managers and associates. Currently, the program offers 26 supermarket oriented courses, eight convenience store courses, and five distribution center courses. Courses are completed primarily through independent study with correspondence via postal mail, e-mail, or fax. Computer-based training (CBT) modules have been developed in the areas of food safety and effective teamwork. The Food Industry Internship Program is a partnership of the Program, food industry companies, high schools, colleges, and cooperative extension to allow high school juniors and seniors to explore careers in the food industry via a coordinated academic and work-based program designed as a school-to-careers experience. The faculty contact for this program is Rod Hawkes, Director, in the Department of Agricultural, Resource, and Managerial Economics.

Horticultural Marketing
http://www.cals.cornell.edu/dept/arme/hortmgt/index.htm

This program is designed to enhance the competitive position of the New York fruit, wine, vegetable, and ornamental horticultural industry through research and targeted, curriculum-driven educational programs. The program recognizes the strategic importance of these sectors in the agricultural industry and seeks to capitalize on the opportunities to promote economic development by increasing the profitability of producers and marketers of fruit, vegetable and ornamental horticultural products and services. Program objectives include selecting products and quality control measures needed to meet large volume, graded and temporal needs of buyers, assisting in developing innovative marketing mechanisms applicable to horticultural businesses, and identifying opportunities in local, national, and international marketplaces for different size horticultural operations. The faculty contacts for this program are Wen-fei Uva and Gerald White in the Department of Agricultural, Resource, and Managerial Economics.

Farming Alternatives Program
http://www.cals.cornell.edu/dept/ruralsoc/fap/fap.html

The Farming Alternatives Program is Cornell's agriculture development and diversification program. Program staff engage in a variety of applied research extension, and community leadership development activities supporting agriculture development in New York and the Northeast. Focal areas related to marketing include marketing innovations for family farms such as on-farm processing, ethnic markets opportunities in New York City, farmers' markets, small-scale fruit and vegetable cooperatives, and cultivating farm-neighbor relations. The contacts for this program are Heidi Mouillesseaux-Kunzman (Program Coordinator) and Duncan Hilchey.

Value-Added Processing Apple Products in the Northeastern United States http://www.cals.cornell.edu/dept/arme/hortmgt/research.htm# development

This project includes faculty and staff in five Cornell departments (Entomology; Plant Pathology; Agricultural, Resource, and Managerial Economics; Food Science; and Horticultural Science) and Cornell Cooperative Extension, as well as a significant amount of industry cooperation through several commercial partners. The objective of this project is to improve apple growers' and processors' likelihood of success in new and emerging opportunities in apple product marketing via enhanced understanding of marketing options, customer preferences, and strategic factors. The marketing and economic analysis component of the project will provide information to the industry on new product feasibility, consumer trends, costs of production, and marketing options. The faculty contacts for this project are Gerald White and Brian Henehan in the Department of Agricultural, Resource, and Managerial Economics.

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Dr. Wen-fei Uva is a senior extension associate in the Department of Agricultural, Resource, and Managerial Economics and directs horticultural marketing extension programs for New York.

The Condition Chain in the Exporting of Empire Apples

Walter Blackler
Apple Acres
Lafayette, New York

The condition of an apple on a grocery store shelf is the result of a chain of many events that start on the tree and last through picking, trucking, storage, packing, and delivery to the stores. A weak link in this chain and the apple's condition suffers. With the competitive situation in apple marketing today, any such weak link will have negative consequences for all those involved in the production of those apples, the most important of which is reduced income for producers.

The internal condition of Empire apples is especially susceptible to weak links in the storage and marketing chain. The condition chain for Empire apples is even more problematic as the major market for the variety is overseas and therefore as much as two weeks longer, due to the overseas freight that is required. The Empire apple is particularly suitable for overseas markets due to its excellent flavor, texture, size, and good firmness on the shelf, but that good firmness on the shelf is only achieved when all the links of the chain are solid. Maintaining good solid links does not require doing anything that we don't now know. All that is required is careful execution of things that we already know, things that many apple producers already practice, but things that must be done right to get desired results. That objective is to ship Empires in the spring of the year that are no more than one pound softer than they were at harvest, and to ship them in such a manner that they will not soften further during shipment. When we do things right, we accomplish this. When we don't, the result is often juice apples.

Grower's Responsibilities in the Condition Chain

1. Start picking at the right time. The right time is when the starch tests at 2.5 to 3.5, Brix test is 12 or higher, pressure test is 17 lbs or higher, and internal ethylene production has not reached the climacteric. The Lake Ontario Fruit Program's *Harvest Fax* provides seasonal updates on ethylene production in Western New York. Color should be above 60 percent and the characteristc Empire flavor present at harvest.
2. Don't delay harvest for color. Waiting will give more red apples, but also apples that produce more ethylene, and become softer. This will result in even more soft apples coming out of storage. Spot picking for color is necessary to get hard apples out of storage. Failure to do this dramatically weakens the condition chain.
3. Pick all the apples with 60 percent color or more.
4. Get the apples into cold storage on the same day they are picked. Those harvested late in the day should be waiting at the storage door first thing in the morning. Bins containing apples left out overnight should be identified and exported early or marketed domestically. They will not make the trip overseas successfully.
5. A timely second picking will usually

KELLY STEVENS/NYSAES

Empire apples should be harvested at the proper maturity and moved to cold storage the same day.

Kelly Stevens/NYSAES

Minimize bruising during harvest.

Kelly Stevens/NYSAES

Harvest apples with a minimum of 60 percent red color. Leave greener fruit for a second harvest.

meet all the conditions in Item #1 and be suitable for export. They will certainly be suitable for domestic shipment.

Storage Operator's Responsibilities in the Condition Chain

1. Leak test every room every summer. Leaky rooms will not keep a consistent atmosphere. Fluctuating oxygen levels can lead to out-turns of soft apples and greater risk of low oxygen-related storage disorders. Each room should hold pressure for a half time of 30 minutes.
2. Test and record starch, pressure, brix, average size, and average color of each lot coming into storage. This information helps the packer select lots for different customers and different times to pack.
3. Segregate and store soft fruit separately, so it is not mixed with fruit for export. Even though it is too soft to stand the overseas shipment, such fruit is usually suitable for domestic shipment.
4. Treat with DPA even though Empires do not get superficial scald. Research shows that DPA treated fruit are harder than untreated fruit.
5. Do not stack more bins of apples in a room than can cool down overnight. Stack fruit two bins high in a room precooled to 32 degrees with good air circulation. If the air temperature is not 32 degrees in the morning, too many warm apples were put in the room. Precooling before room loading is often an overlooked practice, but is essential to good storage. If apples are stacked warm it can be three to four weeks before getting down to storage temperature, with high levels of ethylene resulting and associated fruit softening.
6. If the air in the precooling room is down to 32 degrees by morning, the apples, now cooled to about 45 degrees, can be permanently stacked in another room with other apples similarly cooled, and will cool adequately from there.
7. Fill each room in five days; three days is better.
8. Seal the room. Leak test the door with an air pressure of 1 inch of water and apply soapy water to ensure that a good door seal exists.
9. Flush the room with nitrogen. About 2,000 cubic feet of nitrogen per 1,000 bushels of apples flushed over a 24-hour period, will bring a room down to 5 percent oxygen.
10. Hold the room at 32 to 34 degrees, 2.0 to 2.5 percent oxygen, 2.0 percent carbon dioxide. A steady oxygen level is necessary for good storage of the apples.

Packer's Responsibilities in the Condition Chain

1. After a room is opened, pack the room out in three weeks or less. If the fruit cannot be exported within three weeks, then fruit should be marketed domestically. It will not make the overseas shipment successfully. Do not expect fruit from resealed rooms to ship successfully overseas.
2. Pressure test all sizes when packing. Larger fruit sizes may not test 16 lbs and should not be exported. Use this fruit for domestic markets and save the agony of a rejection.
3. Minimize warming of the fruit during the packing process. Apples should be through the packing process in three hours or less. Bring only small quantities from the cooler at a time, and return packed fruit to the cooler as soon as packed.
4. Force-air cool fruit after packing. This has been one of the biggest recent improvements in packing fruit. Cool the packed cases after packing by forcing cool air through the packed case untill the fruit reaches a core temperature of 32 to 34 degrees. If this is not possible, keep the packed fruit in the cooler at least three days at 32 degrees or cooler, with good air circulation around the fruit. Tests show that even under these conditions, fruit in packed cases is very slow to cool because corrugated cardboard is such a good insulator.
5. Cool the shipping container before loading. Set the container thermostat at 32 degrees. Fruit must not be loaded into a warm container! Open the container vents to the three-quarter position.

Conclusion

Growers, storage operators, and packers all have major roles in the condition chain for export apples. A letdown in performance by any one of these parties will negate the good efforts of the other parties and result in poor condition apples on the grocery shelf. None of the steps listed here is new and none of them are difficult to accomplish. Each is necessary to achieve acceptable condition for export Empires.

If these steps help us deliver a firm, cold apple, "with legs," instead of a soft, warm apple that will soon be worn out, to the export markets, think how delivering the same quality apple to domestic markets would boost domestic consumption, too, and help all involved in producing apples.

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Walter Blackler is a grower, storage operator, packer, and shipper in Lafayette, NY, in partnership with Bob Rigdon. Their company, Apple Acres, has been exporting Empire apples for over ten years. Walter is a member of the New York Apple Research and Development Board.

Progress in Understanding and Controlling Postharvest Decays of Apples

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This work supported in part by the NY Apple Research & Development Program and the NY Apple Research Association.

Empire fruit in CA storage become decayed when *Penicillium expansum* grows into the apple through the stem. Fruit with high boron levels appear more susceptible to decay. Because *P. expansum* is resistant to existing fungicides, improved sanitation is critical for controlling postharvest decays.

Most postharvest decays of apples in New York are attributable to *Penicillium expansum*, the cause of blue mold, and *Botrytis cinerea*, the cause of gray mold. Fruit with blue mold are very soft, watery, and have a musty or earthy odor. Empire fruit with gray mold emerge from CA storage looking like baked apples. They have a uniformly light tan skin, fairly firm flesh, and a cider-like odor.

When first introduced, thiabendazole (TBZ) and the other benzimidazole fungicides were very effective against *P. expansum* and *B. cinerea*. Strains of these pathogens developed resistance to the benzimidazole fungicides soon after the fungicides were introduced, but postharvest treatments continued to provide decay control throughout the 1980s. Postharvest treatments remained effective because strains of *P. expansum* and *B. cinerea* with resistance to benzimidazole fungicides showed increased sensitivity to diphenylamine (DPA)(Rosenberger & Meyer, 1985; Sharom & Edgington, 1985). In the northeast, DPA was always applied with a benzimidazole fungicide, and it served to control the benzimidazole resistant strains *P. expansum* and *B. cinerea.* As a result, the benzimidazole/DPA combination remained effective long after benzimidazole fungicides were no longer effective for controlling other diseases such as apple scab, apple powdery mildew, and brown rot of stone fruits. The combination of DPA and thiabendazole (TBZ) is still effective for controlling *B. cinerea* in stored apples in New York.

Figure 1. Empire apple with blue mold decay caused by *P. expansum* that invaded fruit through the stem during CA storage.

Repeated exposure of *P. expansum* to the benzimidazole/DPA combination gradually selected for strains of this pathogen that were resistant to both DPA and benzimidazole fungicides. Today, most isolates of *P. expansum* in New York apple storages are resistant to the DPA/benzimidazole combination. These strains of *P. expansum* produce prodigious quantities of inoculum in decayed fruit because they are unaffected by postharvest treatments.

Most of the published literature on blue mold indicates that *P. expansum* is primarily a wound pathogen. However, Empire fruit that develop blue mold decay during CA storage often have no wounds or skin abrasions that would provide an entrance site for *P. expansum.* How does *P. expansum* gain access to non-injured fruit? What are the major sources of inoculum for infecting fruit with *P. expansum*? Are there new fungicides under development that might be suitable for postharvest treatment of apples? Postharvest research initiated in 1997 was formulated to answer these questions.

When and How Do Fruit Become Infected?

In a previous report in the *NY Fruit Quarterly*, Rosenberger (1998) described an experiment that proves that Empire apples can become infected via invasion through the stem during long-term CA storage. That experiment was repeated with fruit harvested in 1998 and held in CA storage until April 1999. In both the 1997-1998 and the 1998-1999 storage trials, a high incidence of decay was observed in CA-stored Empire fruit that had been inoculated by placing 500 spores of *P. expansum* on the ends of intact stems (Fig. 1). Apples inoculated the same way but held in air storage instead of CA storage developed very little decay when held for similarly long storage intervals. Thus, Empire apples held in cold air were able to stop the invasion of *P. expansum* through their stems whereas apples held in CA storage were unable to resist the pathogen.

The amount of decay that resulted from stem inoculations varied depending on the orchard in which the fruit was grown. Empire apples used for stem inoculation studies were collected from the same six orchards in both years of the study. In both years, some orchards had significantly more decay than other orchards, but differences among the six orchards were not consistent between years (Table 1). Orchards L-331 and OD had the highest incidence of decay in both years whereas orchards RO and KI had moderate levels of decay in both years. Orchards KA and L-236 showed the greatest variation from year to year.

Analysis of fruit stem characteristics and seasonal fungicide spray records from the six orchards did not provide any clues for explaining differences in susceptibility to decay. However, susceptibility to decay was correlated with high boron levels in fruits and leaves. Regression analysis of incidence of decay as affected by foliar boron levels in the orchard provided an R^2 of 0.69, indicating that 69 percent of the variation in levels of decay in the six orchards over the 2 years of the trial could be explained by differences in foliar boron (Fig. 2). A similar relationship was noted for levels of boron in fruit (Fig. 3). None of the other mineral levels in leaves or fruit had any significant effect on fruit susceptibility to decay. A follow-up experiment is under way to verify the relationship between boron levels and susceptibility to decay in Empire fruit.

Additional stem inoculation tests were conducted during the 1998-1999 storage season to determine what other variables might affect fruit susceptibility to stem invasion by *P. expansum*. One experiment showed that the incidence of decay following CA storage was similar for apples inoculated with 50 spores per stem and for those inoculated with 500 spores per stem. Other tests showed that the incidence of decay was not significantly affected by holding fruit at ambient temperatures for up to 40 hours between harvest and inoculation. Decay incidence was not affected either by a 24-hour delay between inoculation and cooling of the fruit or by holding inoculated fruit at 34°F in air for up to 14 days before putting them into CA storage. Thus, resistance of fruit to decay could not be enhanced by allowing more time between harvest and inoculation, between inoculation and fruit cooling, or between inoculation and establishment of CA atmosphere.

TABLE 1

Effect of orchard source on percent of Empire fruit that developed decay during CA storage following inoculation of uncut stems.

Fruit source	Inoculated 4-6 hr after harvest 1997-98	1998-99	Grand means for 2 yr.	Inoculated 20-24 hr after harvest 1997-98	1998-99	Grand means for 2 yr.
L-331	65 b[1]	65 c	65 c	35 a	56 b	46 b
OD	44 ab	61 bc	52 bc	44 a	52 b	48 b
RO	24 a	43 bc	33 ab	10 a	19 ab	14 a
KI	44 ab	23 ab	33 ab	23 a	8 a	15 a
KA	69 b	3 a	30 ab	34 a	13 a	22 ab
L-236	35 ab	5 a	18 a	20 a	52 b	35 ab

[1] Means for each year are from observations of 25 fruit. Data was subjected to the angular transformation for statistical analyses. Means separations were determined using LSD to compare means from the factorial analysis of 6 farms X 2 years of observations. Means followed by the same letter are not significantly different (P≤0.05).

TABLE 2

Estimated number of *Penicillium* spores per liter of air in CA rooms and packinghouses as determined using a Burkard volumetric air sampler.

	1998-1999*	Winter/Spring 2000**
Packinghouses		
Near water flotation tank in the packing line	49.6	118.5
Bagger end of packing line	27.7	40.8
Closed CA rooms or cold storage rooms	3.4	1.3

*Means from single sampling dates at 9 packinghouses and 6 closed CA storage rooms.
**Means from four sampling dates at each of three packinghouses and cold storage rooms.

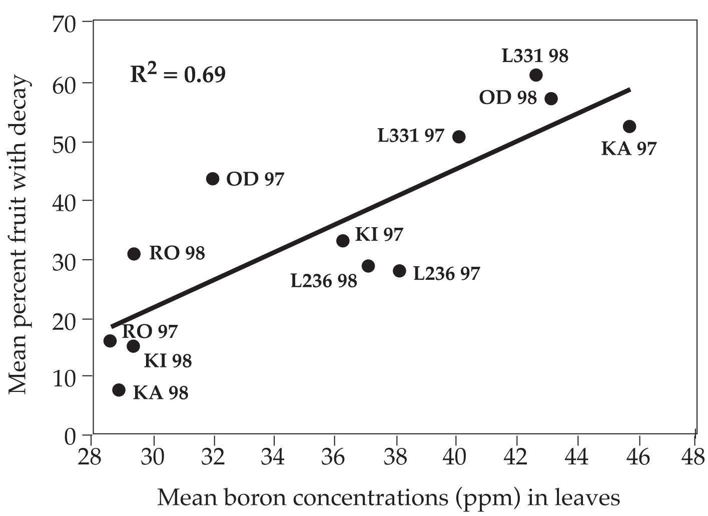

Figure 2. Results of regression analysis of the effect of boron concentration levels in leaves on suseptibility of fruit to postharvest decay, with data taken from six orchards over two successive years (1997 & 1998).

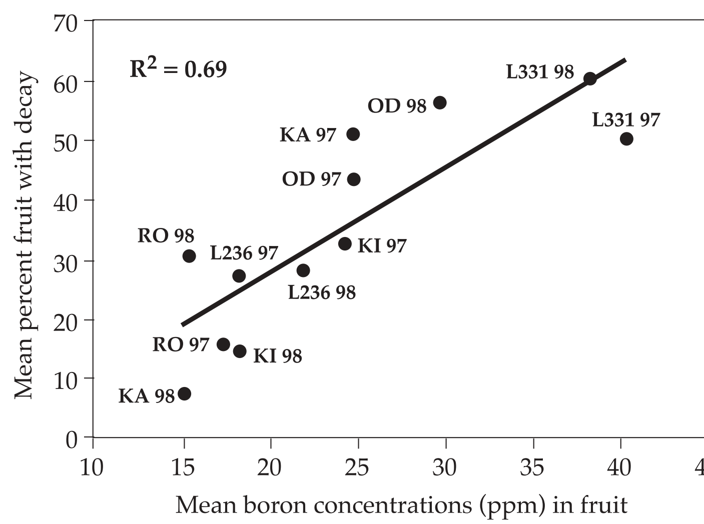

Figure 3. Results of regression analysis of the effect of boron concentration levels in fruit on suseptibility of fruit to postharvest decay, with data taken from six orchards over two successive years (1997 & 1998).

TABLE 3

Results from washing four different lots of empty apple bins, 1999.

	No. of Penicillium spores per bin as estimated from wash water samples	% reduction in spore load on sanitized bins compared to similar non-sanitized bins
Dirty bins from same lot as sanitized bins	835,244,000	
Bins sanitized with fresh sanitizer solution	1,538,000	99.82 %
Bins sanitized just at end of sanitizer usefulness	7,435,000	99.11 %
2nd set of dirty bins	424,542,000	

TABLE 4

Effectiveness of various fungicides applied to wounded Empire fruit for the prevention of blue mold decay caused by P. expansum.

Materials and rate of formulated product per 100 gal	% fruit with decay at various intervals following treatment*			
	8 wk.	10 wk.	12 wk.	14 wk.
Control	62 c**	91 c	96 c	97.0 c
Mertect 340-F 8 fl oz	<1 a	2 a	6 b	5.6 ab
Mertect 340-F 16 fl oz	<1 a	1 a	2 ab	9.3 b
Captan 50W 2.5 lb	46 b	75 b	84 c	88.0 c
Scholar 50W 8 oz	0 a	<1 a	<1 ab	0.2 a
Scholar 50W 16 oz	0 a	0 a	0 a	0.2 a

*Fruit were inoculated and treated on 11 December, then held at 34 F in air storage and evaluated at the indicated intervals after treatment.

**Means followed by the same letter are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

What are the Major Sources of Inoculum for *P. expansum*?

Relatively little is known about the sources of inoculum that contribute to postharvest decays caused by *P. expansum*. Recirculating solutions in postharvest treatment tanks and water flotation tanks have been suggested as the primary sources of inoculum. However, airborne inoculum in packinghouses may contaminate bins as they are moved through and out of the packinghouse. That airborne inoculum landing on bins, along with decayed fruit left in bins coming off the packing lines, may provide inoculum for next year's crop. Furthermore, inoculum that recycles from year to year on bins or as contaminants in packinghouses and storages would receive repeated exposure to postharvest fungicide treatments and therefore are the most likely sources for strains with resistance to DPA.

Experiments were conducted to measure levels of inoculum in packinghouses, storage rooms, and empty bulk bins. A portable air sampler for agar plates (Burkard Manufacturing Co.) was used to measure concentrations of airborne spores of *P. expansum* in various storage and packinghouse environments. Spore trapping was conducted in eight packinghouses and six closed CA rooms during April 1998 and in one additional packinghouse in June 1999. Additional spore trapping was conducted at three packinghouses and their associated cold storage rooms on February 1 and 22, March 14, and April 4, 2000. In packinghouses, air was sampled close to the water flotation tank where apples are floated out of the bins and also at the far end of the packing line where automatic baggers are usually located. Air in CA rooms was measured by inserting the spore trap through portholes in the CA room doors. Each time that spore trapping was done in the winter and spring of 2000, agar plates were also left exposed to the air for one minute near the water flotation tanks to determine how many spores would be captured just by settling of spores from the air.

Airborne inoculum levels ranged from 50 to more than 100 spores per liter of air near the water flotation tanks. Spore levels in air were roughly half as great at the far end of packing lines, and there were very few airborne spores in closed CA rooms and in cold storage rooms (Table 2). Spores of *P. expansum* landed on exposed agar plates at the rate of two spores per square inch per minute when plates were exposed near the water flotation tanks in packinghouses.

The levels of airborne inoculum detected in packinghouses suggest that anything coming out of the packinghouse during the packing season will probably be contaminated with spores of *P. expansum*. Even if water flotation tanks are chlorinated, empty bins may become recontaminated by the time they are bundled and removed from the packinghouse. If the empty bins are stored in empty CA rooms in the same building as the packing operation, then inoculum generated during the packing operation will continually drift into the rooms used to store bins.

A bin sanitation experiment was conducted during July 1999 to determine levels of inoculum residing in empty bins and effectiveness of sanitizing bins with a quaternary ammonia solution. Four separate lots of 25 empty bins were "washed" using a portable postharvest drencher. The four lots included: (a) dirty bins that had been bundled and stacked outdoors for about two months after they were emptied, (b) a comparable group of bins from the same lot that had been sanitized by the packinghouse operator using a fresh charge of Deccosan quaternary ammonia sanitizer, (c) another group from the same lot that was sanitized with Deccosan after several hundred bins had already been processed, and (d) a set of dirty bins from a different CA room. The sanitizer was applied by the packinghouse operator using a modified postharvest drencher that directed cascades of water against all sides of the bins after they had been unbundled and all decayed fruit had been manually removed.

To assess spore levels on non-sanitized and sanitized bins, water samples were collected after sets of five bins had been washed in the portable drencher. This approach provided five replicate samples from each test lot of 25 bins. Inoculum levels in the water samples were assessed by dilution plating. Inoculated agar plates were incubated for 35 days at 34°F to inhibit growth of contaminants while *P. expansum* spores germinated and formed visible colonies on the plates. Colonies of *P. expansum* were counted, and the number of spores recovered per bin was calculated by taking into account the number of bins washed, the total vol

Postharvest decay in Empire has been increasing in recent years.

ume of the wash water in the drencher, and the number of colonies per milliliter of water plated on dilution plates.

The bin-washing experiment showed that a single contaminated bin could carry more than 800 million spores (Table 3). Although sanitizing bins provided a 99 percent reduction in the number of spores per bin, some sanitized bins still carried nearly 8 million spores and the economic benefit from 99 percent control is unknown. The difference between spore numbers remaining on the bins treated at the beginning compared to those treated at the end of the solution cycle was not significant and showed that the sanitizer had reasonable longevity in the recycling wash water.

New Fungicides for Postharvest Decays?

Novartis has a new fungicide with the trade name of "Scholar" that could prove useful as a postharvest fungicide on apples. The generic name for Scholar is fludioxonil. It is a phenylpyrrole fungicide with a different mode of action than any of the other fungicides currently registered for field or postharvest use on apples. Scholar has received Section 18 registrations for controlling brown rot on stone fruits in several states, but Novartis is still uncertain whether the product can be registered on apples.

An experiment was conducted during the 1998-1999 storage season to compare the effectiveness of Scholar with that of Captan and Mertect 340-F. (Mertect 340-F is a commercial formulation of TBZ). Each treatment was replicated four times using 25 fruit per replicate. Empire apples were harvested September 15 and were held at 34°F until December 11 when the experiment was initiated. Fruit were wounded on a single hemisphere using a large cork fitted with three finishing nails spaced about 1 cm apart in a triangular pattern. Wounds simulated stem punctures, a common entry site for *P. expansum* in apples. Baskets containing 25 wounded fruit were dipped for 20 sec into a spore suspension that contained 2,500 conidia per ml or a benzimidazole-sensitive isolate of *P. expansum*. Fruit were allowed to dry for approximately 1 hr after inoculation and were then submersed for 30 sec in treatment solutions. Treated fruit were then arranged on spring cushion trays, placed in wooden crates, and moved to cold storage at 34°F. Apples were evaluated for decay on four different dates. Fruit were considered decayed if any one of the three wounds was infected.

All of the four treatments that involved Mertect 340-F or Scholar were equally effective for the first 10 weeks following treatment. By 12 weeks after treatment, however, the incidence of decay in fruit treated with Mertect 340-F had begun to increase (Table 4). At the end of 14 weeks, both rates of Scholar provided better control of decay than did the high rate of Mertect 340-F. Results from this experiment are consistent with results from other trials where activity of Mertect 340-F seemed to decline with increasing duration of storage. Scholar exhibited better residual activity in this trial than did Mertect 340-F. Differences between Scholar and Mertect 340-F would have been more dramatic if a Mertect 340-F-resistant strain of the pathogen had been used as inoculum. Captan was ineffective for controlling decay in this test.

What Happens Next?

The appearance of *P. expansum* with resistance to both DPA and TBZ means that packinghouse operators no longer have effective fungicides for preventing postharvest decays in apples. Empire fruit may be uniquely susceptible to invasion via stems. Recognition of this weakness in Empire was delayed by the availability of effective fungicides.

In the absence of effective fungicides, better sanitation will be critical for controlling postharvest decays. Even if a new fungicide such as fludioxonil is eventually registered for apples, resistance to the new fungicide will develop quickly unless inoculum levels are kept to a minimum. The negative cross-resistance between DPA and benzimidazole fungicides was a totally fortuitous and serendipitous event that is not likely to be repeated. In the absence of DPA, the benzimidazoles would have controlled postharvest decays for only about 5 years as compared to the 17 years (1973-1990) of good control the industry enjoyed with the DPA/benzimidazole combination.

Research is needed to determine the most cost-effective method for sanitizing bins and storages and to determine if sanitation measures can be correlated with reductions in the incidence of decays the following year. The area of bin sanitation has not been well investigated for any crop. Developing and proving the effectiveness of a comprehensive sanitation strategy will be a complex and lengthy process, especially since much of the work must necessarily be done in commercial packinghouses where establishment of appropriate controls and replications is difficult.

The relationship between high boron levels and increased susceptibility to decay is being pursued by establishing varying levels of boron in replicated field plots. If the relationship can be verified, then growers may want to reduce boron applications in Empire blocks where foliar boron levels exceed 35 ppm. Alternatively, analysis of foliar boron levels in late summer might be used as a predictor for postharvest decay problems and fruit from high-boron orchards could be marketed earlier in the season.

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