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Editorial

Lessons We Should Have Learned from the 2002 Apple Marketing Season

It took the shortest crop in almost 50 years to increase fresh apple prices to the point where growers could make money this year. Even then it was hard work! Only by working together through Premier Apple Cooperative and by growers holding the line on bulk apple prices could growers get and hold a decent price. (We also had a lot of help from Mother Nature in providing one of the best coloring years we have had in a long time.) What does this tell us?

- Supply is critical!
- We have to stay informed, work together and hold the line in order to make money.

The process apple lesson is a bitter one. There is such an oversupply of process apples in New York State that it took diverting apples to fresh and cider markets and increased demand from out of state (and country) processors before the price increased. And this was only on the latest maturing varieties. Even this price increase did NOT surpass 10 cents per pound! What are the process apple lessons learned this year?

- Plan on losing money if you grow process Cortland, Wayne, Twenty Ounce, Greening, Monroe, McIntosh, or Empire for the applesauce market in the future. If these varieties were undesirable (as indicated by price) this year, the price will surely be less next year when New York and the nation have a more normal crop.
- The only way to make money growing the remaining process apple varieties will be to cut costs and increase production (probably over 900 bushel per acre). How many growers are in a position to cut costs and still increase production? Probably not many!
- If you didn't get any buyer respect or empathy this year, you are less likely to get it in the future.

I have little hope for strengthening peeler apple prices in the future. China has the capacity to double apple juice concentrate exports. Most of the countries exporting apple juice concentrate have living standards so low that they will continue to seek our dollar by sending the U.S. more apple juice concentrate. If there has been serious damage to Washington State's trees from the late October freezes, we could probably expect even more low quality apples being dumped into process markets next fall (similar to what happened after the 1968 freeze).

The big lessons that all apple growers should have learned this year are:

1. **PRESERVE ASSETS** for the future! Even though many growers are unlikely to remove unprofitable apple blocks this winter. You will be much better off removing all unprofitable blocks this winter and sitting the game out rather than wasting your time, money and energy losing money in an oversupplied market next year.
2. The future rests with growers keeping informed and controlling supply **together (**tree removal and adequate thinning**)**! A huge crop next year could undermine any progress made with fresh buyers this year. No one can survive going back to the fresh apple prices of 2001.
3. Supplying (not oversupplying) varieties demanded by consumers is the name of the game.
4. We cannot work together if we don't share information; we need cooperation among growers and marketers and accurate tree surveys for strategic planning both on the individual farm level and on an industry-wide level. We are all in this together—there is no honor in being the last man standing when the infrastructure that supports the industry has been gutted.

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Cornell as Catalyst: Supporting the Tree Fruit Industry as it Adapts to Change

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> **Cornell University is committed to helping the tree fruit industry adapt successfully to a demanding new market landscape. In April, Dean Susan Henry charged New York State Agricultural Experiment Station Director Dr. Jim Hunter with forming a Cornell Tree Fruit Industry Task Force to work proactively on this commitment. Since then, the industry and the task force have made significant progress on a variety of important initiatives.**

In this issue of the *New York Fruit Quarterly*, Desmond O'Rourke examines global trends in the world apple market and highlights the challenges and opportunities these trends present for New Yorkers whose livelihoods depend on the tree fruit industry. Cornell University, guided by its land grant mission and long service to this important sector of New York's agricultural economy, is committed to helping the industry adapt successfully to a demanding new market landscape. In April, Dean Susan Henry charged New York State Agricultural Experiment Station Director Dr. Jim Hunter with forming a Cornell Tree Fruit Industry Task Force to work proactively on this commitment. Since then, the industry and the task force have made significant progress on a variety of important initiatives.This article is a report on that progress.

Mission of the Task Force

The mission of the Cornell Tree Fruit Industry Task Force is to significantly enhance Cornell University's traditional role as an educator and effective developer of promising technologies and marketable products. The Task Force will also go beyond tradition by helping Cornell become a major catalyst for positive change and a proactive partner in support of the people, businesses and institutions who will transform the tree fruit industry into a dynamic and vital contributor to New York's current and future economy.

Progress of the Task Force

Cornell's extension, teaching and research efforts have long had dedicated people and valuable programs that have helped equip tree fruit stakeholders with market information and analysis, sound skills with which to make good business decisions, better production practices and technologies, and promising new products. Last spring, New York State Agricultural Experiment Station Director Jim Hunter, who chairs the task force, asked a large group of those involved with the apple industry to a task force meeting in Geneva. Participants included field researchers and educators, as well as Station and Ithaca campus faculty members, George Lamont of the NYS Horticultural Society, NY FarmNet Director Cathy Sheils, and New York State Department of Agriculture and Markets Deputy Commissioner Rick Zimmerman. Area Extension Educator Alison DeMaree presented a comprehensive "state of the industry" report before the group joined in a candid, wide-ranging discussion geared to identifying key problems facing tree fruit farm and marketing operations. Conference participants recommended that the task force focus on four major areas in order to heighten the impact of Cornell's traditionally supportive programs:

1. Facilitate re-engineering of market structure to ensure long-term viability of the New York tree fruit industry.
2. Help improve industry understanding of the dramatically changed market environment; develop and deliver effective management and decision-making tools for use by individual growers.
3. Establish effective leadership development programs designed specifically for the tree fruit industry.
4. Complete high-priority production and handling technology tasks assigned to Cornell in the 2002 NY Apple Industry Strategic Plan and dictated by current needs.

To successfully accomplish these goals, task force leaders spent the summer of 2002 seeking convergence of individual agendas, skills and efforts to make the whole effort greater than the sum of its disparate parts. Others set out to implement recommendations of the April conference. A task force steering committee met again in September to sharpen the focus of the overall enterprise, identify project "champions," and place priorities on various aspects of the initiative.

Re-engineering market structure

Bruce Anderson, Jerry White and Wen-fei Uva, all faculty members in the Department of Applied Economics and Management, lead Cornell's effort to help the industry re-engineer its market structure. Skilled and experienced as these and other members of the task force are, they will play no direct role in grasping the market opportunities identified by Desmond O'Rourke. New York growers, shippers, packers, retailers and their organizations will do the grasping. Indeed, New York's leading players, after reaching hard-earned consensus on a statewide strategic plan for the industry in 2001, have already formed Premier Apple Cooperative as an important vehicle through which to address persistently low producer prices. The task force will put the Cornell College of Agriculture & Life Science's weight, knowledge and experience behind Premier's success and other continuing efforts to improve the performance of tree fruit markets. The first of many projects in this long-term initiative will be to seek funding and carry out a survey of apple marketing costs incurred between the farm gate and the retail shelf.

Understanding and Responding to Change

During the past decade, tree fruit growers in New York State have struggled to cope with negative price and financial trends. The forces of supply and demand still operate in somewhat familiar cyclical fashion. Financial gains, however, have been less pronounced during good years; and down years have taken an increasingly greater toll on operator equity and grower confidence in the future. This new business climate calls for better understanding of current economic forces and their impact on individual operations. Growers also need to develop improved financial and marketing plans, diversified production strategies, innovative business structures, and sharpen their decision-making skills in order to prosper in this daunting new world. Cathy Sheils (Director, NY FarmNet) and Alison DeMaree (Lake Ontario Area Extension Educator) head the task force effort to promote solid market understanding by growers and effective business response to change. In cooperation with NY Farm Bureau, Farm Credit of Western New York and First Pioneer Farm Credit, the task force sponsored recent workshops for growers and agri-service providers on these critical issues, featuring Desmond O'Rourke's seminar on world apple market trends. The New York State Department of Agriculture and Markets is funding the development of a decision-making workbook for growers, to be published by the end of 2002. This network of assistance should prove valuable for all fruit growers and related businesses faced with challenging choices among a wide variety of paths to a viable future.

Preparing Industry Leaders

Only an industry guided by enough skilled, forceful leaders will find and realize economic gains from aggressive new export strategies, innovative marketing programs for new tree fruit varieties, or creative industry alliances such as Premier Apple. LEAD-NY is one of Cornell University's many strong leadership development programs, and it is dedicated to promoting effective leadership in food and agriculture. The task force, in close cooperation with industry, seeks to tailor new training programs to meet specific industry needs for leadership development and to encourage greater participation in the traditional two-year LEAD-NY courses. Task force members Marc Smith (NYSAES), Larry Van de Valk (LEAD-NY), and Hudson Valley Area Extension Educator Mike Fargione are responsible for this initiative.

Developing Production Technologies

Cornell researchers and extension specialists are carrying out important responsibilities assigned to the College of Agriculture & Life Sciences in the 2001 NY Apple Industry Strategic Plan. These action steps include the development of a total quality improvement plan for New York apples, the development of an IFP protocol for use in the export market and the design of a program to enable the safe, effective use of 1-methylcyclopropene (MCP) to dramatically increase the quality of stored apples. Since the strategic plan was announced, the industry has encountered a new production problem related to internal fruit worms. Geneva scientists Harvey Reissig and Art Agnello are building a rapid response project to solve this problem. The task force production technology initiative, guided by Cornell horticultural sciences professors Terence Robinson and Chris Watkins, will bring the college's best resources to the tasks of solving production problems and making the most of critical opportunities for improved profitability. Development of better production practices; the introduction of new, profitable varieties; a sustained, rigorous emphasis on quality improvement; and concerted focus on transferring these new practices and technologies for use by growers will characterize this element of the task force mission.

Alliances

"Cornell as catalyst" and""make the whole greater than the sum of its parts" have been key, recurring principles followed by those charged with fostering the healthy infancy of the tree fruit task force. The group has managed to change some of the dynamics governing the interaction of college programs supporting the tree fruit industry. Dialogue across disciplinary lines, new professional relationships among researchers and NY FarmNet practitioners, and lively debate about thorny issues have already helped us put such principles into practice. Internally, we are finding more collaborative ways to accomplish the mission. Other major institutional players are already taking productive parts in this process. The New York Department of Agriculture and Markets is funding some of our ongoing work. Members of the state legislature are aggressively seeking ways to bolster the initiatives described in this paper. Many members of the New York congressional delegation have expressed strong interest in the goals of the task force and the health of the New York apple industry. New York Farm Bureau and Farm Credit Services have played important roles by sponsoring recent industry workshops organized by members of the task force.

The tree fruit industry is fortunate to have such powerful resources on hand in times of economic crisis. Cornell's positive impact on behalf of the industry will be much greater if we can continue to engage these valuable institutions substantively in the combined effort. The most important alliances will be those formed by and among growers, shippers, packers, retailers and their organizations leading the drive to ensure long-term prosperity in the tree fruit industry. If the task force can facilitate and promote such collaboration, its mission will have been served.

The Long Haul

Changes in the economics of apple and fruit markets here and around the world make themselves felt every day as new, often harsh realities for growers and marketers across New York State. Such realities will influence decisions that could transform farms and rural communities for generations to come. If the Cornell Tree Fruit Industry Task Force is to make any lasting contribution to the industry's viability in this climate of change, the effort will have to be sustained in proportion to the size of the challenge. The opportunities are many, if elusive. New York State's comparative advantages are real, if often unrecognized; and the industry's potential for success is great, if not yet realized. Cornell's commitment to making a positive difference for all those with a stake in the long-term success of a tree fruit industry so important to the past and future of our great state remains firm.

Marc Smith grew up on a dairy farm in Livingston County, and holds a master's degree in economics. He served as New York State Executive Director for the USDA Farm Service Agency from 1994-2001, during which time he worked with the New York congressional delegation, the NYS Department of Agriculture and Markets, farm organizations and growers to design and promote the Apple Market Loss Program. He became assistant director of the New York State Agricultural Experiment Station in Geneva, in August 2001.

Dr. Jim Hunter is a Cornell plant pathologist. He worked on vegetable crops and served as chair of the department of plant pathology at Geneva for 10 years before becoming director of the New York State Agricultural Experiment Station in 1987.

Major Trends in U.S. and World Apple Markets

Desmond O'Rourke

President of Belrose, Inc., Emeritus Professor of Agricultural Economics at Washington State University

Each year, consumers eat about 60 million metric tons of apples (equivalent to 315 billion, size 100 apples). Changing market needs are offering many new market opportunities to producers.
To grasp these opportunities, producers and their organizations must be willing to change.
They must do their homework on where their comparative advantages might lie and they need courage and determination to strike out in new directions.

The apple market in the United States and in the world has seen a number of major trends and a number of major reversals of trends in the last decade or so. However, these are not just a curiosity for apple growers in New York. They have had a very direct impact on your competitiveness and profitability. Your future success will depend on how well you understand what is happening and on how well you adapt your operations to meet the changed situations. In this paper, I discuss some of the key trends that seem most relevant, and some of the opportunities that they offer for the New York apple industry.

Global Trends in Supply and Demand

Global forces of supply and demand have had a major influence on the apple industry in the last decade.

World Fruit Supply Trends

There has been a tremendous surge in the world production of most major fruits in the last decade (Table 1). Annual average world production of major fruits rose 13.1 percent between 1979-81 and 1989-91. In the following decade, the increase was 41.2 percent, or an average increase of 3.5 percent per year. At the same time, world population grew by only 15 percent. Thus, per capita supplies of all fruit rose from 61.63 kg in 1990 to 71.75 kg in 2002, an increase of 16.4 percent. Per capita supplies of apples rose in the same period from 7.56 kg to 9.82 kg, an increase of almost 30 percent; pears rose from 1.79 to 2.76 kg per capita, an increase of 54.2 percent.

Two regions, China and the Southern Hemisphere, have contributed to most of the growth in the past decade. China's production of apples has risen fivefold to over 20 million metric tons in the decade. Pear production has increased more than threefold. This has led to intense competition in the fresh apple and fresh pear markets in East Asia and in the concentrated apple juice market around the world. The Southern Hemisphere increases have been less spectacular. Apple production rose by one-third between 1990 and 1998, before falling back since. Pear production rose by over 75 percent between 1989-91 and 1999-2001. Most of the Southern Hemisphere sales are concentrated in Northern Hemisphere markets in the March-June period. China and the Southern Hemisphere have taken many markets once dominated by U.S. suppliers. This has led to increased supply pressure in the domestic U.S. market.

TABLE 1

World Production of Major Fruits, 1979-81, 1989-91 and 1999-2001 (Annual average, thousand metric tons)

Fruit	1979-81 (1000mt)	1989-91 (1000mt)	1999-2001 (1000 mt)	Change 79-81 to 89-91 (percent)	Change 89-91 to 99-01 (percent)
Apples	34,362	39,724	59,894	+ 15.6	+ 50.8
Pears	8,592	9,529	16,504	+ 10.9	+ 73.2
Other Deciduous	14,589	17,203	30,926	+ 17.9	+ 79.8
Total Deciduous	57,543	66,456	107,324	+ 15.5	+ 61.5
Grapes	66,106	58,457	63,227	- 11.6	+ 8.2
Total Citrus	59,321	77,073	105,451	+ 29.9	+ 36.8
Total Tropical	90,206	106,316	159,115	+ 17.9	+ 49.7
Total Berries	2,487	3,340	5,007	+ 34.3	+ 49.9
GRAND TOTAL	**275,663**	**311,642**	**440,124**	**+ 13.1**	**+ 41.2**
(exc Apples)	241,301	271,918	380,230	+ 12.7	+ 39.8

The mix of varieties produced around the world has also changed dramatically in the last decade. For example, in 1990, supplies of Fuji, Gala and Braeburn were less than one percent of production in either the European Union or the United States. In the current 2002-03 season, they will account for 56 million boxes (15 percent) of the EU crop and 46 million boxes (21 percent) of the U.S. crop. That growth has largely been at the expense of existing major varieties such as Red Delicious, Golden Delicious, Rome and McIntosh. These three varieties have also been making major gains in export markets. By 2010, my forecast is that, excluding China, Gala will be the third largest variety in the world after Red Delicious and Golden Delicious, Fuji will be fourth and Braeburn eighth. If China is included, Fuji will be the world's dominant variety. New contenders include varieties like

Pink Lady, Cameo, Honeycrisp, Pinova, Pacific Beauty, Jazz, etc. Accordingly, we can expect the challenge to older varieties for consumers' favor to continue.

The good news on the supply side is that the acreage planted to many fruits, including apples and pears, has either stabilized or declined in the last two to three years. Depressed market conditions have caused many producers to pull back. Production of most major fruits (except apples) stabilized in 2001 and one can be cautiously optimistic about 2002. However, production capacity still exceeds total demand capacity.

World Economic Trends

Demand for fruits is heavily influenced by the general state of the world economy. Since 1995, many regions have suffered major economic setbacks. The Mexican peso crisis of 1995 foreshadowed the Asian financial crisis that began in 1997. Shortly thereafter, the former Soviet Union, many countries in Central and Eastern Europe, and much of Latin America slipped into recession. One common effect of all these crises was that the affected currencies lost purchasing power vis-a-vis the U.S. dollar. Many still have not recovered. For example, in Northeast Asia (excluding China), GNP per capita in 2002 is still more than 10 percent below 1995 levels. In Southeast Asia, it is more than 20 percent lower. China has been the outstanding exception in East Asia. Its GNP per capita has grown by 57 percent since 1995. Because its GNP per capita is still relatively low (less than $1000), China is still not a major market for U.S. goods. South Asia, especially India, has also escaped much of the recent downturn, but its purchasing power is low. In contrast, Japan, which could be a major positive influence on the whole region, has limped from recession to recession in the last decade.

The fall has been even more dramatic in other regions. For example, the leading economy in the Middle East, Saudi Arabia, had a GNP per capita of $11,260 in 1980 and had enjoyed a growth rate in the previous decade of 9.6 percent. In 2000, its GNP per capita had fallen to $7,230 after a negative growth rate of -1.2 percent in the previous decade.

Much of the economic growth since World War II has been driven by the freeing up of internal economies and the expansion of international trade. The widespread economic problems have been both a reason and an excuse for the world's failure to pursue major trade liberalization initiatives since 1995. The World Trade Organization has made little progress since the "Battle in Seattle," the abortive summit in 1999. Most of the easy gains within the North American Free Trade Agreement (NAFTA) have been made. The new U.S. Farm Bill has boosted protectionist forces in both Canada and Mexico. The Free Trade Area of the Americas (FTAA) has still not got off the ground after almost a decade of talk. Meantime, the European Union appears unable to reform its Common Agricultural Policy (CAP), a policy that has been inimical to freer trade.

World Demand Trends for Food

About 45 percent of the world's population lives in countries with per capita incomes below $1000, so that their main goal is to meet their food necessities. Another 30 percent have per capita incomes between $1000 and $3000. In these countries, a rapidly growing middle class is an important market for imported foods. A further 12 percent have per capita incomes between $3,000 and $10,000. The remaining 13 percent live mostly in the developed world and have average incomes of close to $30,000. In many cases, countries with favorable income profiles have unfavorable demographic patterns in terms of food demand.

In the developed world, the total population is nearing a peak. The number of older people is growing very rapidly. The number of children, teenagers and young adults is either static or declining. The role of the traditional family is shrinking. In many countries, one-third of all households are made up of a single adult who is either unmarried, separated, divorced or widowed. As a result, the demand for food at home is static while the demand for food away from home is increasing. The total volume of food consumed is flat, while more and more of the consumers' income is being spent on food services. This has led to flat or falling demand for basic food products.

Markets have become increasingly segmented as consumers' interests diverge and they have the purchasing power to demand what they want. Some want foods with low salt, low cholesterol or low fat. Some want foods with specific vitamins and minerals present. Some want their food prepared in kosher or halal style. Many have diets influenced by medical needs of age, sickness, allergies or sensitivities. Many pursue different kinds of vegetarian diets. At the other extreme, many consumers are so pressed for time that they eat only convenience foods crammed with fats, sugars and preservatives.

Consumers are also increasingly concerned about how their food is grown, harvested, handled, shipped and prepared. They demand evidence that the food industry has been kind to the soil, air and water, farm animals and wildlife, and has provided adequate housing, working conditions and wages to farm workers. Some abhor synthetic chemicals, genetically modified organisms, or sewage sludge used in food production. Others wish to get more of their food directly from the producer to avoid the middlemen ogres. Farmers' markets, roadside stands, U-pick, community supported agriculture (CSA) networks, etc., are becoming more popular. A stronger mainstream trend is for consumers to choose "better-for-you" foods, not by brands, but by where they shop. Specialty chains such as Trader Joe's and Whole Foods cater to this sentiment.

During the last decade, the traditional supermarket chains that once dominated food retailing in developed countries have faced a triple threat. The fast food industry has taken a growing share of the consumers' food dollar. Discounters such as WalMart have brought their everyday low price strategy to the food business. A transformation has taken place among consumers who have gone from passively absorbing the products the mass marketers supplied them to aggressively seeking the food attributes of their choice. The supermarket chains absorbed a little from each of these threats. They have introduced food service bars and other takeaway food. They have sought internal and external efficiencies through mergers, acquisitions and restructuring. And they have become champions of many of the consumers' social and environmental goals.

The net effect is that retailers in the developed world now demand the same or better quality from their suppliers at lower prices and with many additional warranties and services added. Many have tried to build alliances with a few preferred suppliers for each commodity. These are usually the largest suppliers. Many smaller suppliers have been scrambling for the remaining business, further weakening their bargaining power. Percentage marketing margins in food have grown and since retail prices have been flat or declining, the dollar and percentage returns received by growers have fallen.

Many of these same pressures are beginning to appear in the developing world. Generally, their populations are still growing rapidly. A large proportion of that population is children and young families in their high consumption years. At their relatively low average income levels, even small increases in income translate rapidly into buying more and better food, and, in particular, buying imported food. Without renewed economic growth, many of these countries will not achieve their market potential. And, without further trade liberalization, many consumers will face restricted access to imported foods.

U.S. Trends in Supply and Demand

Even though acreage devoted to fruit production in the U.S. has been static in the last decade except for grapes and oranges, production has continued to rise due to increased productivity (Table 2).

U.S. Fruit Supply Trends:The supply of fruits is influenced by past planting decisions and the length of time trees take to reach maturity, so trends over an interval as short as one decade must be treated with caution.

While apple production in 1999-2001 averaged only 5.6 percent more than in 1989-91, and pear production only 7.5 percent more, average production of all competing fruits grew by almost 24 percent. During the same period, the U.S. population grew by just 10 percent. Apple production actually set a new record in 1998 at almost 20 percent above the 1989-91 average, so apples contributed a lot to increased supplies during the decade.

The strong dollar has also made the U.S. market an attractive target for imports of fruit from many countries (Table 3). While fruit exports have also risen, imports have increased much more rapidly. Some of the biggest percentage increases have been in tropical products such as fresh mangos and fresh and frozen pineapples that are not produced commercially on the U.S. mainland.

In the case of fresh apples and fresh pears, exports have continued to outrun imports and the trade balance has continued to grow (Table 4). Imports of fresh pears have grown at a faster rate than exports. In contrast, the trade balance for apple juice has been overwhelmingly negative, and getting

TABLE 2

U.S. Production of Major Fruits, 1989-91 and 1999-2001
(annual average, thousand metric tons)

Fruit	1989-91 (1,000 mt)	1999-2001 (1,000 mt)	Decade Change (percent)
Apples	4,426.8	4,675.7	+ 5.6
Pears	841.0	903.8	+ 7.5
Other noncitrus	9,164.1	10,470.6	+ 14.3
Total noncitrus	14,431.9	16.050.1	+ 11.2
Total Citrus	10,684.0	14,250.5	+ 33.2
GRAND TOTAL	**25,115.9**	**30,291.5**	**+ 20.6**
(exc. Apples)	20,689.1	25,615.8	+ 23.8

TABLE 3

U.S. Imports and Exports of Fruit Products, 1990 and 2001
(thousand metric tons)

Product	Imports 1990 (mt)	Imports 2001 (mt)	Change 90-01 (percent)	Exports 1990 (mt)	Exports 2001 (mt)	Change 90-01 (percent)
Fruit & Preparations	1,969.9	3,769.3	+ 91.3	2,483.0	3,306.2	+ 33.2
Fresh & Frozen	1,473.5	3,012.4	+104.4	2,092.7	2,831.3	+35.3
Bananas	3,270.0	4,107.4	+ 25.6	0.0	0.0	0.0
TOTAL	5,239.9	7,876.7	+50.3	2,483.0	3,306.2	+ 33.2

TABLE 4

U.S. Trade in Fresh Apples, Fresh Pears and Apple Juice, 1990 and 2001

Product	Imports 1990 (mt)	Imports 2001 (mt)	Change 90-01 (percent)	Exports 1990 (mt)	Exports 2001 (mt)	Change 90-01 (percent)
Fresh Apples	106,146	157,121	+ 48.0	379,433	692,365	+ 82.5
Fresh Pears	40,942	85,316	+108.4	108,741	167,180	+53.7
	(gallons)*	(gallons)*		(gallons)*	(gallons)*	
Apple Juice	233.7	344.3	+ 47.3	15.0	7.3	- 51.5

* million single strength equivalent

Trends in the U.S. Economy

During the 1990s, the U.S. economy enjoyed the longest peacetime expansion in history. The annual rate of growth in GNP was 2.2 percent, an exceptional performance given the size of the U.S. economy. Unemployment declined steadily to near record lows. By the year 2000, per capita income exceeded $34,000. However, the consequences for much of the food sector have been lukewarm. While sales of personal computers, SUVs, fitness club memberships and $3 cups of coffee exploded, overall retail food sales volume limped along. In most cases, retail food prices have barely kept up with inflation. However, the growing muscle of the discount and supermarket chains has meant that even those gains have not been passed back to farmers. The farmers' share of the consumer's food dollar has fallen from 30.6 cents in 1980 to 23.7 cents in 1990 and 18.7 cents in the year 2000.

In addition, the changing demographics and preferences of consumers in developed countries have been mirrored in the United States. An older population, more single person households, more single parent families, a highly mobile way of life and increasing faddishness about food are causing shifts in what different consumers want, wants for which they are rarely willing to pay extra. Consumers have long been concerned about pesticides, food additives and nutritional value. Now they want food suited to their allergies, lifestyles, social interests, etc. A recent *Wall Street Journal* report suggested that throwing a dinner party is now an ordeal because of the growing American obsession with health. Among the requests from guests it cited allergies to nuts, objections to wine, milk, garlic, unpasteurized cheese and Italian pasta (because it was grown too close to Chernobyl) and vegetarian, vegan and other voluntary dietary restrictions.

The lifestyle change that may be most relevant to apples and pears is the decline of planned mealtimes and the increased prevalence of snacking in many people's lives. Even children now have considerable discretion in what and when they will eat. Major food companies such as Kellogg, General Mills and Frito Lay have introduced hundreds of new snack products in the last decade. Some tap into diet and health concerns, but just as many cater to consumers' desires for products that are fun and sweet (and fattening). Carbonated soft drinks continue to dominate the snack beverage market. For the younger generation, the marketing incentives are often more important than the food. For example, McDonald's or Burger King have become the biggest national distributor of toys or videos featured in their promotions.

Attitudes and behavior towards food have an almost schizophrenic quality. People talk one game and act another. For example, most people know that eating fruit is good for their health. Yet, only 17.4 percent in 1994-96 met the healthy eating guidelines for fruit. For moderately active individuals, the Food Pyramid recommendation is for three servings per day. The actual number of servings in 1996 averaged 1.3. This was little changed from the level of 1.1 servings attained 20 years earlier.

U.S. Demand for Apples and Apple Products

These national and international forces have had an influence on the demand for apples and apple products in the U.S. The consumption of fresh apples has been static or declining in the last couple of decades. Per capita consumption rose from an average of 17.7 1bs in 1979-81 to 19.6 lbs in 1989-91, but fell back to 17.2 lbs in 1999-2001. Per capita consumption of apples for canning and freezing has been 5.9, 6.5 and 5.5 lbs for the same three periods, while that for apples for juice has been 11.7, 18.7 and 21.4 lbs, respectively. The growth in juice consumption has been powered almost entirely by increased imports. Domestic supplies for juice have just about kept pace with population growth.

During the last two decades, both retail prices and grower prices of fresh apples in the U.S. have declined in real terms by about 20 percent. Given the static consumption, this would imply that the demand curves for U.S. fresh apples have shifted to the left. However, particularly in the last decade, the proportion of new, higher-priced varieties reaching the market has continued to rise. This would suggest that the demand for older varieties such as Red Delicious, Golden Delicious and McIntosh has been depressed further by competition from the newer varieties. The prices of these older varieties now fluctuate in a much narrower range in response to supply shifts. In turn, the demand for many of the newer varieties is starting to become inelastic; that is, total revenue will begin to fall as volume rises. These findings are borne out by the latest Belrose, Inc. retailer survey. Retailers indicated that they plan to stock more of the Gala, Cameo, Braeburn, Pink Lady, Fuji, Jonagold, and Granny Smith in the coming year and less of the Empire, Mcintosh, Golden, Rome, and Red Delicious. So shifts in preferences between varieties should continue for some time.

Real grower prices of apples for canning, freezing and for juice have also fallen in the last two decades. The average canning price has fallen by 40 percent and the average juice price by over 50 percent between 1979-81 and 1999-2001. The biggest single influence on the canning price was the supply of domestic juice apples. The next most important influence was the supply of imported apple juice. The same factors had the biggest influence on the demand for U.S. juice apples. This suggests that both large domestic crops and large juice imports help to pull down the prices of all major categories of apples for processing.

Bringing the Lessons Home to New York State

How does New York state compare to the major apple producing states? For years, Belrose, Inc. has developed a competitiveness index for major apple producing countries based on production, infrastructure, and financial and marketing considerations. Usually, New Zealand and Chile top the international league table, well ahead of France. This year, the United States was in sixth place after Austria and Belgium. We have had many requests for some measure of competitiveness among U.S. states. The results for 2002 were presented in the May 2002 issue of the "World Apple Report." As a separate entity, Washington State would rank among the top three countries in the world, just behind New Zealand and neck and neck with second place Chile. The index scores for New York, Michigan, California and Pennsylvania were closely bunched together and would have placed them in the top 12 countries internationally. New York's biggest advantage was in stability of production and proximity to market. However, New York was below average in yield per acre and in export performance. It also faced problems with inputs such as land, water, labor, and capital availability.

Total production in New York State has been fairly stable for at least 30 years. Returns per acre have averaged $2,200 over the last three years, a level insufficient to sustain profitability. New York has been able to increase the percentage of production sold fresh in the last decade, which should have boosted returns somewhat. However, average grower prices for fresh apples have been below the U.S. average and below that of neighboring states like Pennsylvania and the New England states. There is no way to separate how much of these low returns are due to varieties being offered and how much due to marketing weaknesses. In contrast, in recent years, New York grower prices for canning apples have frequently been higher than grower prices in Pennsylvania or Michigan, which has put pressure on the remaining processors in the state.

Strategies for Improvement

From the foregoing, it is clear that just to hold its own, the New York apple industry needs to improve in a few key areas:

- It needs a higher proportion of newer varieties that can command a premium in the fresh market.
- It needs to get its average yields per acre up to competitive levels, perhaps double the present average levels.
- It needs to improve its marketing clout with major retailers.
- It needs to exploit alternative emerging markets more aggressively.
- It needs to develop new products that will expand its processing industry.

Many of the ingredients are already in place to execute these strategies. The research and extension agents in the Cornell University system can play a major role in finding new or improved varieties and in developing systems to enhance yields. Nurseries, farm chemical companies, agricultural advisers and other service providers can play a major role in improving productivity. The New York Apple Association has a good image with retailers. However, it needs more resources if it is to compete effectively against the powerful category management programs of Washington State and New Zealand in the domestic market and France and Italy in Europe. The huge urban population in New York and surrounding states offers numerous opportunities for creative direct marketing through on-farm and roadside markets, U-pick, farmers' markets and community supported agriculture networks. Creative uses of the Internet could help exploit these outlets in new and different ways.

One of the difficulties in executing any strategy is that the New York industry has so many different segments, geographical locations, and potential opportunities. Thus, it has been very difficult to develop a statewide strategy. Part of the problem may be in treating the industry as if it were homogeneous. The USDA has come up with a typology of farms that may provide a useful basis for assessing the needs and potential of different districts and of the whole state. Among what they term "Small Family Farm," there are five categories (Table 5). Among "Other Farms," they list three categories.

Nationwide, the USDA estimates that about 6 percent of farms are limited resource, 15 percent are retirement farms, and 43 percent are residential/lifestyle farms. Thus, just over one-third are farms where farming is the primary occupation. In the context of a New York apple farm, sales of $100,000 in the last three years could have been generated from about 45 acres of orchard, $250,000 from 111 acres and $500,000 from 223 acres.

The latest census data for New York apple orchards is now five years old and acreage is now almost 10 percent lower than it was then. However, the 1997 census data give us a rough measure of the distribution of New York apple orchards (Table 6).

From the above data, it would appear that most of the 76.6 percent of New York apple farms with less than 50 acres would fall into the category of limited resource, retirement, residential/lifestyle or lower-sales farms. Given the relatively low tree density, low percentage of bearing trees and low yields, most of these holdings were old or unproductive. Even if the average grower price doubled to 24 cents per pound, sales in most of these farms would be less than $100,000. If all their product was sold for processing at recent average prices of 6.5 cents per pound, their average revenue would be about half of what is shown here. The unknown factor is the asset value of these orchards. Fifteen acres or more near a prime development area could be worth more than the $150,000 used as the minimum for a limited-resource farm. However, this would not be true in areas where farming is the only option.

In contrast, the 301 farms with 50 or more acres all averaged sales of more than $100,000 even at recent depressed price levels. About half of these were small farms with higher sales, and about half were large farms. Together, they farmed 69.1 percent of New York apple acres and accounted for almost 90 percent of New York apple production. Average yields were low and the percent of trees non-bearing varied widely. However, even modest increases in average prices would dramatically increase their average revenues.

Most larger apple operations will have to depend for much of their income on sales to conventional fresh wholesale and processing markets. In either case, it will be absolutely vital to have the right varieties, to increase tree density, and to raise average quality and productivity. Research and extension agents and agriservice representatives can play a vital role in facilitating that transition. The prospects for enhanced marketing to processing channels depend heavily on the new product prowess of the major processing companies. For existing processing products, the pressures of international competition are likely to keep downward pressure on prices. Lowering unit costs will be the primary way to increase net revenues. Enhanced marketing in the fresh market wholesale channels will depend on New York's ability to deliver a year round supply of desirable varieties. About the only four varieties

TABLE 5

USDA Farm Typology

Category	Farm Sales ($1,000)	Farm Assets ($1,000)	Household Income ($1,000)	Occupation
Small Family Farms				
1. Limited-resource farms	<100	<150	<20	Varied
2. Retirement farms				Retired
3. Residential/lifestyle farms				Non-farm
4. Farming-occupation farms: lower sales	<100			Farming
5. Farming-occupation farms: higher sales	100-250			Farming
Other Farms				
6. Large family farms	250-500			Farming
7. Very large family farms	>or = 500			Farming
8. Nonfamily farms (nonfamily corporations) cooperatives or operated by hired managers)				Farming

TABLE 6

Characteristics of New York Orchards, 1999-2001

Acres harvested in 1997	Farms	Acres	Trees/ac	Trees Non-Bearing	Yield/ac	Rev/farm*
	#	#	#	%	42 lbs	$
0.1 to 0.9 acres	134	55	82	14.1	52.6	109
1.0 to 4.9 acres	355	771	97	25.3	123.9	1,356
5.0 to 14.9	254	2,150	129	16	179.6	7,663
15.0 to 24.9 acres	112	2,096	120	15.1	208.0	19,622
25.0 to 49.9 acres	130	4,501	124	14.6	324.2	56,579
50.0 to 99.9 acres	129	9,072	137	16.3	372.7	132,099
100.0 to 249.9 acres	121	18,392	132	10.8	400.2	306,607
250.0 to 499.9 acres	37	11,733	156	14.0	409.3	654,194
500.0 to 749.9 acres	8	4,992	150	26.9	430.3	1,353,213
750.0 acres or more	6	6,487	94	5.8	433.8	2,363,858
TOTAL	**1,286**	**60,250**	**133**	**14.2**	**379.9**	**89,696**

* Assuming average price of 12 cents per pound.

that New York can currently deliver are McIntosh, Empire, Red Delicious and Rome—all varieties that retailers plan to stock less of in the coming season. Even if varieties meet retailer specifications, New York must be able to wrest shelf space away from Washington, New Zealand, Chile and other suppliers. That will take a powerful, coordinated effort from the big players in the New York apple industry.

In the meantime, every segment of the New York apple industry urgently needs to explore the opportunities available in alternative markets, whether traditional direct markets such as U-pick, roadside stands or farmers' markets, or newer outlets such as Community Supported Agriculture (CSAs) and Internet marketing.

Marketing alternatives can be classified in a number of ways. (Table 7). Some of the biggest hype has been given to process-driven alternatives such as organic or biodynamic. These are, in essence, product variants, not alternatives to conventional wholesaling and processing outlets. As volume increases, more of these products must be moved through conventional channels. Direct marketing approaches such as U-Pick, roadside stands and farmers' markets are also well established. These are most suitable in areas near large urban/suburban populations and busy highways. A third marketing alternative is to serve specific demographic segments such as ethnic markets, upscale restaurants or CSA networks that want a different food experience. These offer a great opportunity for vegetable growers who can produce thousands of specialty crops and herbs. They offer less opportunities for apple and pear growers where developing a specialty variety requires a large investment per acre and many years of maturation.

TABLE 7

Marketing Alternatives, by Majotr Category

Category	How Defined	Alternatives Included
Process-Driven	Determined by how the fruit is grown, e.g. no synthetic chemical used.	MOrganic MSustainable MBio-dynamic
Direct Marketing	Farm deals face to face with consumer	MOn-farm Markets MOn-farm U-Pick MRoadside Stands MFarmers' Markets MItinerant Peddlers
Demographic Segment	Specific segments of the population are targeted	MEthnic Markets MUpscale Restaurants MLocal retailers MCommunity Supported Agriculture MTourists
Marks of Excellence	Symbols are used to show a superior product	MBrands MCertificates of Origin MLogos, Marks, etc
Marketing via Alternative Media	Indirect marketing via media	MDirect Mail MCatalog MInternet

There have also been numerous efforts to distinguish products by one or more marks of excellence. These may be proprietary (e.g. Dole) or generic (e.g. New York apples) brands, logos or marks. In Europe, there has been a large investment in geographical indications. Many producers believe that such Protected Geographical Indications (PGIs) can lead to a price premium. In addition, the Europeans have been using these as trade barriers. Various marks and labels are also being promoted as assurances to the consumer of the social desirability of production practices. Like process-driven approaches, their product must compete in the mass wholesale and processing segment. A final group of marketing alternatives relates to use of media for direct sales. Direct mail and catalog selling have long been established. Sales through the Internet are a modem variant on direct mail sales.

The only way to decide whether any of these marketing alternatives is appropriate for your business is to do a thorough analysis. Location is a key factor in some alternatives such as organic production or U-Pick marketing. For all of these alternatives, the size of the potential market and the likelihood of competition and your ability to offer a unique product are critical. The alternatives must pencil out financially. You have to know what your costs will be, what pricing strategy you will use, and what level of promotion will bring in customers but not break the bank. Many of these marketing alternatives will also require major changes in how your personnel operate (e.g. in direct marketing, you must think like a retailer, not a farmer), in your physical facilities and in working conditions. For each alternative you need to get the best information you can on each of these considerations and then objectively assess how your firm would rate on each consideration. I recommend some sort of numbering system. If your firm's total rating is below average in a particular alternative, or very low on a key factor such as market size or personnel skills, it is probably not for you. By comparing your firm's scores for different marketing alternatives, you can establish which one would have the greatest potential for you. It may well be after such an exercise you will decide that the conventional wholesaling or processing outlets are still your best alternative.

Assessing Individual Marketing Alternatives

The sample form below (Table 8) can be used to create an objective score for each marketing alternative you wish to assess. Complete a form for each alternative and then compare results. Follow these easy instructions.

1. Enter a score from 1 to 5 for each consideration.
2. Enter the frequency of each score on the last line
3. Enter the total score.

Note: The purpose of a checklist is to ensure that all key considerations are taken into account. The distribution of scores helps to highlight the areas of greatest strengths and weaknesses. The total score can be used in ranking different marketing alternatives.

Individual Marketing Alternatives Assessment

Considerations	Scoring	1	2	3	4	5
1. Location	Most favorable = 5					
2. Market Size	Largest = 5					
3. Competition	Least = 5					
4. Uniqueness of product offering	Most Unique = 5					
5. Psychic Value	Most value added = 5					
6. Pricing Strategy	Most ability to control = 5					
7. Promotion	Most resources = 5					
8. Financing	Most resources = 5					
9. Personnel	Most suitable to needs = 5					
10. Working Conditions	Lease changes needed = 5					
11. Infrastructure Needs	Least changes needed = 5					
12. Other Factors	Most positive = 5					
Frequency of scores						
	Total Score:					

Summary and Conclusions

Many factors have combined to make life difficult in the apple and pear industries. The total food system is under stress from increased supplies, static or declining demand in the developed world and economic setbacks in the most promising markets in the developing world, and the bruising retail battles that are involving every supplier. Slower market growth or increased competition in one region of the world has a ripple effect on every other region. For example, China's inroads into the Southeast Asian fresh apple market has slowed Washington State exports and brought more pressure from Washington product in the eastern seaboard. The expansion of world apple juice supplies has led to increased U.S. imports of low cost apple juice concentrate and depressed prices of all processing apples.

Each producer, each district and each region has to combat these pressures. At the same time, changing market needs are offering many new market opportunities to producers. To grasp these opportunities, producers and their organizations must be willing to change, they must do their homework on where their comparative advantages might lie, and they need courage and determination to strike out in new directions.

Somehow, somewhere, each year consumers eat about 60 million metric tons of apples (equivalent to 315 billion size 100 apples). I am convinced that if they used their ingenuity, apple growers can figure out ways to sell most of those apples at a profit.

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On-Farm Trials of the Cornell Geneva Apple Rootstocks in NY

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Ten years of on-farm trials have shown the strengths and weaknesses of the elite Geneva rootstocks. Four rootstocks have been released in the U.S. and one in New Zealand. Two more are scheduled for release in 2004. These Geneva rootstocks give growers an excellent option for dwarfing rootstock that are resistant to fire blight.

The Geneva Rootstock Breeding Program

In 1968, James Cummins and Herbert Aldwinckle initiated the Cornell University apple rootstock breeding project located at the New York State Agricultural Experiment Station in Geneva, NY, with the objective of developing rootstock genotypes with improved nursery and orchard characteristics that were better adapted to the biotic stresses of fire blight (*Erwinia amylovora*), and crown rot (*Phytophthora spp.*) so common in New York State and surrounding areas (Cummins and Aldwinckle, 1983; Johnson, et al., 2001). Progeny from planned crosses underwent rigorous greenhouse screening procedures at the small seedling stage to select for tolerance to fire blight and crown rot. Surviving genotypes were then tested for propagation characteristics in the nursery, and productivity and dwarfing in the orchards at the station. Since 1991, the elite selections from the breeding program have been tested in second level field trials at various locations around the world. In this paper, we report on the performance of CG rootstocks at a series of on-farm grower trials in the three apple growing regions of New York where we assessed productivity, precocity and field tolerance to abiotic and biotic stresses.

Current Status of the Program

In 1998, the Cornell University rootstock breeding program was converted to a joint breeding program with the United States Department of Agriculture (USDA) with a USDA breeder as the lead scientist (William Johnson from 1998-2000 , and currently Gennaro Fazio) and with several Cornell scientists as cooperators.

Currently in the program there are a large number of selections in various stages of testing for both nursery characteristics and orchard performance (Johnson, et. al. 2001). New crosses have been made in the last three years and Gennaro Fazio has begun new genetic studies aimed at identifying genes involved in dwarfing, precocity, and disease resistance.

From the advanced selections, five rootstocks have been released for commercial propagation since 1992 (Geneva™ 65, Geneva™ 30, Geneva™ 16, Geneva™11 and Geneva™202). These commercially available rootstocks are designated as "G" rootstocks in this paper while unreleased numbered selections are designated as 'CG' stocks. Three are being commercialized in the United States and one in New Zealand. Several nurseries around the world have been licensed to propagate the CG stocks but progress in other countries has been more limited.

The New York On-Farm Trials

From 1991 through 1999, a series of replicated rootstock trials were planted on growers' farms in the three apple growing regions of New York State (Lake Ontario, Lake Champlain and Hudson River regions) (Table 1). Each trial had from 1-20 CG rootstock clones with appropriate Malling rootstock controls. Each experiment had 4-8 replications. The plots were managed by the growers with decisions on pruning, fertilization, ground cover management and chemical fruit thinning made by the growers. Annual yield, tree size, and survival data were collected by the project leaders.

CG Stock Smaller than M.9: In the 1991 trials with Empire as the scion, G.65 was included at five of the locations. In all trials, it had lower tree vigor than M.9 or Mark rootstocks (Table 2). Precocity has been similar to M.9, but yield efficiency has been less than M.9. Fruit size has also been smaller than M.9. None of the trees in any of the trials died because of fire blight or *Phytophthora*. In the trial at Gunison's farm in the Champlain Region of New York State, G.65 survived a severe winter cold event in January 1994 where temperatures dropped to –35°C. Trees on G.65 showed very little bud or foliar damage the next spring, but trees on several other rootstocks were damaged severely (Table 3).

TABLE 1

On-farm replicated rootstock trials planted in New York state.

Farm Name	Region of New York	Year Planted	Variety	Rootstocks in Trial
Wafler	Lake Ontario Region	1991	Empire	G.65, M.9, Mark, M.26
Furber	Lake Ontario Region	1991	Empire	G.65, M.9, M.9EMLA, Mark, M.26
Bittner	Lake Ontario Region	1991	Empire	G.65, M.9, Mark, M.26, B.9
DeMarree	Lake Ontario Region	1991	Empire	G.30, CG.3041, CG.4202, CG.4013, Mark, M.9/MM.106, M.7
Ophardt	Lake Ontario Region	1991	Empire	G.30, CG.3041, CG.4202, CG.4013, CG.8189, Mark, M.9/MM.106, M.7
Watt	Lake Ontario Region	1991	Empire	CG.6210, CG.7707, ~~CG.222~~, ~~CG.103~~, M.26, M.7, MM.106
Debadts	Lake Ontario Region	1991	Empire	G.30, CG.4003, CG.4013, CG.4202, CG.4088, CG.6210, CG.6253, CG.7707, CG.8189, ~~CG.222~~, ~~CG.103~~, ~~CG. 521~~, ~~CG.602~~, ~~CG.934~~, M.7a, MM.106, MM.111
Trapani	Hudson River Valley	1991	Empire	G.65, G.30, CG.3041, CG.4013, CG.4202, CG.4088, CG.5935, CG.6210, CG.7707, ~~CG.222~~, ~~CG.103~~, M.9, B.9, M.9/MM.111, M.26, M.7
Gunision	Lake Champlain Region	1991	Empire	G.65, G.30, CG.3041, CG.4013, CG.4202, CG.4088, CG.5935, CG.6210, CG.7707, ~~CG.222~~, ~~CG.103~~, M.9, B.9, M.9/MM.111, M.26, M.7
Tantillo	Hudson River Valley	1991	Gala	CG.4013, CG.4202, CG.6239, CG.7707, CG.7760, CG.9778, ~~CG.001~~, ~~CG.004~~, ~~CG.103~~, ~~CG.934~~, ~~CG.071~~, ~~CG.068~~, M.7, MM.106, MM.111
Forrence	Lake Champlain Region	1993	Liberty	G.30, CG.4013, CG.4202, CG.6210, CG.7707, ~~CG.222~~, ~~CG.934~~, M.7, MM.106, MM.111
Pettit	Lake Ontario Region	1995	Ace Delicious	CG.6253, CG.6239, CG.7707, CG.8189, ~~CG.008~~, ~~CG.005~~, ~~CG.93~~, ~~CG.229~~, ~~CG.229~~, ~~CG.96~~, ~~CG.756~~, ~~CG.602~~, ~~CG.521~~, ~~CG.934~~, MM.106, MM.111
Pettit	Lake Ontario Region	1995	Empire	CG.3902, CG.4809, CG.4003, CG.4202, CG.4214, CG.4013, CG.4814, CG.5087, CG.5156, CG.6143, CG.7707, CG.7760, ~~CG.134~~, ~~CG.103~~, M.7, M.106
Wilbert	Lake Ontario Region	1996	Delicious	CG.4013, CG.4202, CG.4814, CG.4214, CG.5701, G.30, CG.6253, CG.7707, CG.8189, CG.9778, ~~CG.228~~, ~~CG.103~~, ~~CG.521~~, B.9, M.26, M.7a, M.7EMLA, MM.111, Bemali
Wilbert	Lake Ontario Region	1996	Gala	CG.3041, CG.6210, CG.6143, ~~CG.222~~, M.9
Wilbert	Lake Ontario Region	1996	Empire	CG.3041, CG.4247, G.11, CG.6143, ~~CG.5179~~, ~~CG.222~~, M.9
Smith	Lake Ontario Region	1997	Gala	CG.3041, G.16, CG.4003, CG.4202, CG.4214, CG.4247, G.11, G.30, CG.5757, CG.6210, CG.6723, CG.6737, CG.7760, CG.7511, ~~CG.005~~, ~~CG.103~~, ~~CG.134~~, ~~CG.060~~, ~~CG.602~~, ~~CG.008~~, M.9EMLA, M.26EMLA, MM.111, Marubakaido, P.14
Burnap	Lake Ontario Region	1997	Gala	CG.3041, CG.4003, G.11, CG.4202, G.30, ~~CG.5179~~, M.9, M.26
Everett	Lake Champlain Region	1998	Gala	G.16, M.9
Dembrowski	Hudson River Region	1998	Gala	G.16, M.9
Dembrowski	Hudson River Region	1998	Jonagold	CG.3041, G.16, M.9
Loomis	Lake Ontario Region	1998	Jonagold	CG.3041, G.16, M.9
Lamont	Lake Ontario Region	1998	Jonagold	G.16, M.9
Peters	Lake Ontario Region	1999	McIntosh	CG.3041, CG.4013, CG4202, CG5935, ~~CG.5179~~, CG.6210, CG.6814, CG.7707, G.16, G.30, M.9, M.26, M.7, Supporter 1, Supporter 2, Supporter 3, Supporter 4

*Clones with a strike-through have been discarded from the program.

TABLE 2

Ten year performance of Empire apple on elite CG rootstocks in several on-farm trials in New York State.

Rootstock*	Trunk Cross Sectional Area Increase (% of M.9)	Cumulative Yield (% of M.9)	Cumulative Yield Efficiency (% of M.9)	Average Fruit Size (% of M.9)
G.65	58	60	111	94
CG.3041	99	119	123	101
M.9	100	100	100	100
CG.5935	138	171	122	97
M.26	150	116	83	101
G.202	153	143	101	103
CG.6210	191	196	104	99
G.30	191	181	101	98
M.7	276	130	46	103
LSD pA0.05	48	38	25	5

*Rootstocks ranked by final trunk cross sectional area.

CG Stocks Similar to M.9.: Among CG rootstocks similar in size to M.9, two stocks (G.16 and CG.3041) have performed as good or better than M.9. G.16 was not tested until 1998 which means our results are still preliminary. Tree growth and vigor of G.16 has been similar to the vigorous clones of M.9 (Table 4). Precocity has been similar to M.9 and cumulative yield efficiency has been slightly better than M.9. It has been highly resistant to natural infection of fire blight and *Phytophthora*. In a trial planted in 1998 which received a massive natural infection of fire blight during bloom of 2000, none of the G.16 trees died while

TABLE 3

Winter damage of three-year-old Empire apple on elite CG rootstocks in the Champlain region of New York State (Gunison plot).

Rootstock*	Winter Damage Rating** (1-4scale)
CG.077	1.6 b***
G.65	1.4 bc
CG.3041	1.0 c
M.9	1.3 bc
CG.5935	1.2 bc
M.26	1.3 bc
G.202	1.2 bc
CG.4013	2.1 a
CG.6210	1.3 bc
G.30	1.3 bc
M.7	1.1 bc
CG.103	2.1 a
CG.7707	1.1 c

*Rootstocks ranked by final trunk cross sectional area.
*Winter Damage Ratings taken on June 3, 1994 following a winter cold event in January 1995 of –35°F. Rating scale: 1=no damage, 2=Lateral bud death and shoot tip die back, 3=Dead branches, 4=Dead tree.
***Mean separation by Duncan's multiple range test pA0.05.

TABLE 4

Four-year performance of Jonagold on G.16 and CG.3041 rootstocks in the Lake Ontario region of New York State (Loomis plot).

Rootstock*	Trunk Cross Sectional Area 2001 (% of M.9)	Cumulative Yield (% of M.9)	Cumulative Yield Efficiency (% of M.9)	Average Fruit Size (% of M.9)
M.9EMLA	100	100	100	100
G.16	103	133	122	89
CG.3041	111	166	142	98
LSD pA0.05	15	33	33	10

* Rootstocks ranked by trunk cross-sectional area.

most of the M.9 and M.26 trees died (Table 5).

CG.3041 was tested in 4 of the 1991 trials and in each case tree vigor was similar to M.9 EMLA (Table 2). Precocity was also similar to M.9. Cumulative yield efficiency after 10 years was numerically higher, but not statistically different than M.9. In a 1998 trial, CG.3041 has had significantly greater yield efficiency than M.9, but not greater than G.16 (Table 4). Fruit size has been similar to M.9 in both the 1991 trials and the 1998 trial and appeared to be larger than G.16 in the 1998 trial. We observed that trees on CG.3041 have wide crotch angles of the major scaffold branches. In a plot in the Champlain Region, CG.3041 showed no signs of winter damage during the 1994 test winter (Table 3). It has also been highly resistant to fire blight (Table 5 and Table 6) and *Phytophthora* in these field trials. It also has shown some tolerance to apple replant disease. A comparison of performance of stocks in an infected soil site and an uninfected soil site showed CG.3041 had similar growth in both sites while M.26 and M.9 showed significantly less growth in the infected site (Table 7). In one trial with Gala as the scion, a few trees (10 percent) broke at the graft union following a severe wind storm.

CG Stocks Similar to M.26: Among CG stocks similar in size to M.26, three stocks (G.5935, G.11 and G.202) have performed better than M.26. Tree vigor of CG.5935 and G.202 has been slightly greater than M.26 (Table 2). Precocity, yield efficiency and productivity of CG.5935 have been exceptional for a semidwarfing stock with similar efficiency as CG.3041 and M.9. Fruit size has been as good as M.9 or M.26 and the tree has wide crotch angles. It had no winter damage during the 1994 test winter (Table 3). It also has shown some tolerance to apple replant disease with similar growth in an infected site as an uninfected site (Table 7). There were no tree losses to fire blight or *Phytophthora* in these field trials.

G.202 has also been similar in tree vigor to M.26 (Table 2). It has had high precocity and higher yield efficiency than M.26. Its yield efficiency has been similar to M.9 but not quite as high as CG.3041 or CG.5935. It has had fruit size similar to M.26, and also high resistance to fire blight (Table 5 and Table 6) and *Phytophthora* in these field trials. It also has shown very high tolerance to apple replant disease with similar growth in an infected site as an uninfected site (Table 7).

CG Stock Similar to M.7: Among semi-dwarfing CG root-stocks, G.30 and CG.6210 have performed better than M.7. With both CG stocks, tree growth and vigor through year 7 was similar to M.7, but after year 7, growth has been less than M.7 resulting in a final tree size between M.26 and M.7 (Table 2). Precocity has been similar to M.26 and much better than M.7. Cumulative yield efficiency has been 3-5 times better than M.7 and significantly better than M.26. Branch angles have been wider than M.7. Both G.30 and CG.6210 have high tolerance to apple replant disease with similar growth in an infected site as an uninfected site (Table 7). The test winter of 1994 (-35°F) caused very little bud damage on G.30 or CG.6210. Both stocks have been highly resistant to natural infection of fire blight (Table 5 and Table 6) and *Phytophthora* in

TABLE 5

Rootstock infection with fire blight of three-year-old Gala trees following a massive natural infection in 2000 at the Smith plot (from Norelli et al., 2003).

Rootstock	% of Trees with Rootstock fire blight
M.9	36
M.26	93
M.7	31
MM.106	43
MM.111	15
CG.3041	0
G.16	0
G.11	23
G.202	7
CG.6210	7
G.30	4

TABLE 6

Survival of five-year-old Gala trees on elite CG rootstocks after natural infection by fire blight in 2000 (Burnap plot).

Rootstock	Tree lost due to fire blight (%)
M.9	93
M.26	75
CG.3041	13
G.11	19
CG.4202	14
G.30	15

TABLE 7

Relative tolerance of CG rootstocks to apple replant disease (Gunison and Trapani plots).

Rootstock	Tree size from infected site as a percentage of tree size from uninfected site.
CG.3041	96
M.9	92
CG.5935	97
M.26	70
G.202	121
CG.6210	108
G.30	105
M.7	101

these field trials. With G.30, a few trees (10 percent) in these trials snapped off at the graft union during high winds. With CG.6210, no trees snapped off, but a few trees leaned over following high winds with heavy rain.

Conclusions from New York Trials

The results of these on-farm replicated trials have helped identify superior CG rootstock genotypes and also helped identify the weaknesses of each elite stock. The results have also helped eliminate other poor performing stocks. Concurrently, with the New York on-farm trials, other groups have conducted trials with the CG rootstocks such as the U.S. national rootstock testing group, NC-140 (Robinson et. al., 2003), the CTIFL national trials in France (Masseron and Simard, 2002) and Hort Research in New Zealand (personal communication from Stuart Tustin). Since 1992, five CG clones have been named and released for commercialization and two more will be released in 2004.

Geneva™ 65 which is a cross of M.27 X Beauty Crab was released in 1992. Although G.65 has proven to be highly resistant to infection of fire blight and *Phytophthora* and tolerant to replant disease (Isutsa and Merwin, 2000). t has proven to be difficult to propagate in the stoolbed and has not found significant commercial acceptance. In addition, the results of our trials have shown that it is more dwarfing than M.9 with smaller fruit size. Although many growers are looking for a rootstock that is more dwarfing than M.9, G.65 may be too dwarfing in most situations except at very high planting densities with large fruited varieties such as Jonagold and Mutsu. Under these conditions, G.65 may have significant advantages to M.27 and may find a market niche. Presently there is very limited commercial production of about 5000 liners per year from only two licensed nurseries.

Geneva™30 which is a cross of Robusta 5 X M.9 was released in 1994. In our trials and in commercial plantings, G.30 has proven to be a very productive semi-dwarf rootstock with large fruit size that is highly resistant to fire blight. The inoculation of grafted trees in a 1997 orchard/fire blight trial at Geneva showed that G.30 is essentially immune to fire blight (Norelli et al., 2002). Tree size has been between M.26 and M.7. In the early years, tree growth and vigor are very similar to M.7. But the heavy crops on G.30 starting in year 3 limit tree growth and vigor in later years so that, by year 10, it is usually significantly smaller than M.7 and often closer to the size of M.26. Cumulative yield efficiency has been 3-5 times better than M.7 and is very similar to M.9. Branch angles have been wider than M.7. It is also very winter hardy having survived the test winter of 1994 in NY (-35°F). It also has been shown to be very tolerant of replant disease in New York (Isutsa and Merwin, 2000) and to have wide climate and soil adaptability (Robinson et al., 2003).

The superlative orchard performance has been countered by two significant problems with G.30. First, it produces numerous side shoots (spines) on each shoot in the propagation bed. This requires manual trimming of these shoots either before or after harvest from the stoolbed. The removal of the lateral shoots on the liner also removes essentially all of the lateral buds so that new growth the next year in the nursery row must depend on the development of adventitious buds. This is a slow process which allows 10-30 percent of the plants to dry out and die before they begin to grow. A solution to this problem is to remove only the side shoots on the lower 25 cm of the liner leaving 5-10 cm at the top of the liner untrimmed with live buds for next year.

The second problem with G.30 is that it has a relatively weak graft union with Gala and possibly other similarly brittle varieties. Work by Johnson and Robinson (unpublished) has shown that the graft union of Gala and G.30 is more brittle than M.26 and the union of Empire and G.30 is more brittle than M.7. This means that although G.30 is a semi-dwarf tree, it will require a multi-wire trellis to support the tree. Despite its problems G.30 may be useful in the apple industry due to its high productivity and wide soil and climate adaptability. It should be used with moderate densities of 400-1,000 trees/acre, but it will require tree support in all situations.

Geneva™16 which is a 1981 cross of Ottawa 3 X *Malus floribunda* was released in 1998. Our trials with G.16 are too young for firm conclusions. Our data show it to be a fully dwarfing rootstock with tree growth and vigor similar to vigorous clones of M.9 (i.e. Nic29 or Pajam2). It is essentially immune to fire blight. In the 1997 inoculated orchard fire blight trial at Geneva, none of the G.16 trees died while most of the M.9 and M.26 trees died (Norelli, et al. 2002). In 2000 a natural infection occurred in one of the on-farm plots which resulted in 75-95 percent tree death of M.9 and M.26, but we didn't lose a tree of G.16. It has excellent performance in the stoolbed and produces a large tree in the nursery. Tree growth in the first 2 years in the orchard is vigorous, but with the onset of cropping, tree vigor is moderated giving a tree similar in size to M.9. G.16 appears to have wide soil adaptability and some tolerance to replant disease (unpublished data). However, we do not yet know if it is cold hardy. Its greatest known deficiency it that it is sensitive to one or more latent viruses in scion wood. Infected scion wood results in death of the trees in the nursery or the first year in the orchard. This requires absolute use of virus free scion wood.

G.16 is still relatively new and untested. We know little about its winter hardiness or tolerance to replant disease. It has survived since 1998 in northern New York, but we have not had a severe test winter since then. We have limited observations that indicate it may have good tolerance to replant disease, but more rigorous tests are needed to confirm that. We have not yet measured its graft union strength, but it likely is no different than M.9 in this regard. Despite the known limitations of G.16 and its unknown characteristics, it is currently one of the best alternatives to M.9 in high fire blight areas. It should be planted at high densities of 600-2,400 trees/acre. Several nurseries produce G.16 with a current production of about 100,000 liners.

Geneva ™ 11 which is a 1978 cross of Malling 26 X Robusta 5 was released in 1999. Our trials with G.11 are too young for firm conclusions. Our data show it to be similar in size and yield efficiency to M.26 (Robinson et al., 2003). It has fire blight tolerance similar to M.7 (Norelli, et al. 2002) and good resistance to *Phytophthora* root rot, but it is not resistant to woolly apple aphids or apple replant disease (Isutsa and Merwin, 2000). G.11 has good layerbed and nursery characteristics. It may prove to be an excellent replacement for M.26. Presently G.11 is available only in North America and will be sold commercially for the first time in 2003 on a limited basis.

Geneva™202 which is a 1975 cross of Malling 27 X Robusta 5 was released in 2002 in New Zealand. It is not yet released in the U.S. Our data show G.202 produces a tree slightly larger than M.26. Like G.30 and G.16, G.202 is essentially immune to fire blight (Norelli, et al. 2002). In addition, it has good resistance to *Phytophthora*, apple replant disease and to woolly apple aphid which is an important rootstock pest in many climates. It performs very well in the stoolbed and produces good quality nursery trees. It has had higher yield efficiency than M.26, but it has not been as productive as CG.5935. In New Zealand, it has been more productive than M.26 and is one of the best stocks available (Stuart Tustin, personal communication). It appears that G.202 will be a useful alternative to M.9 and M.26 in climates that have problems with Woolly apple aphid. Presently it is only available in New Zealand, but will be available in the U.S. in 2004.

CG.3041 which is a 1975 cross of Malling 27 X Robusta 5 is scheduled to be released in December 2004. Our data show that CG.3041 is the most productive M.9 size rootstock in our trials. It also has excellent fruit size and induces wide crotch angles. It is highly resistant to fire blight and *Phytophthora*. In the 1997 orchard fire blight trial at Geneva, there were no trees lost with CG.3041 (Norelli, et al. 2002). In a severe natural infection in 2000 with one of our on-farm plots, 75-95 percent of trees M.9 and M.26 died but none of the trees on CG.3041 died. Its precocity and productivity have been exceptional surpassing M.9. It has survived a winter cold event of –35 °F in 1994. We believe it is very winter hardy. It is similar in size and yield efficiency to G.16 and M.9; however, it does not have the virus sensitivity of G.16. We have not yet tested its graft union strength, but we judge it to be similar to M.9. In one trial with Gala, a few trees (10 percent) broke at the graft union during a high wind event. It has not yet been released for commercial propagation. However, Cornell University has indicated it plans to release CG.3041 in Dec. 2004. At the moment , it appears that CG.3041 will be a possible replacement for M.9.

CG.5935 which is a 1976 cross of Ottawa 3 X Robusta 5 is scheduled to be released in December 2004. Our data show that CG.5935 slightly larger than M.26 size. CG.5935 is the most precocious and productive semidwarf CG rootstock. It has similar efficiency to M.9 along with excellent fruit size and wide crotch angles. In addition, it showed no symptoms of winter damage during the 1994 test winter. It is highly resistant to fire blight and *Phytophthora*, but its resistance to woolly apple aphid is unknown. It has good propagability in the stoolbed and produces a large tree in the nursery. Cornell University has indicated that it plans to release it in December 2004. It appears that CG.5935 will be a possible replacement for M.26 when released. It has similar efficiency to M.9 along with excellent fruit size and wide crotch angles. It is highly resistant to fire blight (Norelli, et al., 2002) and *Phytophthora* and appears to have some tolerance of apple replant disease. It appears to be very winter hardy, but its resistance to woolly apple aphid is unknown. It appears that CG.5935 will be a possible replacement for M.26 when released.

References

Cummins, J.N. and Aldwinckle, H.S. 1983. Breeding apple rootstocks, p294-394. In J. Janick (ed.) *Plant Breeding Reviews*. Westport CT, USA, AVI Publishing.

Isutsa, D.K. and Merwin, I.A. 2000. *Malus* Germplasm varies in resistance or tolerance to apple replant disease in a mixture of New York orchard soils. *HortScience* 35:262-268.

Johnson W.C., Aldwinckle, H.S., Cummins, J.N., Forsline, P.L., Holleran, H.T., Norelli, J.J. and Robinson, T.L. 2001. The USDA-ARS/Cornell University apple rootstock breeding and evaluation program. *Acta Hort*. 557:35-40.

Masseron, A. and Simard, M.H. 2002. Les porte-greffe du pommier: 20 années d'études en France. 2^{e} partie. *Infos-Ctifl no. 175*.

Norelli, J.L., Holleran, H.T., Johnson, W.C., Robinson, T.L., and Aldwinckle, H.S. 2002. Resistance of Geneva and other apple rootstocks to *Erwinia amylovora*. *Plant Disease*. (in press).

Robinson, T., Anderson, L., Azarenko, A., Barritt, B., Brown, G., Cline, J., Crassweller, R., Domoto, P., Embree, C., Fennell, A., Ferree, D., Garcia, E., Gaus, A., Greene, G., Hampson, C., Hirst, P., Hoover, E., Johnson, S., Kushad, M., Marini, R., Moran, R., Mullins, C., Parker, M., Perry, R., Privé, J.P., Rom, C., Roper, T., Schupp, J. and Warmund, M. 2003. Performance of Cornell-Geneva Rootstocks in the Multi Location NC-140 Rootstock Trials Across North America. *Acta Hort*. (in press).

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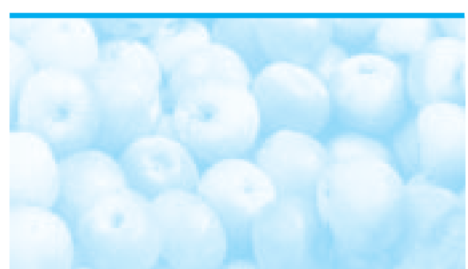

Summer Pruning: The Good, The Bad and the Ugly

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Summer pruning can have detrimental effects on fruit size and return bloom especially when trees are carrying heavy crop loads. However, during dry years, summer pruning may compensate for carbohydrate reductions by improving the water status of the tree.

Color and size are the two most important criteria in the market value of apples. To obtain good red fruit color, fruit must be exposed to a significant amount of direct sunlight. As canopies become denser during the season, summer pruning has become a routine practice in modern apple orchard management to improve light penetration to the fruit and control tree size. This is especially important for red varieties such as McIntosh grown in New York where the light intensity in the summer is not always ideal for color development. Removing shoots from the outer canopy of dense trees in August increases light penetration into the canopy and increases fruit color. However, summer pruning reportedly reduces final fruit size. Why would this occur?

The removal of exterior shoots reduces the canopy size and that might reduce the amount of sunlight the tree captures to provide the energy to produce carbohydrates by photosynthesis. We have also found that the interior spur leaves that are re-exposed after summer pruning are not as efficient at photosynthesizing as the healthy and well-exposed leaves of exterior shoots removed by pruning. These leaves do not recover their photosynthetic ability with time. Problems with reduced fruit size are likely due to the combination of reduced sunlight capture and reduced photosynthetic efficiency leading to reduced carbohydrate supply to support fruit growth, especially if there is too heavy a demand for carbohydrates for fruit growth. We propose that it is an imbalanced carbohydrate supply and demand that leads to reduced fruit size.

This imbalance has already been shown to be the reason for reduced fruit size caused by European Red Mite damage in apple trees (Lakso, et al., 1995). Furthermore, a shortage of carbohydrates might not only affect fruit growth, but also the growth of other parts of the tree, such as the root system, and possibly flower bud development. Research with summer pruning on small trees indicated that root growth was markedly affected. Problems with root development and return bloom may then carry over into following years as well.

These effects are dependent, of course, on how severely the trees are pruned. Defining summer pruning is not easy, as it can vary in style and severity. Several preliminary observations and measurements on commercial levels of summer pruning have indicated that 25-30 percent of the tree's leaf area is commonly removed. Growers may remove twice the amount of leaves on varieties with a higher demand for color such as McIntosh.

There may be other advantages of summer pruning beyond fruit color and tree size control. Removing leaves by summer pruning can be expected to reduce total canopy water loss (transpiration), and consequently improve tree water status. In Washington State, heavy summer pruning has been

Photo 1. Clear "balloon" chambers used to control and monitor air flowing by apple trees help researchers measure the trees' photosynthesis and transpiration (water loss).

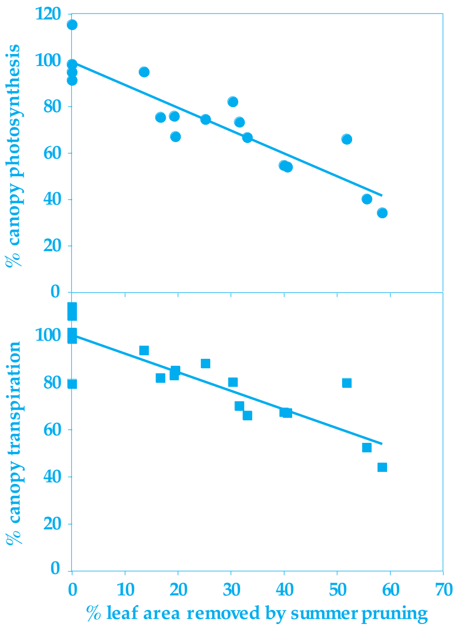

Figure 1. Effects of summer pruning on canopy photosynthesis and transpiration rate

used to help pear and peach orchards survive in severe drought seasons. Therefore, in dry years in New York, summer pruning might help relieve drought-induced reductions in fruit growth.

The effects of summer pruning might be more complex than we previously thought. To document the interactions of summer pruning, fruit quality, and tree productivity, we conducted research over several years on the intensity of summer pruning on canopy leaf area, canopy photosynthesis and transpiration, fruit growth and quality, return bloom, and new root production.

Methods

We summer pruned 20-year-old slender-spindle 'Empire' apple trees on M.9 in early August with various intensities. Vigorous exterior extension shoots from the upper and outer parts of the canopy were removed to allow improved light penetration. Relatively few cuts were made into older wood. Pruning intensity varied by varying the percentage of extension shoots removed (see Photo 2 for visual appearance of pruning intensity).To quantify the severity of summer pruning, we measured the total leaf area removed by summer pruning to obtain the percentage of leaf area removal.

Whole canopy photosynthesis and transpiration were measured on sunny days before and after summer pruning by enclosing each tree in a clear Mylar canopy balloon chamber with air passing through. We recorded the changes in carbon dioxide and humidity in the air in the balloon (see Photo 1). Selected fruits within each tree were monitored for growth rates before and after summer pruning. At harvest, total fruit number and weight per tree were recorded, and fruits quality assessed. The number and percentage of flowering spurs were counted the following spring to estimate return bloom.

Root growth before and after summer pruning was monitored with a minirhizotron-video recording system. This device, a miniature camera slid through clear plastic tubes installed in the root zone under the trees, periodically examined and recorded root growth. Root production was expressed as the number of new fine roots appearing over time. Since individual roots could be followed over the season, the functional lifespan of each active fine root could be estimated.

Results and Discussion

Canopy Photosynthesis, Fruit Growth and Return Bloom: There were clear reductions in canopy photosynthesis rates approximately proportional to the severity of summer pruning as expressed as percentage leaf area removal (Fig. 1). There was a similar reduction in canopy transpiration (i.e. water loss). We estimate that the intensity of summer pruning in commercial orchards is equivalent to the moderate to severe pruning in this study. This means that commercial growers remove up to about 50 percent of the leaf area during summer pruning resulting in a 50 percent reduction in canopy photosynthesis, and 40 percent reduction in canopy transpiration. Interestingly, the 50 percent reduction is about the same effect caused by severe bronzing of leaves in August on trees exposed to over 2000 cumulative European Red Mite days, which is four times the IPM threshold, and clearly unacceptable!

Decreased canopy photosynthesis after summer pruning may cause a shortage of carbohydrate supply for fruit growth and especially in trees with high crop loads. Both fruit growth and return bloom were affected by summer pruning (Fig. 2). The more severe the summer pruning, the more fruit size was affected in light cropped trees. Even light summer pruning affected fruit size in trees with heavy crops (Fig. 2, top). The effect on return bloom the year following summer pruning was similar to fruit growth patterns but was affected

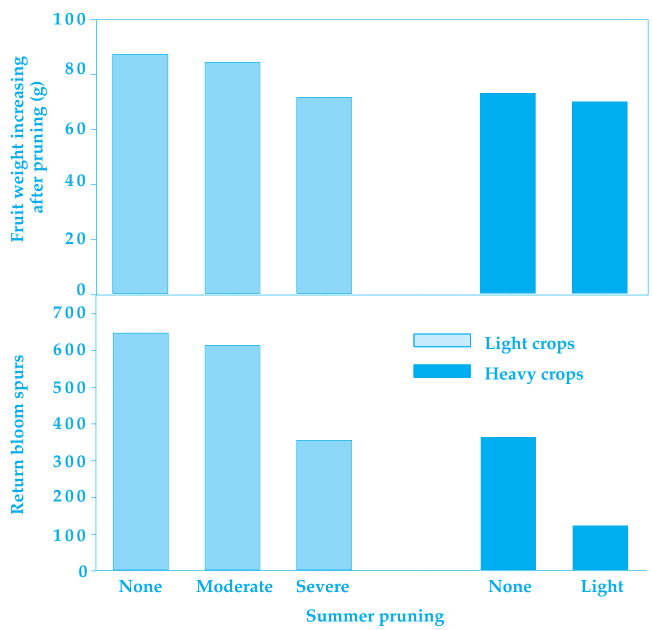

Figure 2. Interaction of summer pruning intensity and cropping level on fruit weight and return bloom in Empire apples.

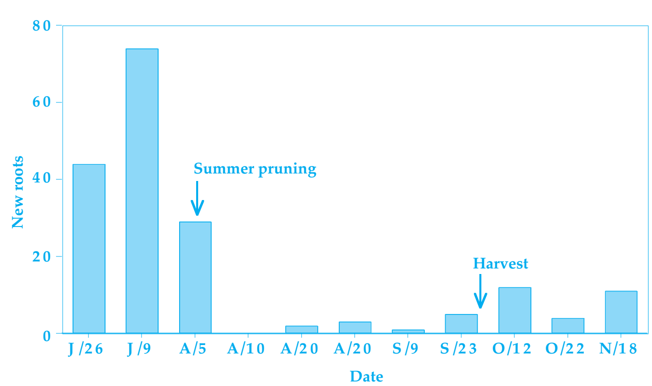

Figure 3. New root production in relation to the time of summer pruning and harvest in Empire apple trees. The number of new roots was recorded from 27 minirhizotron tubes installed around nine trees.



Photo 2. Light (left), moderate (middle), and severe (right) summer pruning used in this study to remove various numbers of extension shoots from the trees in early August.

more strongly (Fig.2, bottom). In heavily cropped trees, a light summer pruning reduced fruit size somewhat and very strongly reduced return bloom. This suggests that it is the carbohydrate supply vs demand balance that is important in fruit sizing and return bloom, not just the intensity of summer pruning or the crop load alone.

Canopy Water Loss and Water Status: The reduced canopy transpiration rate indicates that less water was lost through the leaves after summer pruning. In a follow-up study, we found the tree water status for fruit expansion, expressed in mid-day stem water potential, improved after summer pruning. Therefore, for overall fruit growth, improved tree water status might compensate for the shortage of carbohydrate supply in drought years.

Fruit Quality Effects: Internal fruit quality as expressed as total sugar content, starch levels, firmness, and internal breakdown after cold storage was not markedly affected by summer pruning or the initial fruit set. Nor was the percentage of acceptable red skin surface of the fruit. Although one of the major objectives of summer pruning is to improve fruit color development, it has been reported that this may be true only on fruit in a dense canopy. We harvested a high percentage of well-colored fruit in both years regardless of the pruning intensities the trees received. This might be due to the well trained and relatively open canopy of the trees used in this study that allowed sufficient light to reach a large proportion of the fruit inside the canopy.

Root Growth: Our root growth observations in 1999 and 2000 showed similar patterns of new apple root production (Fig. 3). In both years, the peak of new root production was completed by early August before summer pruning. Our treatments apparently did not affect root production in the current year. Even though a small growth peak was recorded after harvest in 1999, the amount of root production was not related to the intensity of summer pruning. New roots remained active for only about 2 to 4 weeks. There were indications of possible interactions between root lifespan and pruning and crop load, but that needs more research.

Summary

This study suggests that summer pruning can cause significant losses in canopy photosynthetic activity which results in a potential shortage of carbohydrate supply for final fruit sizing. When the crop load was high or trees were severely summer pruned, an imbalance between carbohydrate supply and demand occurred. Consequently, fruit growth and flower bud development was retarded. Flower bud development the following year was more severely affected than fruit growth. Production of new roots was not affected since most root growth occurred earlier in the season prior to summer pruning. The reduction in canopy transpiration after summer pruning, however, might alleviate the impact of carbohydrate imbalance by improving tree water status. A possible carry over effect of summer pruning and crop loads might potentially affect tree productivity in the long term.

Literature Cited

Lakso, A.N., A.H.D. Francisconi, J. Nyrop, and S.S. Denning. 1995. Heavy crop loads increase apple tree sensitivity to European red mites. New York Fruit Quarterly 3(1):6-8.

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