NEW YORK
FRUIT QUARTERLY

Editorial

A question I have been hearing recently, and often, is whether or not public Cooperative Extension Fruit programs are still needed in today's world. After all, there are crop consultants specializing in fruit production who have more timely and relevant information specific to the farms, there is the Internet with information and discussion forums online that can answer just about any question that comes up, we have chemical salesmen, equipment dealers, fruit storage operators, packers and shippers, along with a bevy of outstanding support organizations such as the NY Apple Association, the NY Horticultural Society, and the NY Farm Bureau that we already pay for. In our counties and towns, we are supported by our local legislators who understand the importance of our industry. And all the information and support provided is not only useful but essential for our businesses. With increasing pressure to find more funds and increasing costs, can't we do without Cooperative Extension?

I may be biased but my answer to that question is a resounding NO. Very few have a complete picture of what Cooperative Extension does. Most visibly, CCE in the counties provides a direct link to the University and the latest and best information. And that information is unbiased. We do not have a product to sell or promote. Much of our research and information is designed to answer questions that cannot be answered easily by private industry. Some of it provides a reality check for existing information. Sometimes CCE is just a shoulder to cry on or a sounding board for grower innovations. We often provide encouragement for growers to try something new. And frequently, we are the catalyst for change for the better.

Currently, beneficial extension and research efforts cover a wide array of areas that benefits the fruit industry. These include pest control, planting systems, new products, production techniques and economics, labor issues, formation and guidance of organizations, equipment and genetic engineering, food preparation techniques for our products, starting a business, farm management and storage issues, just to name a few.

Our organization is not perfect. We work within financial and time constraints like everyone else. Sometimes we don't know the answer, sometimes the answer we have is not correct within a certain context and in today's charge-ahead world we are not as nimble as people would like. Perhaps we do need to be more focused and not try to be everything for everyone as we have in the past.

Those who want Cooperative Extension to remain a consulting service are missing the point. Cooperative Extension is an idea-generating organization, a testing laboratory, a cheerleader for adoption of new and different ideas and opinions. Many of the practices you see around you today are ones originally researched and promoted by CCE. A few examples - ones that growers use every day -include the development of the principles and techniques for reliable pest scouting, high density planting systems, and all the new materials for pest control and growth regulators for tree and crop control. There is always something new that needs to be examined, tried, proven and adopted.

Perhaps if our industry was wildly profitable we wouldn't need this system. But when improving the efficiency of production remains the only way to continue to remain profitable, I believe we need it even more than ever.

Many of you know by now that I will be moving to the Hudson Valley to assume the position formerly held by Dr. Jim Schupp at the Hudson Valley Laboratory in pomology. I will now be working with the Hudson Valley Team, Dave Rosenberger, Peter Jentsch, Mike Fargione, Kevin Iungerman and Steve McKay to research ways to improve the efficiency of fruit production for the entire fruit industry in New York. I will have statewide responsibility so I hope to keep in close contact with my many friends in Western NY. I couldn't turn down the opportunity to be able to spend more of my time conducting applied research that will have immediate benefits for the entire NY fruit industry. I hope you believe in our system as much as I do and will support it when you have the chance!

Steve Hoying

CONTENTS

FRONT COVER: (top) High tunnel planting on October 22, 2005. (bottom) Row covers used to protect raspberry plants on extremely cold nights in November.

BACK COVER: Honeycrisp apple tree on M.9 killed by fire blight infection of the rootstock. Insets: fire blight-infected M.9 rootstocks showing dark ooze

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High Tunnels for Late Fall Raspberries

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Raspberries are a high value crop that, in the middle of winter, can sell for more than $10.00/lb. A high tunnel is simply a large hoophouse covered with plastic. There are no fans, heaters or lights and can be used to extend fall raspberries later in October and November, after the field season ends from frost and rain, and when price is high.

Producing fruits, vegetables and flowers out-of-season is one way to increase value and income because crops usually can be sold at a higher price at that time. High tunnels is a technology that can be implemented just about anywhere for a modest cost, and can be used to bring crops on earlier or extend them later in the season. A high tunnel is simply a large hoophouse covered in plastic, with sides that can be rolled up or opened for ventilation. High tunnels are not powered by electricity so they do not typically have fans, heaters or lights. Because the plastic covering is generally applied and removed seasonally, and because they are not powered with electricity, high tunnels are usually classified as temporary structures and may fall outside of certain tax, building and zoning requirements.

Plants are set directly into the soil under the tunnel. Tunnels are high and wide enough to allow tractors to spray and cultivate. A typical size is 15 to 30 feet wide and 96 feet long. Europeans have been using this technology for years, and often connect several tunnels together (Figure 1). The Chinese also have been using a type of tunnel technology to produce fruits and vegetables (Figures 2 and 3). Because the United States is so geographically large, we have found it economical to grow crops in the south and ship them north to extend the season. However, even in warm climates, tunnels are helping to improve fruit quality (Figure 4). Researchers at Penn State University have demonstrated that many crops can be grown under tunnels in the Northeast. Our objective was to take one of the most promising crops and push the limits of season extension.

Raspberries are a high value crop, that in season, sell for more than $3.00 / lb. In the middle of winter, raspberries can sell for more than $10.00 / lb. Our goal was to produce raspberries in October and November, after the field season ends from frost and rain, and when the selling price of raspberries increases. We planted primocane-fruiting raspberry varieties, managed them in various ways to delay their production beyond the normal late August-September season, and then fruited them under a plastic tunnel.

Primocane-fruiting raspberries were planted in April of 2004 in 4 rows spaced 7 ft apart. Plots were 16 ft. long (6 per row). All canes were mowed to the ground in the fall of 2004 after summer's growth. In spring of 2005, we installed the framework for a tunnel over the planting.

Figure 1. Raspberries under a high tunnel in Scotland.

Figure 2. Strawberries grown under a Chinese tunnel.

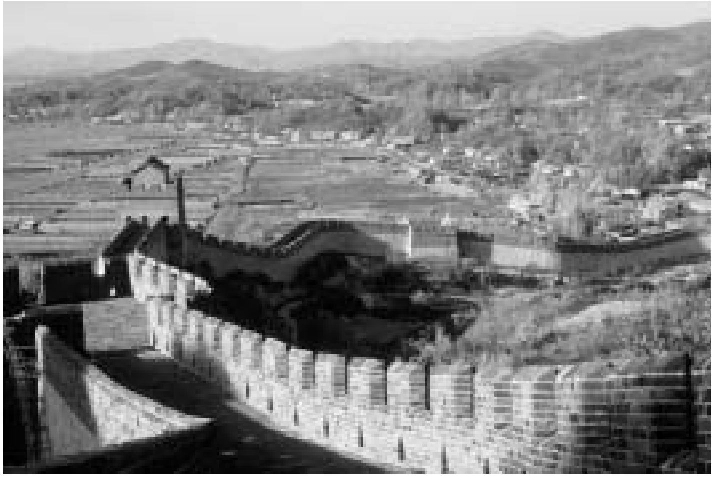

Figure 3. Partial high tunnels along the Great Wall of China are used to produce early fruits and vegetables.

Figure 4. Raspberries under rain shelters in central California.

Figure 5. High tunnel planting on October 22, 2005.

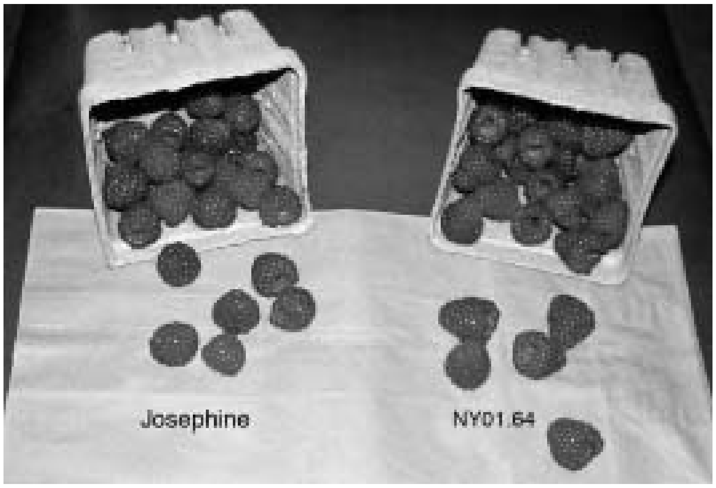

Figure 6. Raspberries harvested in Ithaca in early November.

The tunnel was covered with plastic on September 13, 2005, just prior to harvest.

Typically, a grower would prefer that fall-bearing types fruit early to avoid frost so a full harvest can be realized. Our objective was to delay fruiting of 'Heritage' until late in the fall when they would be protected by the high tunnel, and when the availability of fresh raspberries is low and the price is high. Five treatments were used: an unmanipulated control, application of straw over plots in late February to delay cane emergence, mowing canes to the ground in early June shortly after they emerge, pinching primocanes (removing the top 4 – 6 inches) when they reach a height of about 2 ft., and pinching when canes were 3 ft. tall. Each of these manipulations delayed flowering and shifted production later in the season.

A second experiment examined several high quality varieties that often cannot be completely harvested due to frost. These varieties were Caroline, Josephine, Autumn Britten, NY01.63, NY01.64, and NY01.65. The numbered selections were made by fruit breeder Courtney Weber who suspected that they may have traits that allow them to perform well in high tunnels.

Harvest started in early September at the normal time. Tunnel sides were rolled up in the morning and closed in the evening to regulate temperature. As the weather turned colder, outdoor plants slowed their production and fruit quality deteriorated. October was characterized by record rainfall, so any outdoor fruits that survived were moldy and tasteless. Inside the tunnel, however, fruit quality remained high (Figure 5) and harvest continued into November (Figure 6). On particularly cold nights, we covered the plants with row cover since tunnels do not provide suficient frost protection (Figure 7). On most nights, however, we simply closed the sides and doors of the tunnel while allowing some ventilation during the day.

We were concerned that pollination would be a problem in the fall, so we thought we would need a beehive. However, native bumble bees were attracted to the house in large numbers, without adding a hive. The stayed in the house continuously, sleeping under the leaves and foraging on raspberry flowers during the day.

Yields were high; we averaged nearly 2 lbs. per ft. of row in control plots of Heritage. Because rows were closer together than in the field, our yield per unit area was about 4 times higher than yields from outdoor plantings. Since much of the fruit was produced out-of-season, we sold our fruit at the Cornell Orchards store for $5.00 / pint ($6.70 / lb). Assuming that all of the plants in the tunnel produced as well as the Heritage controls, and assuming that we could sell everything from the tunnel, our gross sales from our 96 ft long x 30 ft wide tunnel would have been $5,150. Extrapolating to an acre, the value of the crop would be close to $80,000.

Material costs for the tunnel were about $5,000 and labor added another $1,000, so sales from the first year were nearly enough to cover the cost of the tunnel materials. Of course, labor and other costs have to be covered from the first year sales, but even so, our preliminary observations suggest that high tunnels will be profitable in the long run. We have obtained support from the New York Farm Viability Institute to document the profit potential over several years.

A second aspect of our study was to evaluate how other varieties performed in the tunnel, particularly those that fruit too late for the field. Josephine produced outstanding fruit quality in the tunnels and fruited quite late without manipulation. The other varieties also performed well, but their season was similar to that of Heritage. Autumn Britten produced large fruit, but yields were smaller than Heritage. The selections were not quite up to cultivar standards, but they were certainly late and one selection had enormous fruit size.

We plan to follow this first year's observations for another year and collect detailed economic data for analysis. We also plan to construct a second tunnel to examine early season blackberries, strawberries, and dayneutral strawberries.

Energy and transportation costs will no doubt continue to rise, and knowing that high tunnels use free solar energy, it may worth considering placing a few high tunnels on the farm to extend the season of the most highly valued crops.

Figure 7. Row covers used to protect raspberry plants on extremely cold nights in November.

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Managing External Carbon Dioxide Injury With and Without SmartFresh™ (1-MCP)

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This work supported in part by the New York Apple Research and Development Program.

External carbon dioxide injury has long been a problem for varieties such as 'McIntosh', 'Empire' and 'Cortland'. Fruit that are kept "fresh" after harvest are particularly susceptible to injury and therefore it is not surprising that 1-MCP can increase risk. We have been developing strategies to help the New York apple industry avoid fruit losses from this injury.

External carbon dioxide injury is a skin disorder of apple fruit that occurs during storage, resulting in disfigured fruit that are unmarketable (Figure 1). The injury usually occurs on the unblushed side of the fruit and can range from barely noticeable to covering most of the skin in severe cases. It is manifested as light brown to colorless areas on the skin surface, and affected areas are irregularly shaped, rough and wrinkled (Figure 1). We have also found in trials that the initial injury develops on fruit during early storage periods and has a smooth and soaked appearance (Figure 2). The common injury symptoms presumably represent the same tissues that have dried out and collapsed.

The injury is usually associated with controlled atmosphere (CA) storage, but can occur during air storage of freshly harvested fruit packed quickly after harvest in poorly ventilated cartons. External carbon dioxide injury has long been a potential problem for storage operators in New York and elsewhere. Several varieties are susceptible to the disorder, including 'McIntosh', 'Cortland' and 'Empire', and in fact the Cornell recommendation for 'McIntosh' has long recognized this susceptibility. Although the 'McIntosh' variety benefits by having elevated carbon dioxide concentrations (3-5%) in the storage environment, our recommendation is to maintain these concentrations at 2% or less during the first 4-6 weeks of storage to minimize risk of disorder development. Little injury was seen in 'Empire' fruit until the early 1990s, when a recommendation to stop using the superficial scald inhibitor diphenylamine (DPA) resulted in losses of 20-40% in some storage rooms. Until that time, it was not appreciated that DPA not only prevented superficial scald, but also prevented external carbon dioxide injury. This discovery explains why we rarely observe external carbon dioxide injury in 'McIntosh' and never in 'Cortland' apples under commercial conditions. Occasional outbreaks of injury occur only in the Champlain Valley growing region of New York, where they typically do not apply DPA to 'McIntosh' apples, whereas 'Cortland' apples are always treated with DPA. Occasional severe injury in 'Empire' has occurred also in the Hudson Valley when fruit were not treated with DPA.

Studies by Jennifer DeEll and coworkers in Canada showed that the susceptibility of fruit to external carbon dioxide injury was greater in 'McIntosh' apples that were treated with SmartFresh™ technology. The technology is based on application of gaseous 1-methylcyclopropene (1-MCP) and has been widely incorporated by apple industries around the world because of its beneficial effects in maintaining quality, especially texture, throughout the whole marketing chain. Our early results, together with anecdotal reports from the New York apple industry, suggested that there may be increased susceptibility of 'Empire' apples to injury when treated with 1-MCP. We have carried out a series of experiments to investigate external carbon dioxide injury in this variety and to devel-


Figure 1. External carbon dioxide injury in 'Empire' apples.


Figure 2. Early symptoms of external carbon dioxide injury in 'Empire' apples before tissues have dried out.

op methods to control risk of injury development during storage. The information obtained for 'Empire' is likely to apply to all external carbon dioxide injury-susceptible apple varieties.

Experimental Outline

A series of experiments have been carried out using 'Empire' apples which include:

1. A study of the effects of carbon dioxide concentration and 1-MCP application on the incidence of external carbon dioxide injury.
2. An investigation of whether 1-MCP increases the period of highest susceptibility of fruit to injury.
3. An investigation of whether 1-MCP affects the decline in susceptibility to injury that occurs when fruit are kept in air before being exposed to CA storage.
4. A study of the effect of different DPA concentrations on external carbon dioxide injury.

The fruit used in these experiments were obtained from an orchard block with a known history of high susceptibility to external carbon dioxide injury. Except in the experiments in which different carbon dioxide concentrations were applied, a 5% concentration was used as a severe treatment to maximize the chances of injury. We assume that using fruit of high risk under high gas concentration conditions represent conditions greater than the worst-case scenario that could occur commercially.

All experiments were carried out at 35-36°F using flow-through systems in which fruit were treated in large glass jars (Figure 3). Each treatment had four replicates.

Increasing Carbon Dioxide and 1-MCP Treatment Increase External Carbon Dioxide Injury

Fruit were harvested and either treated or not treated with 1ppm 1-MCP after overnight cooling. Fruit were then exposed to 1%, 2.5% or 5% carbon dioxide (in 2% oxygen) for 20 weeks and evaluated after seven days at 68°F. External carbon dioxide injury occurred even at 1% carbon dioxide, but its incidence increased markedly in 2.5% and 5% carbon dioxide (Table 1). In all cases, treatment of fruit with 1-MCP increased the incidence of injury.

1-MCP Does Not Increase the Early Period of Risk in CA Storage

Fruit that were untreated or treated with 1-MCP were exposed to either 2.5% or 5% carbon dioxide (in 2% oxygen) for three week periods during 20 weeks of CA storage, either weeks 0-3, 4-6, 7-9 or 10-12. When not in elevated carbon dioxide, fruit were exposed to 1% carbon dioxide. For example, fruit treated with 5% carbon dioxide during weeks 4-6, were in a 1% concentration for weeks 0-3 and 7-20.

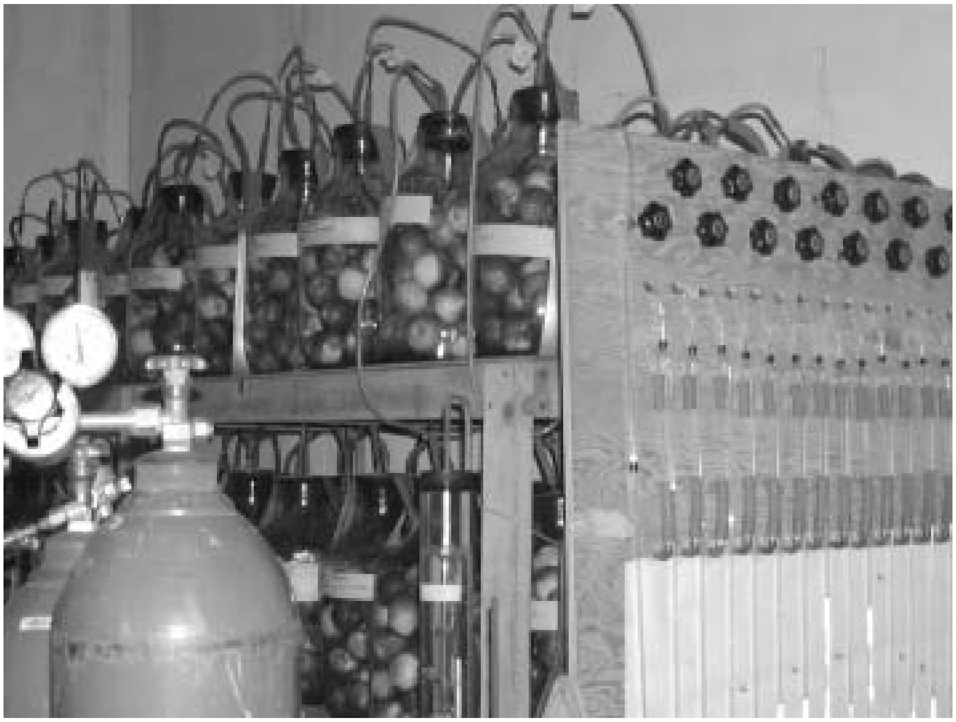

Figure 3. Experimental set up for treatment of fruit with 1%, 2.5% or 5% carbon dioxide (2% oxygen).

TABLE 1

External carbon dioxide injury (%) in 'Empire' apples either untreated or treated with 1ppm 1-MCP and exposed to 2.5 or 5% carbon dioxide (in 2% oxygen) for 20 weeks. Effects of carbon dioxide and 1-MCP are significant at P<0.001 and P=0.011, respectively.

	External carbon dioxide injury (%)	
Carbon dioxide (%)	**- 1-MCP**	**+ 1-MCP**
1	4	8
2.5	25	38
5	31	57

The highest injury incidence occurred during the first three weeks of exposure to either 2.5% or 5% carbon dioxide (Figure 4). While the injury levels were slightly higher in 1-MCP treated fruit than in untreated fruit, the time that fruit were most highly susceptible to injury was not extended by 1-MCP treatment.

1-MCP Prevents the "Adaptation" Period Between Karvest and CA Storage

Untreated fruit were exposed to 5% carbon dioxide (in 2% oxygen) after overnight cooling (1 day), or 2, 7 or 14 days after harvest. 1-MCP treated fruit were exposed to elevated carbon dioxide 2, 7 or 14 days after harvest. Fruit were stored for 10 weeks.

The susceptibility of untreated fruit to external carbon dioxide injury decreased rapidly to about 50% of the incidence at harvest to essentially none by day 14 (Figure 5). 1-MCP prevented that "adaptation" so that by day 14 there was no statistical reduction of injury.

DPA Eliminates Risk of External Carbon Dioxide Injury

Fruit were dipped in water, or 250, 500 or 1000ppm DPA on the day of harvest, cooled overnight and exposed to 5% carbon dioxide for 10 weeks. DPA at all concentrations completely eliminated external carbon dioxide injury (Figure 6).

Discussion

The observation that the risk of external carbon dioxide injury was increased by 1-MCP, led to our initial recommendation that carbon dioxide concentrations in the storage atmosphere

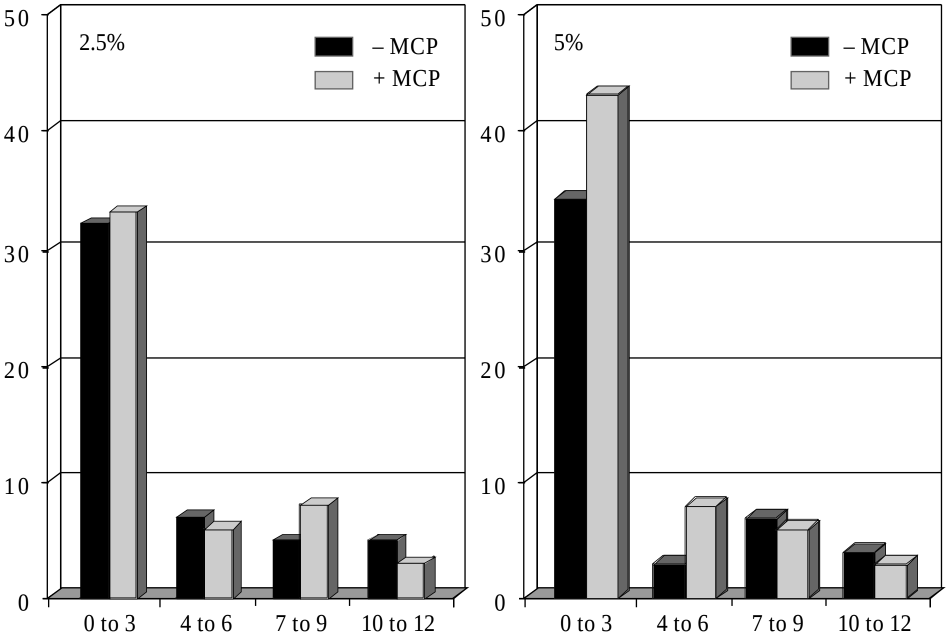

Figure 4. External carbon dioxide injury (%) of 'Empire' apple fruit either untreated or treated with 1ppm 1-MCP and exposed to 2.5% or 5% carbon dioxide (in 2% oxygen) for 3 week periods during storage.

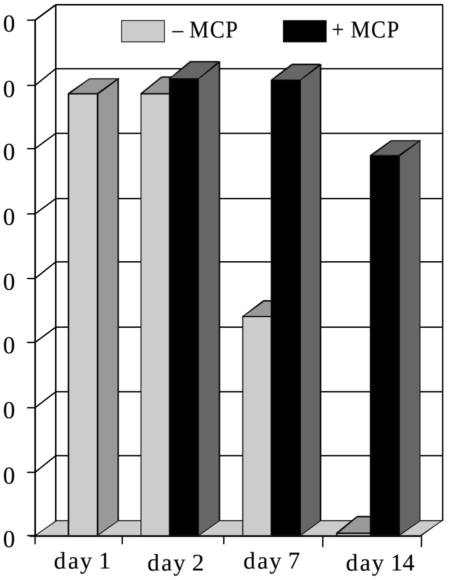

Figure 5. External carbon dioxide injury (%) in 'Empire' apples exposed to 5% CO2 one day after harvest, or untreated or treated with 1-MCP and exposed to CO2 2, 7 and 14 days after harvest.

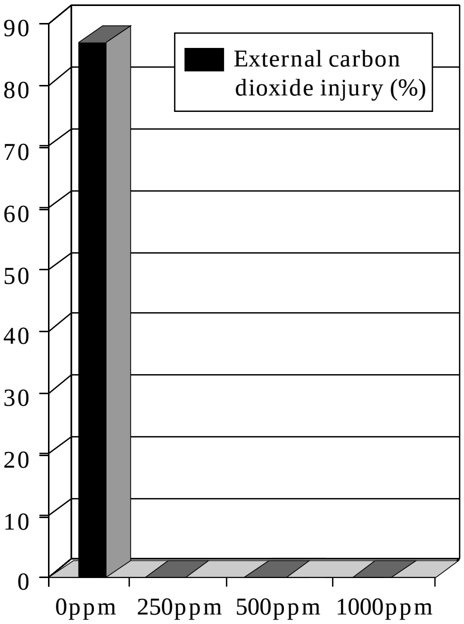

Figure 6. External carbon dioxide injury (%) of 'Empire' apples treated with water or 250, 500 or 1000ppm DPA and exposed to 5% carbon dioxide (in 2% oxygen) for 10 weeks.

should be kept to below 1% for the first 4-6 weeks of storage. However, even at this level, some injury risk exists and some storages reported unacceptable levels of injury when using this method. If carbon dioxide concentrations are reduced further, e.g. 0.5%, then injury might be further reduced. Nevertheless, it may be that reduced decay as a result of avoiding postharvest DPA offsets the losses due to external carbon dioxide injury found at low carbon dioxide concentrations in the storage, especially for storage of predominantly high colored fruit since injury usually occurs on the green or unblushed area of the fruit.

Our study indicates that the increased external carbon dioxide injury associated with 1-MCP treatment is not a result of greater risk periods, so we are not extending the length of the early period over which carbon dioxide concentrations should be kept low beyond the current recommendation of 4-6 weeks. It is important to understand that the period of injury risk is relatively short. How quickly should the carbon dioxide concentrations in the storage atmosphere be allowed to increase? Maintaining carbon dioxide in the storage environment between 2 and 3% is critical to maintain fruit firmness in fruit that are not 1-MCP treated, and therefore we like to see such levels within a couple months of storage. With 1-MCP-treated fruit, we have found that these higher carbon dioxide concentrations are not necessary to maintain firmness unless storage periods are beyond six months. However, in a CA room there is a chance that some fruit lots do not respond to 1-MCP as well as others; if this occurs then maintaining low carbon dioxide concentrations for extended periods could be detrimental to these fruit as they will soften prematurely.

Interestingly, however, our study shows that 1-MCP treatment increases the "adaptation" period prior to CA establishment. This is the time period between harvest and CA establishment during which fruit sensitivity to carbon dioxide decreases. When major losses were reported in the 1990s as a result of stopping DPA usage, the worst damage occurred in those storages that applied CA conditions within a few days of harvest – by doing things correctly, storage operators probably increased injury! In contrast, in those storage operations where application of CA conditions was delayed, there appeared to be less injury. The bottom line from our studies is that 1-MCP treated fruit maintain susceptibility to injury in the period after harvest and before CA establishment. Therefore, unless DPA is used to eliminate risk of injury development, storage operators need to be aware of the increased risk and manage to avoid fruit losses. It is dangerous to assume that risk is low because of the absence of external carbon dioxide injury in the last few years as seasonal variation can result in unexpected susceptibility.

In the foreseeable future, the no-risk solution to prevent external carbon dioxide injury development is DPA treatment after harvest. DPA is registered as an inhibitor of superficial scald and must be applied for that purpose under label restrictions. However, our results show that risk of external carbon dioxide injury is eliminated with a DPA treatment, even at concentrations as low as 250ppm. Therefore it may be possible to reduce costs associated with DPA treatment, especially as superficial scald susceptibility of 'Empire' apples is low. Some New York storage operators have employed DPA together with low carbon dioxide and delay treatments. If DPA is used, then no other methods are necessary to avoid external carbon dioxide injury.

Summary

1. Susceptibility of 'Empire' apples to external carbon dioxide injury is increased by higher carbon dioxide concentrations in the storage environments and further increased by prior treatment of fruit with 1-MCP.
2. The early period of fruit susceptibility to carbon dioxide is not lengthened by 1-MCP treatment and therefore it is not necessary to extend the time that carbon dioxide concentrations in the storage atmosphere must be kept low.
3. 1-MCP treatment prevents the "adaptation" period after harvest and before CA storage during which the susceptibility of fruit to carbon dioxide normally declines markedly. Therefore, special care by storage operators is required to avoid injury risk in 1-MCP treated fruit.
4. Two methods are available to minimize or prevent external carbon dioxide injury in apple fruit. The first is to maintain carbon dioxide concentrations below 1%, but some injury can occur if fruit are highly susceptible. The second is DPA treatment, which appears to completely eliminate risk of injury.

Acknowledgements

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Fanjaniaina Razafimbelo is a Ph.D. student doing research on the effects of 1-MCP on physiological disorders and on nutritional status of apple fruit. Jackie Nock is a Research Support Specialist and Chris Watkins is a Professor of Postharvest Science in the Department of Horticulture, Cornell University, Ithaca, NY.

Rootstock Blight in Apple

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This work supported in part by the New York Apple Research and Development Program

Rootstock blight has become increasingly prevalent in recent years due to the increasing use of both highly susceptible apple cultivars and susceptible dwarfing rootstocks. Losses from rootstock blight can be devastating. It is not unusual in young plantings on M.9 to witness losses of 50% in a heavy fire blight year. Resistant apple rootstocks could significantly reduce tree mortality rates primarily when highly susceptible cultivars are planted. New disease resistant rootstocks are now available providing growers with better options for new orchard blocks.

Originally discovered in the Hudson Valley in the late 1700's, fire blight is a bacterial disease of rosaceous plants caused by *Erwinia amylovora.* In recent years, due to changes in climate and horticultural techniques, fire blight epidemics have become more frequent, gaining serious attention from the agricultural and scientific communities. Fire blight is a recurring problem in Western New York and the Hudson Valley where epidemics can be devastating, costing growers significant amounts of time and money for intensive management practices, loss of productivity, and tree replacement. Climatic changes, including elevated temperatures early in the growing season, have expanded the optimal geographic range for fire blight infection.

Over the past 60 years, beginning with the adoption of streptomycin by agriculture, great strides have been made in predicting and managing disease outbreaks. Utilizing modern technology and new materials growers have greatly reduced losses due to shoot and blossom blight. Forecasting systems, such as *MARYBLYT™* and *Cougarblight*, adequately predict the proper timing for bloom application of antibiotics, limiting the incidence of blossom blight. Shoot blight, although unpredictable and sporadic, can be reduced by pruning infected shoots and through the use of the plant growth regulator prohexadione-calcium (Apogee from BASF company), which reduces excessive shoot growth during the growing season. Only rootstock blight, the most fatal form of fire blight, remains without an effective control strategy.

Rootstock blight is a fire blight infection persisting in the rootstock of the tree. The initial infection is often overlooked since above ground symptoms do not appear until late in the season, after the rootstock has died and the tree begins to decline. The most prominent symptom of rootstock blight infection is the secretion of glossy, dark colored ooze (Figure 1). The production of ooze is most common after a rain event or heavy dew, but only occurs for a short time. As the disease progresses, the rootstock blackens and the bark may begin to peel. Rootstock blackening and peeling however are not diagnostic symptoms, since some rootstocks display similar symptoms when healthy. Later in the season, infected trees undergo a premature leaf color change and leaves will turn a deep purple and remain fixed on the tree. Without visible ooze, an outbreak of rootstock blight is easily mistaken for other root diseases. Fungal-like organisms, called Phytophthora *sp.*, which cause root and collar rot, may also bring about a premature color change in foliage. One factor differentiating these diseases is the conditions favorable to development. Phytophthora occurs more often in wet soil whereas rootstock blight is more frequent during periods of hot dry weather, normally in combination with severe blossom or shoot blight. Rootstock blight symptoms will generally persist only in the main trunk of the rootstock and usually do not progress into the outlying root system or into the scion. There is no evidence that fire blight bacteria can survive in the soil or on root residue in the orchard. Soil residue poses little threat to replacement trees, although research on this topic has been limited. To avoid any risk of recurrent rootstock blight use of a fire blight resistant rootstock is recommended.

Bacteria may gain entry into the rootstock through open wounds such as mechanical damage or insect feeding sites. Rootstock suckers may also serve as a source of infection, though the risk of rootstock blight associated with suckers


Figure 1. Symptoms of rootstock blight in apples.

is limited. Excessive suckers should be removed to eliminate risk of infection. The most significant method of infection is the migration of bacteria from infected blossoms and shoots, down the trunk, into the rootstock. Bacteria move within the vascular system of the tree without causing visible necrosis. Migration occurs rapidly into the rootstock and bacteria reach detectable levels only a few weeks after infection. Once bacteria gain entry into the rootstock no treatment is available to prevent the development of rootstock blight.

Rootstock blight has become increasingly prevalent in recent years. The advent of new apple cultivars, most of which are highly susceptible to fire blight, coupled with the increasing acceptance of susceptible dwarfing rootstocks, has provided conditions favorable to rootstock blight. In an effort to remain competitive many growers have converted to high-density planting systems, which require less land, generate higher yields, and produce better quality fruit. High-density systems use dwarfing rootstocks that accelerate cropping of young trees by promoting early flowering. This enables orchards to reach bearing potential much sooner than low-density systems. Unfortunately rapid shoot growth and early flowering promote fire blight infections in young trees, which are more susceptible to rootstock blight. Young trees are more likely to develop rootstock blight when they reach bearing age and will remain vulnerable until their fifth or sixth leaf. The most vulnerable aspect of high-density systems is the reliance on traditional highly susceptible dwarfing rootstocks, specifically M.9 and M.26. Losses from rootstock blight can be devastating. It is not unusual in young plantings on M.9 to witness losses of 50% in a heavy fire blight year. When planting densities require 1,000 trees per acre, losses of 50% can be immense. With pressure to plant more marketable cultivars and the escalating premiums associated with club varieties, growers cannot afford to lose trees that have yet to make a profit. Even moderately resistant rootstocks such as M.7 are not immune to heavy disease pressure. The only guaranteed method of control is the use of resistant rootstocks. It is important to clarify that resistant rootstocks are only effective against rootstock blight and do not significantly affect levels of shoot blight or blossom blight.

When it became obvious that rootstock blight was a threat to the apple growing industry several rootstock-breeding programs made fire blight resistance a priority. Due to high demand a significant number of new rootstock varieties have been released from various programs around the world. The Cornell Geneva Rootstock Breeding Program originally founded by Drs. James Cummins and Herb Aldwinckle, and now a joint venture between the USDA (Gennaro Fazio) and Cornell University (Herb Aldwinckle, Terence Robinson), was the first rootstock-breeding program to focus on fire blight resistance. To date seven Geneva® rootstock varieties covering a wide range of dwarfing ability have been released. Additional rootstocks, from various breeding programs, are also being evaluated for fire blight resistance some with promising results. Rootstocks worthy of mention include, several Pillnitz (PiAu) selections from Dresden, Germany, the Vineland Series from Ontario, Canada, and several Japanese varieties including the JM series (See Table 1 for more information).

Rootstock Breeding Programs

Program (Country of Origin)	Rootstock	Size Chart	Fire Blight Resistance
Budagovsky (Russia)	B.9 Europe	M.9	Resistant
	B.9 US	M.9	Resistant
	B.62-396	M.26	-
Cornell Geneva (USA)	G.11	M.9	Tolerant
	G.16	M.9	Resistant
	G.30	M.7	Resistant
	G.65	M.27	Resistant
	G.41	M.9	Resistant
	G.202	M.26	Resistant
	G.935	M.26	Resistant
Morioka (Japan)	JM1	M.9	-
	JM2	M.7	Susceptible
	JM4	M.26	-
	JM5	M.7	-
	JM7	M.26	-
	JM8	M.26	-
	JM10	M.9	-
Pillnitz (Germany)	Supporter 1	M.9	-
	Supporter 2	M.9	-
	Supporter 3	M.26	-
	Supporter 4	M.7	Tolerant
	PiAu-51-4	M.7	Resistant
	PiAu-56-83	M.7	Resistant
	PiAu-51-11	M.9	-
Poland	P.16	M.9	-
	P.14	M.7	Resistant
	P.60	M.9	-
Vineland (Canada)	V1	M.26	-
	V2	M.26	-
	V3	M.9	-
	V4	M.9	-
	V7	M.9	-

Resistance Not Determined (-)

Limited selection of resistant rootstocks, many of which lacked practical information on orchard performance, made growers hesitant to plant new rootstocks. In an effort to alter grower perception, researchers have made a concerted effort to evaluate orchard performance of new rootstocks, in varying soil and climactic conditions. This was undertaken as part of the national NC-140 rootstock evaluation initiative, established to promote economic and environmentally sound horticultural improvements by focusing on rootstock development. Through this project rootstocks are consistently screened at the New York State Agricultural Experiment Station and at many other sites for productivity and orchard performance in an effort to better recommend planting material suitable for NY growing regions. In addition rootstocks are screened at the New York State Agricultural Experiment Station for fire blight susceptibility.

In our evaluation of rootstock resistance, blossoms of grafted trees are artificially inoculated with fire blight bacteria.

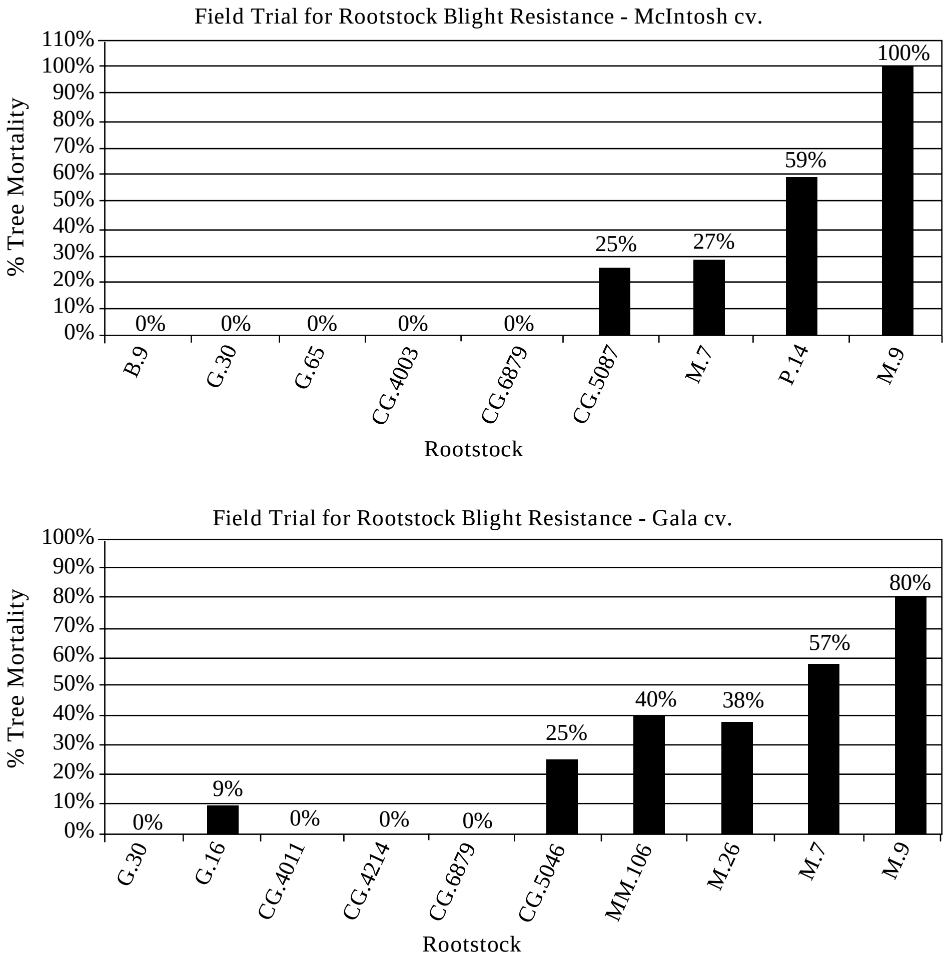

Figure. 2 Field Trial for Rootstock Blight Resistance.

Rootstocks are compared based on the resulting number of trees that die from rootstock infection, described as percent tree mortality. Severe blossom blight infection ensures the highest possible disease pressure. If a rootstock can resist disease pressure of this magnitude, it is likely to remain healthy in a typical orchard.

The East Malling rootstocks were not bred to withstand fire blight infection, and typically suffer heavy losses in our field trials evaluating rootstock blight resistance. In a trial consisting of Gala and McIntosh cultivars, M.9 suffered a total of 80% tree mortality with Gala and 100% mortality with McIntosh. M.7, which is generally listed as fire blight tolerant, had 57 and 27% tree mortality on Gala and McIntosh respectively (Figure 2). In this particular trial, M.26 had atypically low levels of infection; nevertheless 35% tree mortality would still be crippling in a high-density planting. This field test also demonstrated how well rootstocks withstand infection pressure when fire blight resistance is included in the breeding program. In this same field experiment, Geneva® rootstocks had no significant level of rootstock blight infections. Unreleased CG rootstocks that showed less than acceptable resistance were eliminated.

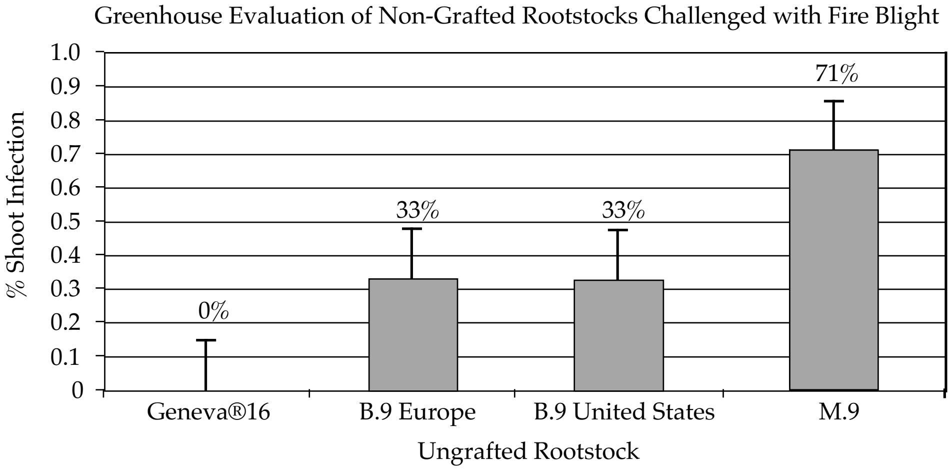

Figure 3. Comparison of shoot infection with non-grafted rootstock liners.

Another rootstock that has been gaining considerable attention in recent years is B.9, which has consistently shown resistance to rootstock blight in orchards. Budagovsky 9 (B.9 or Bud.9) is a dwarfing rootstock developed in the early 20th century at the Michurinsk College of Agriculture in Russia. B.9, a cross between M.8 and 'Red Standard,' a *Malus niedzwetzkyana* Diek red leaved variety, was originally bred for winter-hardiness, layering capacity, and graft compatibility. Similar in size and productivity to M.9, B.9 has a good reputation with growers and is readily available from many nurseries. Historically when inoculated as liners in the greenhouse, B.9 had appeared to be highly susceptible to fire blight. This classification prevented its widespread acceptance.

A number of anecdotal reports indicated B.9 might have some fire blight resistance, however, conflicting reports made it impossible to confidently recommend B.9 to growers as a fire blight resistant rootstock. Rootstocks are usually screened for fire blight resistance by inoculating non-grafted rootstock liners with *E. amylovora* and measuring the resulting lesion. Sensitivity of the non-grafted rootstock liners corresponds to a great extent to the level of susceptibility to rootstock blight of grafted trees in the field, making this an accurate and easy screen for breeders. In our recent experiments, using this type of screening procedure B.9 has been repeatedly categorized as susceptible to fire blight infection. Yet several growers have reported that side-by-side plantings of trees grafted to M.9 and B.9 have experienced heavy tree losses from rootstock blight with M.9, while trees on B.9 failed to develop symptoms. Conflicting reports are also found in the research community where multiple experiments show a wide range of rootstock blight sensitivity from highly sensitive, to tolerant, to completely resistant. Nurserymen were also concerned that material from two stool bed sources of B.9, located in Oregon (B.9 United States) and the

Netherlands (B.9 Europe), seem to have visible differences in growth habit, indicating a difference in genetic background which may play a role in resistance.

Verification of B.9 resistance and genetic identity has been a focus of our research. To date, no evidence of genetic irregularity in B.9 source material has been identified. Apparent differences in growth habit are likely due to propagation method and juvenility of plant material. If minute genetic differences do exist they are most likely too minor to be detectable by current methods, and it is doubtful they have any effect on fire blight resistance. Clones of popular rootstocks, such as M.9, are well known but these 'clonal' differences have never been shown to affect disease resistance.

Susceptibility tests of non-grafted B.9 liners were performed on rootstock material from European and US sources, and compared with resistant Geneva®16 (G.16) and susceptible M.9 (Figure 3). B.9 has an intermediate but still highly susceptible reaction, supporting the early classification of B.9 liners as susceptible. This test also concluded that B.9 liners, from both sources, had similar levels of susceptibility when challenged directly with fire blight. Research plantings at the NYSAES of grafted B.9 (US and European) however, continue to show high levels of rootstock blight resistance even when grafted to highly susceptible scion varieties.

Absence of rootstock blight in the field is so consistent that we now recommend B.9 to growers as a good disease resistant rootstock to replace M.9. The cause of the B.9 resistance is not clear and is unlike any other resistance previously described. The phenomenon seen with B.9 is the only known instance in which a rootstock displays different levels of resistance to rootstock blight; susceptible to infection as liners in the greenhouse while somehow resistant in grafted field plantings. Our preliminary study suggests B.9 develops resistance either due to the influence of grafting or through a developmental change in tissue related to aging. Further understanding of the mechanisms involved in B.9 resistance will aid in the selection of new rootstock varieties in the future.

Excessive use of streptomycin has led to the development of resistant fire blight bacterial strains on the West Coast and Michigan. If resistance becomes widespread the ability to control blossom blight would be greatly reduced and would lead to significant rise in the occurrence of all three forms of fire blight. Without a viable control option rootstock blight could become a more serious threat to NY orchards. Rootstock blight is preventable with the adoption of resistant planting material. Resistant apple rootstocks could significantly reduce tree mortality rates primarily when highly susceptible cultivars are planted. New disease resistant rootstocks are now available providing growers with better options for new orchard blocks.

Nicole Russo is a Ph.D. student doing research on rootstock blight and the mechanisms of rootstock resistance. Terence Robinson is a research and extension professor of pomology who specializes in rootstock performance in high density systems. Gennario Fazio is an ARS geneticist and adjunct Cornell professor who leads the joint UDSA-ARS/Cornell apple rootstock breeding program. Herb Aldwinckle is a professor of plant pathology who leads in fire blight research effort at Geneva, emphasizing epidemiology and genetic, biological and chemical control.

Pest Management Efficacy and Economics in the New York Risk Avoidance and Mitigation Program

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Apple and peach pest management systems have traditionally been based on organophosphates, carbamate and pyrethroid insecticides. This project compared pest management systems based on reduced-risk tactics to greatly reduce residues and worker exposure to organophosphate, carbamate, and pyrethroid insecticides. By using sampling, monitoring-based spray decisions and reduced-risk materials, fruit damage from direct pests such as plum curculio, codling moth, oriental fruit moth, and apple maggot was as low as when organophosphates were used, and at a generally comparable per-acre cost when mating disruption is not used.

A four-year research project was initiated during the 2002 growing season to evaluate, on a regional scale, apple and peach pest management systems based on reduced-risk (RR) tactics that previous research and experience had indicated would be effective, sustainable, economically viable, and lead to enhanced biological control. The participating states were: Michigan, New Jersey, New York, North Carolina, Pennsylvania, Virginia and West Virginia. The goal of this project was to design pest management systems that greatly reduced residues and worker exposure to organophosphorous (OP), carbamate, and pyrethroid insecticides.

Using a uniform protocol across all states, side-by-side comparisons were made of RR and conventionally managed orchards (5- to 10-acre plots) with 65 cooperating growers across seven states. Pesticide programs in conventional blocks were determined by individual growers or their consultants and relied extensively on OP insecticides; OPs accounted for 84% and 83% of insecticide active ingredient applied to apples and peaches, respectively. Pest management decisions in RR blocks were made by the PIs in each state, and relied on RR or OP-replacement insecticides and pheromone-mediated mating disruption. Within each state, some apple RR blocks used hand-applied pheromone ties (Isomate) for mating disruption of both codling moth (CM) and oriental fruit moth (OFM) (referred to as RR + PT) and others were managed with only RR insecticides and, in many instances, one or more sprayable OFM pheromone applications. All peach blocks relied on RR or OP-replacement insecticides plus mating disruption for OFM and peachtree borer. Data were collected on the abundance of pest and beneficial arthropods and fruit quality, and a partial budget analysis was conducted to assess the impact of these new programs on net profit.

General Methods

The following pest control tactics were used in programs designed for apples and peaches throughout the region: (1) selective insecticides and acaricides (insect growth regulators, antibiotics, microbials, nicotinoids, oxadiazines, kaolin, horticultural mineral oil, tetrazines, hexythiazox); (2) mating disruption; (3) conservation of natural enemies; (4) cultural practices. These tactics were integrated into specific pest management programs designed to be most appropriate for each state and major production region within each state. The range of potential tactics that were tested and the development of specific IPM programs were based on site-specific sampling protocols, local pest complexes and market destination of the crop. Reduced-risk management programs in apples and peaches were tested in plots of 5A or larger. A block with similar tree training systems, cultivars, ages of trees, and planting spacing was also selected adjacent to, or nearby each reduced-risk block. This block was treated with the grower's standard pest management practices so that pest levels, fruit quality, harvest damage, and pest management inputs in the two blocks could be compared.

At least three reduced-risk blocks and standard comparison blocks were set up in each major growing region of each participating state during the 2002 growing season. Research sites were selected that represented typical horticultural production systems and levels of potential damage from the insect and mite pest complex in each growing region in each state. Research was conducted during each of the four years of the project in the same research and comparison plots at each site in order to compare results among different seasons and to monitor the pest and damage levels over multiple seasons. All control sprays in both the reduced-risk and standard comparison plots were applied by growers. Both the reduced-risk research plots and the standard comparison blocks were sampled throughout the season so that population levels of selected natural enemies and the infestation levels and damage could be compared.

The reduced-risk research plots were monitored according to pest management protocols established by the various states to determine the need and timing for control tactics against insect and mite pests throughout the season. The growers and private pest management consultants determined which pest management practices were used in the standard comparison blocks, but these practices included use of organophosphate, pyrethroid, and carbamate insecticides. An economic assessment was conducted to compare the costs of insecticides and acaricides, pesticide application costs, and percent fruit damage in the reduced-risk vs. grower standard comparison blocks. In order to eliminate variability between yields among blocks not related to pest management practices, the profitability of the research plots and standard blocks was compared by estimating the returns to growers using the average state yield and market value for fresh and processed fruit for each state.

New York Results

Results from the 17 New York sites in which this study was conducted are summarized for each of the four years of the project.

2002 – Moth catch trends from the non-disrupted blocks showed codling moth (CM) levels to be fairly moderate throughout the season throughout the state; in the most western sites, lesser appleworm (LAW) levels tended to be modest, but oriental fruit moth (OFM) pressure was sometimes severe. In the eastern orchards, the opposite trend was observed, with OFM scarcely present, particularly during the latter half of the season, and LAW at reasonably high levels in most of these blocks, particularly towards the end of the season and beyond harvest. Phytophagous mite populations were relatively low throughout the season: RR, an average of 1.6 motiles per leaf, 6% of samples indicating over-threshold populations; grower standards, 1.1 motiles per leaf, 4% of samples over threshold. Fruit damage at harvest caused by insect feeding or infestation was uniformly low in the RR blocks with (91.5% clean) or without (92.0% clean) pheromones, and the grower standards (93.6% clean). Average per-acre insecticide costs were $216 (plus an additional $148 for pheromones) in the RR and $149 in the grower standard blocks. Some localized damage from internal Lepidoptera was noted in two cases. Other fruit-feeding insects caused nominal damage in a few cases, including rosy apple aphid, leafrollers, San Jose scale and tarnished plant bug.

2003 – Again, pheromone ties suppressed trap catches of the target species at levels near zero. European red mite (ERM) populations surpassed economic threshold levels in three each of the RR and grower standard plots during the summer; average foliar numbers were 3.4 and 1.0 motiles per leaf, respectively. Predator mite numbers were low (~0.14 per leaf) throughout. Fruit insect damage at harvest was again uniformly low across all blocks and treatments, with no statistically significant differences between the RR blocks with (95.5% clean) or without (95.7% clean) pheromones, and the grower standards (96.0% clean). Overall damage was somewhat reduced from 2002, however, with only six farms exhibiting any internal Lepidoptera feeding damage, compared with eight farms in 2002. Insecticide costs averaged $262 and $202 per acre for RR (8.2 total applications) and grower standard (8.7 total applications) programs, plus a $141 per acre pheromone cost in the RR sites. Other fruit-feeding insects causing nominal damage in isolated cases included leafrollers, tarnished plant bug, and plum curculio.

2004 – The pheromone ties continued to suppress trap catches of all three species at levels near zero. ERM populations surpassed economic threshold levels in two RR plots during the summer. Fruit insect damage at harvest showed no significant differences between the RR blocks with (95.5% clean) or without (94.7% clean) pheromones, and the grower standards (94.6% clean), similar to the previous two years. Overall damage from internal Lepidoptera was considerably reduced from

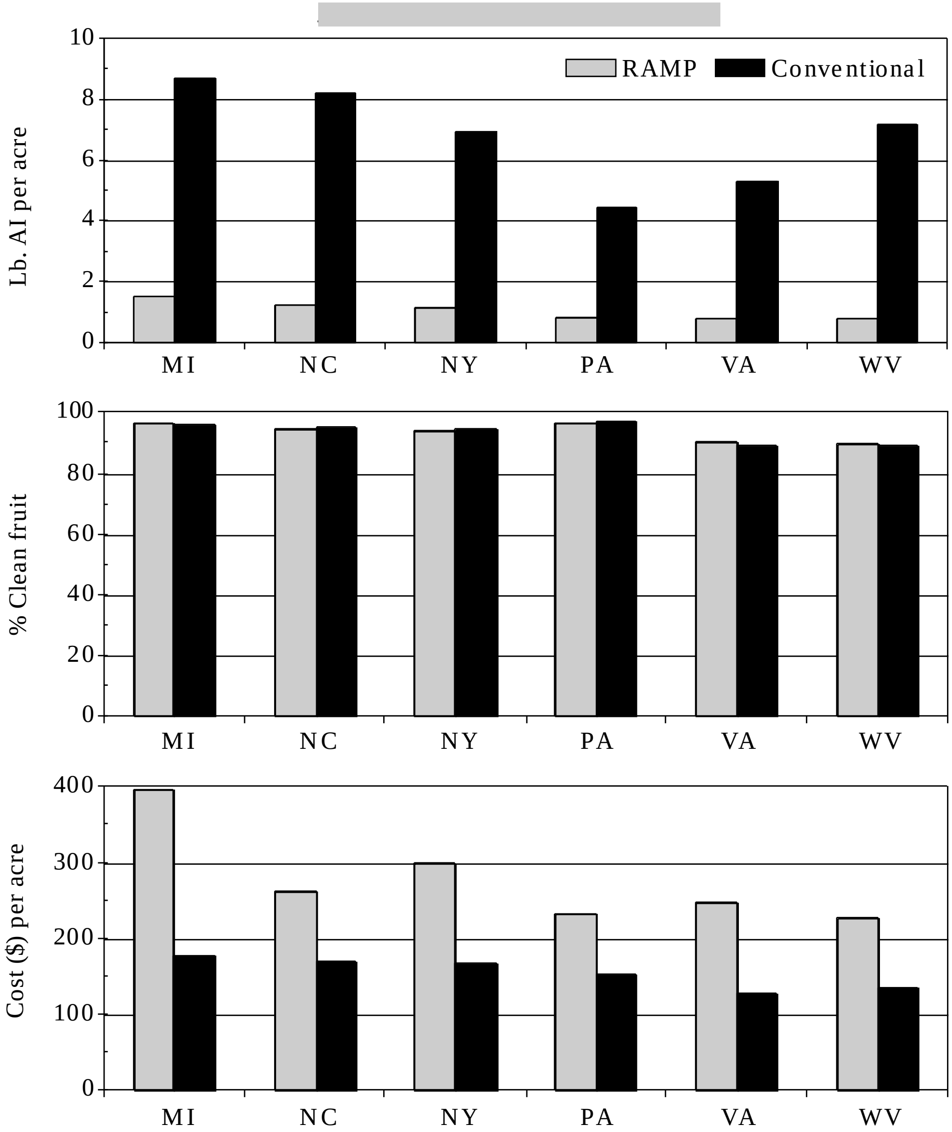

Figure 1. Mean insecticide use, fruit quality and insect management costs in RR and conventionally managed apples, over four years in each state.

2003, with only seven farms exhibiting any internal worm damage, and a maximum value of 1.1%. Insecticide costs averaged $225 and $156 per acre for RR (7.1 total applications) and grower standard (7.9 total applications) programs, plus a $136 per acre pheromone cost in the RR sites. Other fruit-feeding insects causing damage in isolated cases included tarnished plant bug, plum curculio, and apple maggot.

2005 – Because of uniformly low internal Lepidoptera pest populations in most sites during previous years, pheromone mating disruption in combination with the RR pesticides was implemented at only 2 of the 17 farms; these successfully suppressed most moth catches all season. Levels of ERM surpassed threshold only once in an RR block and three times in grower standard blocks, with maximum predator mite numbers averaging 1.1 per leaf (range, 0.02–2.6) and 0.96 per leaf (range, 0–3.13) in RR and grower plots, respectively. Fruit insect damage at harvest again showed no significant differences between the RR blocks (94.4% clean) and the grower standards (93.8% clean). Internal worm damage was minimal overall, occurring in only one plot for each treatment (RR: 0.07%, Std: 0.28%). Insecticide costs and use patterns for 2005 were lower than in previous years because of our recommendations to implement some of the following tactics: border sprays for some plum curculio and apple maggot treatments, omitting pink bud sprays where no threat of rosy apple aphid, spotted tentiform leafminer, or tarnished plant bug exists, omitting petal fall leafroller materials in low-pressure blocks. Costs averaged $161 per acre (5.5 total applications) in the RR blocks without pheromones ($321 per acre in the two sites with pheromone disruption), compared with $147 per acre (7.5 total applications) in the grower standards.

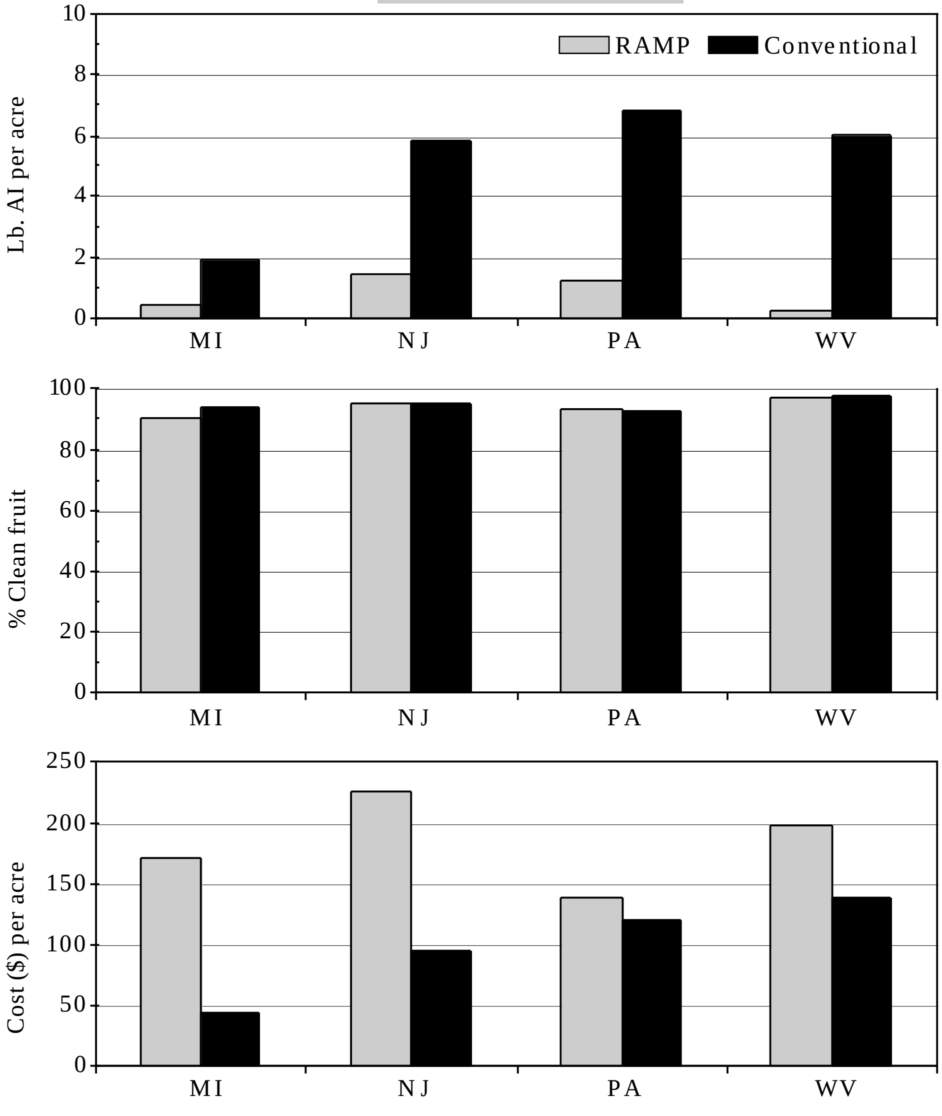

Figure 2. Mean insecticide use, fruit quality and insect management costs in RR and conventionally managed peaches, over four years in each state.

Multi-State Results

Overall results of this project for both apples and peaches are summarized in Figs. 1 and 2, respectively, which depict means across four years for each state. Most impressive was the dramatic reduction in pounds of insecticide applied in RR compared with conventional orchards; averaged across all states there was a 81.7% and 77.7% reduction in pounds AI per acre in apples and peaches, respectively. To illustrate the potential of these programs to minimize adverse environmental impacts, the four-year average cumulative environmental impact quotient (EIQ) (Kovach et al. 1992) for pesticides applied in seven Pennsylvania apple orchards was 157.9 and 29.5 in conventional and RR orchards, respectively, or a 5.3-fold EIQ reduction in RR orchards. Similarly, in five peach orchards the EIQ load in RR orchards was 5.9-fold lower than conventional orchards (195.9 vs. 33.4). This level of reduction equates to approximately 381 tons AI annually of mostly OP and carbamate insecticides if RR IPM programs were used on all apple acreage in the 6 states represented in this proposal (73% of eastern apple production), or 513 tons for all 186,000 acres in the east. For peaches, such a reduction would lead to 37 tons less AI of mostly OP insecticides applied annually to the participating states, with the potential of 97 tons less on the 58,300 acres in the east.

The level of insect control in RR and conventional blocks was very similar; the overall percentage of clean fruit (non-insect damaged) in apple plots was 93.7 (RR) and 94.3 (conventional) and in peaches 94.1 (RR) and 94.8 (conventional). However, the cost to obtain this level of control was considerably higher in RR blocks, with the cost for insect control averaging almost 78.5 and 85.1% higher in apple and peach RR blocks, respectively. Although RR insecticides were considerably more expensive than older broad-spectrum insecticides used in conventional blocks, pheromone dispensers for mating disruption were a major component of this higher cost. Average costs in the RR blocks without pheromone ties varied from a low of $210.82 / A in 2005 to a high of $237.73 / A in 2002, and average costs for the RR + PT varied from a low of $327.63 / A in 2005 to a high of $374.74 / A in 2004.

For the partial budget analysis used to evaluate the impact on profit from changes in insect management costs and fruit quality when adopting RAMP systems, yields were held constant at five-year averages (1998-2002) for the individual states, so only quality issues and spray costs relating to insect management were captured in the analysis. In apples, a total of 263 profit comparisons were made between blocks with conventional and RR programs, and only 57 RR comparisons (22%) were more profitable than their conventional insecticide program comparisons. When the analysis was further broken down, RR treatments without pheromone ties were more profitable in 43 out of 150 comparisons (29%), but in only 14 out of 113 comparisons (12%) for RR with pheromone ties. Overall, the difference in income between the conventional and RR blocks had narrowed from a high of $162.90 / A in 2002 to only $38.04 / A in 2005. The difference between conventional and RR + PT had narrowed from a high of $285.69 / A in 2002 to $128.27 / A in 2005. In peaches, a total of 65 comparisons were made of conventional and RR programs. The RR treatments were more profitable in 15 out of 65 comparisons (23%). However, unlike apples, the difference in income between the standard and RAMP blocks had actually widened from a low of only $6.27 / A in 2002 to $122.15 / A in 2005.

Summary

Extensive evaluations of insect pest management programs that use organophosphate (OP) insecticides to control plum curculio, CM, OFM and apple maggot have shown the effectiveness of these insecticides. In addition, because some predaceous mites and aphid predators have become resistant to OPs, successful biological control of phytophagous mites and aphids has been possible. However, because OP insecticides are toxic to other natural enemies in orchards, it has been difficult to obtain biological control of foliar pests such as leafhoppers and leafminers. In addition, leafrollers, OFM and leafminers that were formerly of minor importance in orchards, have become resistant to OPs and now must be controlled with other classes of insecticides, many of which are toxic to mite predators. Results from these small-plot evaluations of the new more selective, reduced-risk insecticides have shown that these compounds are effective against secondary pests such as aphids, leafhoppers, leafminers, and leafrollers. By using sampling and monitoring-based spray decisions, we have been able to show fruit damage from such direct pests as plum curculio, CM, OFM, and apple maggot in plots treated with reduced-risk materials to be as low as that occurring in plots treated with organophosphates, and at a generally comparable per-acre cost when mating disruption is not used. This project has helped show that selective insecticides alone, and in some cases integrated with mating disruption, can provide adequate control of direct pests of fruit for which there is no allowable tolerance of damage.

Acknowledgment

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Developing Gooseberries for Commercial Specialty Markets

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NorthEast Sustainable Agriculture Research and Education

The market is wide open for quality dessert gooseberries. Gooseberries are the most shelf-stable berry handled commercially. A gooseberry picked at the green mature stage and held at 0.5 C will ripen normally at room or refrigerator temperatures.

Gooseberries are an ideal candidate for development as a specialty fruit crop. Prices and demand have been high and have continued to grow during recent years. There is a wide variety of colors, shapes, and textures in the more than 200 varieties of gooseberries that are accessible in germplasm collections around the world. A small fraction of these are being cultivated commercially, and more of the varieties could easily be introduced commercially. A number of the varieties are similar, and it is possible to group them according to similarities for the convenience of buyers.

Growing Gooseberries

Gooseberries have the reputation in Europe as being easy to grow. Once established in New York plantings, they do fine, but getting them started can be a challenge. Anthracnose leaf spot, powdery mildew, and imported currant worm are the pests that have the greatest impact during establishment of the plants. During the first three years plants seem to creep along as they gain leaf area. Often I find that growers have anthracnose infections that appear and go undetected. In a matter of a couple of weeks the plants become defoliated, and begin to grow again in the late summer. Plants that are debilitated by such infections are much more susceptible to winter damage and winter kill of the entire plant. The bottom line is that pest control, especially for the three mentioned pests is critical, especially for young plants.

Cordon pruning is the recommended training system for fresh dessert gooseberries (Figure 1 and Figure 2). Advantages include larger fruit size, easier picking, better air ventilation for disease control, better spray penetration, and easier maintenance pruning. The disadvantaga-

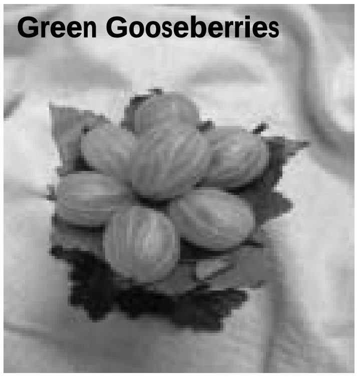
Figure 1. (left) Mature, cordon -trained gooseberry plants.
Figure 2. (above) Cordon-trained gooseberry plants.


Yellow Gooseberries


Red Gooseberries


Early Sulfur Gooseberries

Figure 3. Gooseberry grouping by color, texture, shape and size.


Green Gooseberries

es include cost of establishment and additional worker skill and attention needed for plant establishment. Cordon plants are spaced about 0.5 meters apart and trained up a single stake. Lateral branches are pruned out annually after bearing fruit as they are replaced by new one year wood.

Gooseberries are most easily propagated by stooling or layering to assure good rooted cuttings. Cuttings propagated during the summer months in the greenhouse are also quite successful. Success with rooting dormant cuttings varies with variety, but is not usually very dependable in New York.

Evaluating Gooseberry Varieties

As with any fruit species, it is important to evaluate fruit quality, yield, disease resistance, and bush growth habit. The focus of our evaluations has been on fruit quality since the berries have proven to be a very high value crop. Moderate yields with certain varieties can be compensated for by higher prices and pests mentioned above can be controlled with IPM practices. New higher yielding, disease-resistant varieties will be slow to appear due to limited funding for breeding and selection programs. We can build an industry by carefully choosing marketable varieties, and expanding breeding research in the future as funds become available.

The flavor sensation of gooseberries can be described as:

a) The juice, which is usually sweet in ripe gooseberries, is first to reach the palate, followed by a balancing when the acid is released as the skin is chewed.

b) The fragrance unique to each variety is picked up last as the fruit remains in the mouth and olfactory sensations are realized. Most gooseberries are sour when unripe, and sweeten up as they ripen. When slightly unripe to ripe, the fragrance is light and fruity. As the berries turn dead-ripe to over ripe, most of them take on a muscat-type heavy flavor.

Fruit size, texture, color, and shape varies among varieties. Size is determined genetically and by cultural practices. Some varieties such as 'Marigold' have the capacity to set heavy yields of large fruit, while others require cordon training and thinning to produce large fruit size. Shapes can include round, oval, and tear-dropped. Textures can be smooth or hairy. Colors vary in all shades of red, yellow, purple, green, and white. Some named varieties look and taste almost identical, and experts say that DNA tests could possibly prove them to be identical.

Varieties Commercially Available Today

Varieties available in the US are limited. A few are available on a commercial scale, and others on a small scale, or in the form of germplasm in the collection at Corvallis. One variety, 'Jeanne', was just released this summer at Corvallis, and the germplasm is available for multiplication. 'Jeanne' gooseberries are highly resistant to white pine blister rust and to powdery mildew. The plant's robustness protects it from insect threats as well. 'Jeanne' is highly resistant to pests like aphids and sawflies. According to NCGR research leader Kim Hummer, the plant produces green berries that ripen to a deep red as they mature to their full size of about 5 grams. 'Jeanne' also boasts a higher yield than similar cultivars such as 'Invicta' and 'Captivator', producing about 3.3 pounds of the flavorful fruits per plant during the growing season.

The following varieties are available in commercial quantities from nurseries in the US.

- 'Captivator': Antique red, tear-drop shape, medium size, late bearing, good flavor, semi-thornless
- 'Hinnomaki Red': Brilliant red, oval shaped, medium size, good flavor
- 'Invicta': Mildew immune, anthracnose susceptible, large, green, somewhat hairy, bland flavor
- 'Poorman': Red, oval shape, medium size, good flavor
- 'Tixia': Large, red, semi-thornless

The following varieties are available on a small scale

- 'Achilles': Large, red, round, industry standard in Holland
- 'Careless': Large, green, oval, good as cooking or fresh berry, industry standard in England
- 'Catherine': Large, green, oval to round
- 'Colossal': Large, green, oval to round
- 'Crown Bob': Large, oblong, red
- 'Early Sulfur': Early, hairy, golden, oval, excellent flavor

- 'Hoenigs Earliest': Smooth, golden, medium, good flavor
- 'Keepsake': Large, smooth, green
- 'Leveller': Very large, round, yellow-green, industry standard dessert berry in England, slow growing
- 'Sabine': Medium round, ruby red, sweet fruit
- 'Whinham's Industry': Large, round, red, industry standard in Holland
- 'Whitesmith': Large, round, green, industry standard in Holland

Varieties Not Yet Available, But Desirable

These varieties are available in European germplasm collections, and we are working to get them into the collection at Corvallis. Their fruits are desirable for the fresh dessert market. All have good flavor.

- 'Ajax': Large, round, deep red
- 'Champagne Yellow': Brilliant yellow, hairy, round
- 'Cousen's Seedling': Transparent golden, tear-drop shaped, a favorite when displayed
- 'Dan's Mistake': Round, red, smooth, large
- 'Firbob': Transparent yellow, large, smooth, as much as six week shelf life at 0.5 C
- 'Heart of Oak': Long tear-drop shaped, green smooth
- 'Ingall's Red Prolific': Long, tear-drop shaped, red, smooth
- 'Langley Gage': the sweetest gooseberry, white, smooth, oval to round
- 'London': Large, red, smooth
- 'Lord Elco': The largest gooseberry produced with no special care, green, smooth, oval
- 'Marigold': Yellow, late, large, very productive plant

Grouping Gooseberry Types

Gooseberries have been grouped together for their similarities. They could be sold as the same "type" of gooseberry on the commercial market without distinguishing between varieties. Grouping is possible by color, texture, shape, and size (Figure 3).

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