Orchard Network

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Temperature and UV Effects on Apple Trees and Crop Maturity

Author: John Gardner - Apple Specialist/OMAFRA
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Last winter's minimum temperatures have played a big role in hurting and indeed killing out blocks and individual trees through winter freeze injury. This is especially true for some of the more tender and less hardy apple cultivars grown in Ontario.

In contrast to the low temperatures this past winter, it's not difficult to convince anyone these days that this is one of the warmest summers on record. Compared to last year, one would think we're in a totally different climatic zone.

Apple trees and crop can suffer from extended periods of heat and high UV in the absence of liberal supplies of water in the soil environment. Rains in mid-late July in many of the districts have helped immensely in relieving stress symptoms in various blocks of trees. In this article I will attempt to summarize some of the temperature effects and possible outcomes.

The cost of maintaining cell function in apple at temperatures approaching 30°C can be very high in terms of tree respiration and net loss of carbohydrate in Ontario. This is one reason why a country like New Zealand can produce such high volumes of fruit on a per acre basis as compared to North Eastern North America.

The 2200 hours per year of sunshine in the Hawke's Bay area of New Zealand are typically coupled with relatively cool temperatures. Because of these moderate temperatures during the growing season, the trees do not have to work as hard in holding and sizing the crop. This is completely unlike what we have experienced in Ontario during the 2005 growing season. We have the sunshine but also extreme heat and UV to go with it.

The effect of high summer temperatures on certain cultivars is very obvious. Excessively high temperatures and solar radiation can cause sunburn. Cultivars like 'Crispin' or 'Mutsu' are especially vulnerable. This may be made even worse with summer pruning and opening up the canopy and removing foliage that would otherwise shade the fruit. The effects of this can be buffered with the use of irrigation water and more reliably products like Surround™ Crop Protectant containing kaolin. The Surround is also known to increase the rate of photosynthesis when compared to trees under heat stress.

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The volume of heat we have had in the early part of this growing season will likely influence fruit maturity of cultivars like 'McIntosh'. Growing degree days @ base 10ºC for the first 30 days after petal fall and time of pollination is more influential on maturity than higher temperatures around the onset of maturity. Growers are encouraged to use the starch

iodine test to follow maturity 2-3 weeks ahead of anticipated harvest dates for the 2005 growing season. Fruit maturity this year could be accelerated depending on cultivar, spray program and/or other factors influencing ethylene development in the canopy.

We have found through experience that aggressive use of calcium sprays for instance can accelerate maturity of cultivars like 'McIntosh' and 'Northern Spy'. The mechanism by which this occurs is not well understood but it appears to be related to the generation of canopy ethylene far above threshold values. Tests done in the late 90's in Ontario revealed that 'McIntosh' treated aggressively with various calcium salt formulations matured up to 10 days ahead of untreated checks. This represented a net loss in fruit volume, as apples did not have the opportunity to size. There was also the potential for premature abscission of fruit due to the presence of ethylene in the canopy several fold greater than what is considered to be a threshold value of 1 ppm.

Other treatments or conditions that can influence maturity of cultivars like 'McIntosh' include rootstock, varietal strain, presence or absence of infectious diseases and insects (mites), and the use of particle films such as Surround ® crop protectant.

How long into the growing season this heat will stay with us is anyone's guess. Temperatures during the 4-6 weeks immediately preceding harvest can influence the quality of the fruit at harvest and during the storage period.

There is plenty of evidence to relate the incidence of scald and watercore to temperatures being too high in the preharvest period. See the discussion on 'ReTain'™, in Publication 360, Fruit Production Recommendations. Please note that watercore (or "honeycore" as it is known in some cultivars) is a desirable characteristic and does not take a cultivar like 'Fuji' out of grade. 'Fuji' is a cultivar that was selected for its ability to produce honeycore. This is a trait that in some markets commands a premium price.

Cooler temperatures in the preharvest period result in less watercore (internal and visible watercore) and a reduced susceptibility to superficial scald. Researchers claim that what is needed is 100-150 hours of temperatures less than 10ºC in the month or so preceding harvest in order to reduce the chances of these disorders showing.

Colour development for some cultivars is related in part to night time temperatures, as all growers know. The pigments responsible for colour development in apples activate more efficiently with temperatures under 21ºC in the preharvest/ colouring period, provided there is sufficient light exposure on cultivars like 'McIntosh', 'Fuji', 'Empire' and 'Gala'.

Related Links

- Caution using ReTain on Stressed Trees, Hort Matters article, Vol 1, Issue 21
- Growth Regulators for Apples, OMAFRA Publication 360
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Making Compost in the Summer

Author: Hugh Martin - Organic Crop Production Program Lead/OMAFRA

Creation Date: 14 July 2005

Last Reviewed: 14 July 2005

Spring and summer is a great time to make compost. Get the manure in the spring and add extra carbon materials if needed to raise the C:N ratio to around 30:1, and put it out in windrows. Temperature should increase to over 55ºC with no problem, especially in a year like this.

There is however one other very, very important factor - water! To make good compost, the water content should be about 50-60% moisture. That is fairly easy to achieve in the spring with moist materials and an occasional rain. In a dry year like 2005, there has been no rain (in many areas) to replenish the moisture that is lost during the composting process. If the compost gets too dry, the microbes will stop working, and it will take longer to finish the compost. More importantly, if it gets too dry, spontaneous combustion can occur, which could destroy the compost and/or result in a fire hazard.

When making compost you should periodically check the temperature. During the active phase, the temperature should be over 55ºC for at least 15 days when in windrows (or 3 days if using an in-vessel or aerated system). During this time the bacteria and fungi are breaking down the carbon materials (straw, shavings, etc) to carbon dioxide, water and some other gases. Some water will go to the lower part of the pile (with gravity) and some of this water evaporates from the pile with the flow of warm air. As the compost in the top half and edges of the pile dries, the temperature increases above the optimum temperature and this kills some bacteria/fungi. Turning at this stage will help to eliminate the hot spots and the wet spots by making the pile/windrow more uniform and keep the compost process going.

You should also check the pile for moisture. The easiest way is to use a grab test. Reach into the pile in several areas and grab a handful. Squeeze it tight and then open your hand. If moisture oozes from between your fingers when you squeeze, it is too wet. If when you open your hand you see some beads of moisture on your hand but there is no excess water, it is about right. If you see no sign of moisture and the ball of compost is totally loose in your hand, it may be too dry.

When the compost is too dry you should add water to the pile. The best way to do this is to add water while turning. Some compost turners have adapters to add water while turning. This can take a significant amount of water. Irrigation over the top can help, but typically it would just put water on the top and a lot would run off, making it too muddy to turn the pile right after watering to mix it in.

Covering piles is another way to reduce moisture loss in the summer, but you still need to monitor the moisture and temperature. Covers can be fabric or a 6 inch layer of compost or straw. Plastic sheets are not suitable because the pile must be able to breathe to allow for carbon dioxide and other gases to escape, and for oxygen to get into the pile.

It is easy to put out the compost and forget it when you are busy, but stop and have a look once in a while. For more information on composting see the new OMAFRA factsheets - Agricultural Composting Basics (Order #05-023) or

Manure Composting as a Pathogen Reduction Strategy (Order #05-021).

Compost turner mixing pile to distribute moisture and heat evenly.
Note the steam released from the centre of the pile

Freshly turned compost pile with moisture returned to the surface.

Related Links

- Agricultural Composting Basics, OMAFRA Factsheet Order 05-023
- Manure Composting as a Pathogen Reduction Strategy , OMAFRA Factsheet Order 05-021

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Light Management Using Reflected Light

Author: John Gardner - Apple Specialist/OMAFRA

Creation Date: 15 August 2005

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It was great to see the good turn out at Simcoe in late June to look at the various research projects underway at the station. For many Ontario growers, it was the first opportunity to see the reflective ground cover technology that is gaining a lot of attention worldwide in temperate tree crop culture and in particular where apples are grown.

One of the continuing interests I have is that of light management. If we look at the limiting factors for total yield and recoverable yield of high quality fruit, light interception and distribution can make or break a planting. Under average conditions in Ontario, we normally underutilize the incoming light and have traditionally been unable to capture and use light that ends up going to the ground.

The different fruit production areas of the Northern Hemisphere are now familiar with the use of reflective blankets between tree rows. Jonathan Toye of Extenday mentioned that approximately 30% of the tree fruit acreage in the Hawke's Bay area of New Zealand now see treatment by these fabrics compared to almost none only a few years ago. On any given farm the grower will move the material from crop to crop and cultivar to cultivar depending on the wanted effect.

In Ontario, we have some experience with this type of technology, in our use of reflective mulches. Some Ontario growers have shown the effects of these types of treatments for several years now.

A lot of the orchards in New Zealand are very high yielding and report a rate of return on investment using the fabric shown in Simcoe of over 100% based on the usable life of the fabric. Under high light conditions these re-usable materials will last 30 months of in-orchard use.

The fabrics are normally handled mechanically as far as application and recovery at the end of the growing season. They are spooled out and retrieved by various motorized pieces of equipment. They can be easily moved from block to block using something as simple as a four wheeler.

A fastening system using bungee cords holds the fabric in place. The fabric is suspended over the sod and loose enough to allow air movement and wind action to throw dirt and debris off the surface of the material. Both air and rain water can move freely downwards into the soil.

This fabric comes in various widths, lengths and reflective properties to allow for custom fit into any planting. Some growers in the U.S. and elsewhere have opted for alternate row application, which drops the cost in half while maintaining the bulk of the benefits that arise from its usage on a per acre basis. Estimated costs range from about $500.00 – 3000.00 U.S. per acre depending on the width of the fabric and where it is used (one side, both sides of the row, fully covered or alternate rows only).

Figure 1 – Light reflective blanket manufactured by Extenday®. The blanket has the ability to control light distribution in the tree canopy as well as helping to control evaporative water losses from the orchard ecosystem.

Benefits can vary from enhanced fruit bud development, fruit colour, sugars, recoverable yield, and water conservation. The attached figure (Figure 1.) shows the sod under the end of the blanket on July 19th. The arrow indicates the line of division between treatments. The sod and soil under the blanket remain cool and moist while the control sod is more or less dormant and the soil would be considered to be hot and very dry. There is enough light going through the blanket material to allow the sod to live and yet not enough to have it overly vigorous and unmanageable. The fabric is tough enough to drive over. The sod is left unmowed for the time that it is covered.

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An Update on the Provincial Apple Cultivar Trials

Author: John Gardner - Apple Specialist/OMAFRA

Creation Date: 15 August 2005

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This year we will be keeping a close watch on some of the last material to be planted at the various sites across Ontario. Specifically we will be looking at some of the B.C. cultivars and selections for finish problems. The one notable is the 'Aurora Golden Gala' formerly 8S-69-23 out of the PICO program. At this point in time in Ontario, mature trees of this specific cultivar planted out years ago while it was still a numbered selection are not producing a quality finish that is necessary for a 'Golden Delicious' type of apple.

'Aurora Golden Gala' was planted into the eight sites in the spring of 2004 and most of the trees now have enough crop on them this year to get a feel for the apple at maturity. Like some of the other 'Gala' x 'Splendour' crosses tested in the North East at various locations including Michigan, New York etc. fruit finish has not generally been satisfactory.

The 'Aurora Golden Gala' tree is known for its excellent and tight growth habit as well as its high quality fruit as grown under B.C. conditions and climate. Unlike B.C., our climate can be described as a humid continental climate that produces russeting problems on sensitive cultivars.

Ontario's growing season this year may not produce the amount of russet we can see in a year when spring conditions can be described as cooler and damper. This year our spring has been very warm and dry for the most part. I would suggest that some of the russeting we normally see may not be seen this year in any sort of abundance on susceptible cultivars.

This of course is subject to the various treatment regimes that these cultivars may be grown under. As of early August, no evidence of russeting is showing on the 'Aurora' test trees at the Lambton County site.

I would be pleased to hear from any producers or experimenters who have 'Aurora Golden Gala' in production.

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Feeling the Burn of Fire Blight

Author: Kathryn Carter - Apple IPM Specialist/OMAFRA; Neil Carter - Tender Fruit and Grape IPM Specialist;/OMAFRA; Michael Celetti - Plant Pathologist, Horticultural Crops/ OMAFRA

Creation Date: 15 August 2005

Last Reviewed: 15 August 2005

In the past week, fire blight symptoms have begun to appear in apple orchards throughout Ontario and even in Quebec. Fire blight is caused by *Erwinia amylovora*, a pathogenic bacteria that infects the blooms, fruit, leaves, shoots, limbs, trunks and rootstocks of apple and pear trees.

So why are we starting to see these symptoms in orchards now? Fire blight often enters the tree through blossoms during bloom. Although many growers applied streptomycin sprays at bloom based on predictive models (Cougar Blight, and MaryBlyt), the extended bloom and secondary bloom that we saw in some regions may have left blossoms vulnerable to attack from bacteria. The symptoms of these early season infections may be appearing now in apple orchards. Fire blight also enters trees through wounds caused by hail, insects, summer pruning, deer feeding, and even high winds. So the infections that are appearing in some areas may be a result of post bloom infections. It is also important to remember that trees (particularly young trees) can be infected the previous year and may not exhibit symptoms of the disease until the subsequent year (personal communication. Dr. Antonet Svircev, AAFC). Once a tree is infected with fire blight, the bacteria move quickly through the current seasons growth into older growth. The bacteria that causes fire blight multiplies in the hot humid conditions we have been experiencing over the past few weeks, rapidly increasing the development of the disease. Young trees (bearing and non-bearing) can be killed by this disease, and older mature trees may survive but show significant damage.

So now that fire blight is present in orchards what options do growers have for managing this serious disease? To prune or not to prune—that is the question all growers are asking. Unfortunately there is no easy answer to this question, since the severity of the infection and the weather conditions suitable for infection both have an impact on the decision.

Pruning the trees at this time of year can have several effects:

- Reduce the innoculum, and prevent the spread of disease
- Increase shoot growth, making the tree even more susceptible to fire blight
- Increase labour costs.

So how do you know whether to prune or not to prune? When dealing with older (>10 year old) vigourous trees that have many fire blight strikes, avoid pruning out shoot and blossom strikes early in the growing season. Extensive early pruning stimulates trees to produce succulent shoots, making the tree more susceptible to infections. When dealing with high vigour trees that have only a few fire blight infections, pruning out the fire blight may help to provide complete control of this disease. In slow growing, low vigour trees, the bacteria generally doesn't move into major limbs or trunks during the growing season, so lesions can be pruned out when the tree is dormant. This may help save time and

money. . In comparison, young vigourous trees are very susceptible to fire blight and the bacteria may move rapidly into the trunk and down to the rootstock, killing the tree. As a result, pruning is recommended on young trees.

In orchards where fire blight is not a major concern this year, growers may still consider pruning fire blight strikes. Pruning out fire blight cankers, under dry conditions and low disease pressure may reduce the amount of bacteria that will be present in the orchard in future years.

If you are considering pruning out infections in a young orchard, you should do so as soon as they appear to prevent the spread of the disease to adjacent trees. Depending on the variety, it may or may not be practical to prune out infections in mature trees. Keep in mind that once the terminal buds have set on apple trees, fire blight stops spreading within infected trees and between trees. However, leaving the disease in the orchard may serve as a source of inoculum, and cause increased infections should a hail storm, severe storm, or high wind damage the trees and provide an entrance wound for the bacteria to infect.

If you decide to prune out fire blight strikes, pruning should not be initiated until terminal bud set has occurred (early to mid August) and remember to make cuts into at least 2-year-old wood where the bacteria is less likely to multiply. Pruning cuts should be about 30 cm (12 inches or more) below the visible symptoms. Always prune during dry weather, since it reduces the potential for spreading the disease. The efficacy of sterilizing pruning shears to prevent the spread of fire blight is debatable, and sterilization may not always be practical. Regardless, pruning tools should be sterilized in a solution of 1 part bleach to 5 parts water, this solution will be effective in about 1 minute of wetting. It should be noted that there is no benefit by spraying cut surfaces on the tree with chlorine products, since the chlorine binds with the wood and is inactivated immediately. See info sheet from the Washington State University on Cutting Fire Blight from Infected Apple and Pear.

In sections where trees are severely affected, it may be more cost-effective to simply remove the whole tree than to prune it. Pruning clippings should be tossed into the row middles and allowed to dry before mowing them down. Avoid hand thinning, bud pinching and other activities until after terminal set, since these activities may help to spread the disease. Monitoring and managing insects (aphids, leafhoppers) that may spread the bacteria or cause wounds for the pathogen to enter tissue is important fire blight management. Orchards with high levels of fire blight this year will have a high inoculum next year, and as a result growers will need to use predictive models (Cougar Blight, and MaryBlyt) to determine if and when applications of streptomycin at bloom are necessary.

Consult the OMAFRA factsheet *Fire Blight of Apple and Pear in Ontario*, Order No. 02-011 for more information on fire blight.

Related Link

- Info Sheet on Cutting Fire Blight from Apple & Pear, Washington State University
- Fire Blight of Apple and Pear in Ontario, Order No. 02,011

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Summer Diseases of Apple: To Spray or Not to Spray

Author: Michael Celetti - Plant Pathologist, Horticulture Crops Program Lead/OMAFRA

Creation Date: 15 August 2005

Last Reviewed: 15 August 2005

To spray or not to spray, that is the question for summer disease control in apple and pear, especially during a dry year. Summer diseases of pome fruit can significantly reduce the quality and marketability of fruit. Severe disease is favoured by cool wet springs, with extended periods of wetness from summer rains, and cool weather prior to harvest. But what is the risk of these diseases causing significant damage during this dry season?

The two most important summer diseases of apple and pear in Ontario are:

- Sooty blotch caused by the fungi *Gloeodes pomigena, Peltaster fructicola, Geastrumia polystigmatis, Leptodontium elatius*
- Fly speck caused by the fungus *Schizothyrium pomi* (*Zygophiala jamaicensis*).

Sooty blotch appears as brown or green blotches on the outer skin of the fruit. These blotches are in fact dark, tiny fruiting structures of the fungi, all connected with a loose, profusely branched thread-like fungal growths. On the other hand, flyspeck appears as small, shiny black dots that cluster in groups of a few to about 100 (Figure 1). These dots are the sexual fruiting structures, also connected by inconspicuous thread-like growth. Neither of these fungi penetrates the epidermis, growing superficially on the surface. The result is dirty looking fruit, unappealing to consumers. Both diseases have similar biology, occur around the same time and can be managed the same way.

Both diseases overwinter on branches of wild woody plants, in addition to apple and pear. Infection and disease development are favoured by extended periods of wet, humid weather during late summer. Although wet weather has been sporadic so far, the development of these diseases can still occur quickly if favourable conditions occur.

Fly speck produces ascospores (they will be the primary inoculum released next spring from before bloom until 10 days after petal fall). This is similar timing for apple scab spore release. Fungicides such as Flint or Sovran applied for apple scab in the spring also control fly speck primary infections. Unlike apple scab, very few of the fly speck ascospores would reach the small developing fruit in the spring. Regardless, these spores do reach alternative wild hosts near orchards, and will initiate infections that produce secondary inoculum. This secondary inoculum is blown from the alternative hosts into the orchard throughout the summer. Look for these diseases on fruit in border trees in close proximity to wooded areas.

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Figure 1 – Small shinny black dots in a cluster are typical symptoms of Fly Speck.

The fungi do not grow well, if at all, when temperatures reach above 29ºC. Researchers in North Carolina have shown that 270 hours of accumulated wetness either due to rains or dew is required to produce symptoms of fly speck. This was verified in trials conducted by Cornell University researchers in 2003. Because of our warm spring and early summer temperatures, any spring infections may not show up until the weather turns cool and wet in late summer.

Dr. Dave Rosenberger, plant pathologist at Cornell University, calculated that the initial infection on wild hosts requires 270 hours of leaf wetness in the spring, and that an additional 270 hours of fruit wetness in mid-summer is required for fruit infection. This means that a grand total of 540 hours of wetness after petal fall are required before symptoms actually appear in the orchard. During a dry year, fungicide sprays are not necessary for summer disease control until later in July.

To spray or not to spray for summer disease this year is still a good question. Last year was a cool, wet summer, with ideal conditions for summer diseases to buildup on alternative hosts. The overwintering inoculum on wild hosts was likely higher than in previous years. Although conditions have not been conducive for summer diseases so far this season, and symptoms may not show up until mid August, a registered fungicide at the end of July will ensure protection of fruit. Poor summer disease control is usually a result of poor spray coverage. Spray coverage for summer fungicides is better when fruit are smaller and limbs are not bent with fruit loads. A fungicide application at the end of July will also help prevent powdery mildew, black rot and white rot.

A single application in late July may provide season long control of summer disease during a dry year. However, an application at the end of July followed by another application 3 weeks later is a safer strategy. If more than 5 mm (2 inches) of rain falls after the second application, another application may be necessary in early September, particularly on varieties that won't be harvested until late September. So keep an eye to the sky to decide if a third fungicide application is necessary.

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Blister Spot on Mutsu (Crispin) Apples

Author: Michael Celetti, Plant Pathologist- Horticulture Crops Program Lead/OMAFRA

Creation Date: 09 June 2005

Last Reviewed: 09 June 2005

Apple growers know the cultivar Mutsu (or Crispin) is highly susceptible to the disease Blister Spot. The disease is caused by a bacterium *Pseudomonas syringae* pv.*papulans* that is present in most orchards. Other cultivars like Golden Delicious, Red Delicious, Jonagold and Cortland are also susceptible to this disease, especially when grown near infected Mutsu trees.

The bacteria overwinter in buds, leaf scars and diseased fruit on the orchard floor from the previous season. Infected buds may appear healthy, but the bacteria multiply during the spring and are rain splashed throughout the orchard. Bacteria can survive and multiply on leaves, wood and weeds in the orchard without causing any disease symptoms. During late spring or early summer, a brief shower can splash bacteria onto the fruit to infect through the fruit pores or lenticels. Fruit are most susceptible from 2-6 weeks after petal fall. Symptoms may not appear until 2-3 months later, but at this time, bacteria can no longer infect the fruit. Initial infections appear as small water-soaked raised blisters associated with the lenticels. The first spots are often near the calyx of fruit from the sun-facing side of the tree. Lesions become purplish black, only expanding to 4-5 mm in diameter, and rarely penetrate the flesh (Figure 1). Lesions do not develop into fruit decay, but several (to 100+) blister spots can occur on a single fruit reducing the quality significantly.

Figure 1. Blister spot symptoms on a Mutsu (Crispin) apple.

Two products are registered to control Blister spot in Ontario, Aliette WDG and Copper 53W.
Aliette WDG is applied at petal fall, followed by 2 more applications at 7-day intervals. No more than 3 applications of Aliette are allowed per season. Research in New York and Ohio during the mid 1990's indicate that Aliette will suppress the severity of Blister spot infections under heavy disease pressure. Earlier applications may provide better control; however, the economics of 3 applications may not be justified if only suppression results. Early application at petal fall appears to be the most important.
Copper 53W should be applied not earlier than 10 days after petal fall to reduce injury. Hydrated lime should also be mixed with the copper as a safener. Do not mix Aliette with copper.

For more information consult OMAFRA Fruit Production Recommendations.

Related Links

- OMAFRA Fruit Production Recommendations, Publication 360

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Research Updates from the 9th International Controlled Atmosphere Research Conference

Author: Dr. Jennifer DeEll - Fresh Market Quality Program Lead/OMAFRA
Creation Date: 15 August 2005
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The following summaries are a few of the notable oral and poster contributions related to controlled atmosphere storage of apples that were recently presented at the 9th International CA Research Conference in East Lansing, Michigan.

Inhibition of ethylene action alters apple and pear fruit responses to CA environments with elevated CO_2, O_2 and/or temperature – David Rudell, Jim Mattheis, and John Fellman, USDA and Washington State University

Several cultivars of apple ('Delicious', 'Gala', 'Golden Delicious') and pear ('Bartlett', 'd'Anjou') were used to evaluate how inhibition of ethylene action by 1-MCP impacts fruit response to CA conditions and temperature during storage. In some studies fruit were harvested on multiple dates to incorporate maturity at harvest as another variable. In all studies, fruit were exposed to 1-MCP on the day of harvest for 14-16 hours, then transferred to CA chambers and held for 24 hours prior to establishment of CA conditions. Studies were conducted using CA systems in which atmospheres were established and maintained using flow-through or static environments. Fruit were removed from CA chambers at either 2 ('Bartlett', 'Gala') or 3 ('d'Anjou', 'Delicious', 'Golden Delicious') month intervals and then rated for external color, disorders and decay incidence. After a 7-day period during which fruit were held at 20ºC, external (color, disorders, decay) and internal quality were evaluated. For the cultivars evaluated, impacts of higher O_2 and CO_2 CA conditions observed were dependent in part on maturity at harvest and storage duration. Exposure to 1-MCP slowed ripening in CA with up to 5% O_2, however, the impact of 1-MCP decreased with increased O_2 concentration and storage duration. Exposure to 1-MCP also slowed ripening at temperatures up to 5ºC. Control of superficial scald on 'Delicious' and 'd'Anjou' was not compromised by increased O_2 set points. Accelerated ripening (softening, degreening) of 1-MCP treated 'd'Anjou' pears stored in 3 or 5% O_2 was observed after 6 and 9 months plus 7 days at 20ºC, but only after 9 months did fruit soften to less than 5.8 lb. Peel degreening increased with CA O_2 concentration but occurred at a slower rate in 1-MCP treated fruit. Development of peel CO_2 injury on 'Golden Delicious' apples was enhanced by 1-MCP treatment.

Absorption of 1-MCP by non-target materials during storage – Fernando Vallejo and Randolph Beaudry, Michigan State University

We tested the sorptive capacity of a number of non-target materials found in apple storage rooms on their capacity to remove 1-MCP from the storage and thereby compete with the fruit for the active compound. Further, we evaluated the

impact of temperature and moisture. Non-target materials included bin construction materials (high density polyethylene (HDPE), polypropylene (PP), weathered oak, non-weathered oak, plywood, and cardboard) and wall construction materials (polyurethane foam and cellulose-based fire retardant). Each piece had an external surface area of 76.9 cm^2. We placed our 'non-target' materials in 1-L mason jars and added 1-MCP gas to the headspace at an initial concentration of approximately 30 ppm. Gas concentrations were measured after 2, 4, 6, 8, 10 and 24 hours. The concentration of 1-MCP in empty jars was stable for the 24-hour holding period. Little to no sorption was detected in jars containing dry samples of HDPE, PP, cardboard, polyurethane foam, or fire retardant. Inclusion of plywood, non-weathered oak and weathered oak lead to a loss of 10, 55, and 75% of the 1-MCP after 24 hours. Using dampened materials, no sorption resulted from the inclusion of HDPE, PP, polyurethane foam, or the fire retardant. However, the rate of sorption was not impacted by temperature, and increasing the surface area by approximately 100% only marginally increased the rate of sorption. When dampened oak bin material was included with apple fruit in a proportion similar to that found in fruit storage, 80% depletion occurred in 5 hours compared to approximately 24 hour for fruit alone. The data suggest that in situations where 1-MCP levels can be compromised by wooden and cardboard bin and bin liner materials, but not by plastic bin materials or typical wall construction materials.

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Lenticel breakdown of apples following storage and packing – Eugene Kupferman, Eric Curry and Chris Sater, Washington State University

International competition among apple producers has elevated apple appearance to the point that any blemish or marking is unacceptable. Lenticel breakdown (LB) has become more common in recent years on certain varieties including 'Gala', 'Fuji' and possibly 'Pink Lady' apples. LB develops after the fruit has been stored (CA or air), washed and waxed. LB does not develop as significant marking on fruit until after all processes have been completed and all economic inputs have been made. LB appears as either dark black spots surrounding some lenticels or as brown larger circles centered around lenticels. Not all lenticels are affected and the flesh of the fruit is not impacted. Certain orchards have fruit that develops LB more than fruits from other orchards. Evidence will be presented to show that LB develops on lenticels that are cracked, dehydrated and lacking in natural wax. A test has been developed to determine the susceptibility of fruit from specific orchards. Packing procedures have been evaluated extensively in which fruit and water temperatures, soap and detergents, and waxes have been tested. Strategies will be presented on how commercial packers can minimize economic loss from this disorder.

Commercial application of 1-MCP affects storability and disorders of 'Empire' apples – Jennifer DeEll, Jennifer Ayres, and Dennis Murr, Ontario

The objective of this study was to determine the effects of commercial 1-MCP treatment on the incidence of disorders and storability of 'Empire' apples. 'Empire' fruit were commercially harvested from 21 orchards in southwest Ontario and delivered to two storage operations during the 2003 season. Samples were collected from each orchard and half of the fruit from each sample was placed in the appropriate CA room for 1-MCP treatment (SmartFresh™, 0.7-0.8 ppm, 24 hours at 1.1-1.4ºC), while the other half was placed at a similar temperature during the treatment period and then returned to the matching CA room for storage. 'Empire' apples treated with 1-MCP had significantly less internal ethylene and were firmer than non-treated fruit after 14 days at 22ºC following treatment. These effects were also observed after CA storage, although there was no significant effect on fruit firmness at storage A where apples had also maintained good firmness (> 15 lb-force) without 1-MCP treatment. Internal browning developed after 9 months in 'Empire' apples at storage A and treatment with 1-MCP did not significantly affect the incidence. External CO_2 injury was observed on some 'Empire' fruit at storage B and the incidence was higher in apples treated with 1-MCP. It is important to note that no CO_2 injury was observed at storage A, where all apples were drenched with DPA prior to storage.

Interactive effects of 1-MCP, methyl jasmonate and CA storage on quality of 'Fuji' apple

fruit – Luiz Argent, Jim Mattheis, et al., USDA, Washington State

The present study evaluated how postharvest treatment with 1-MCP and methyl jasmonate (MJ) affects responses of 'Fuji' apple fruit to CA storage conditions. 'Fuji' apples were harvested 1 week after optimum maturity for long-term storage from a commercial orchard in north central Washington (seasons one and two) and from four commercial orchards in Santa Catarina, Brazil (season three). Fruit were cooled to 0.5ºC within 24 h of harvest and then stored in air or controlled atmosphere (CA). Fruit from season one were stored in CA with 2% O_2 + 0.05% CO_2; 0.25% O_2 + 0.05% CO_2 or 2% O_2 + 3% CO_2 for 6 months. Fruit from seasons two and three were sorted in CA with 1.5% O_2 + 0.05% CO_2 or 1.5% O_2 + 3% CO_2 for 8 months as a rapid CA (established within 72 h of harvest) or a delayed CA (established after 2, 3, 4 or 6 weeks or harvest). In addition, CO_2 levels in low CO_2 –CA (1.5% O_2 + 0.05% CO_2) were increased to 3% after 1, 2 or 3 months of harvest. Fruit were treated with 1 mM MJ or 1 ppm 1-MCP at harvest. Both CA conditions and 1-MCP treatment reduced ethylene production, improved maintenance of firmness and titratable acidity and reduced incidence of scald and core flush during long-term storage compared with untreated fruit stored in air. 1-MCP treatment was as or more effective as low CO_2-CA storage for reducing ethylene production and preservation of firmness and acidity in 'Fuji' apples depending on season and/or storage period. 'Fuji' apples stored in 3% CO_2 developed internal browning (CO_2-injury) while fruit stored in 0.25% O_2, 0.05% CO_2 or air did not, regardless of 1-MCP treatment. There were no significant impacts of 1-MCP treatment enhanced incidence and severity of CO_2 injury in rapid CA-stored fruit from Washington, while 1-MCP treatment enhanced incidence and severity of CO_2 injury in rapid CA-stored fruit from Brazil. MJ treatment reduced severity of CO_2-injury. Delaying CA (1.5% O_2 + 3% CO_2) or CO_2 (3%) accumulation during CA reduced the incidence of CO_2-injury. However, CA– and CO_2-delay procedures were less effective on prevention of CO_2-injury for fruit treated with 1-MCP compared with untreated fruit regardless of orchard and region. Results indicate that 1-MCP treatment increased CO_2 injury sensitivity in the earlier period of storage when 'Fuji' apples are more susceptible to CO_2-injury.

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1-MCP affects physiological disorders in 'Granny Smith' apples depending on maturation stage – Gabriela Calvo and Candan Ana Paula, Argentina

'Granny Smith' apples are very susceptible to various physiological disorders, with superficial scald being the most important. Application of 1-MCP to 'Granny Smith' may extend storage life by reducing scald, loss of firmness and acidity. However, other skin disorders may be enhanced by 1-MCP. The effect of 1-MCP on the incidence of disorder development, ripening during storage, and subsequent shelf-life was investigated in 'Granny Smith' apples from different maturity stages (38, 42 and 52% starch degradation). Fruit were exposed to 0 (control) or 0.6 ppm 1-MCP at 1ºC during 24 hours. After 120, 180, 210 and 240 days in regular air at 0.5ºC, fruit were evaluated upon removal from storage and after 7 and 14 days at 20ºC. Application of 1-MCP effectively delayed the ripening rate of the fruit harvested at different times, as indicated by better retention of green peel color, firmness and titratable acidity. 1-MCP treatment significantly reduced superficial scald. Treated fruit developed scald after 240 days of cold storage, while controls developed scald after 120 days. Core flush incidence was also reduced by 1-MCP treatment, even in the fruit from the later harvest, which was the most affected by this disorder. In every evaluation, there was fruit affected by physiological disorders related to calcium deficit, such as bitter pit and lenticel blotch pit. In early-harvested fruit, 1-MCP treated fruit developed less bitter pit and more lenticel blotch pit, but the incidence of both disorders was higher in 1-MCP treated fruit than in control. No significant differences between treatments were detected in second and third harvest dates. We concluded that the effect of 1-MCP on different physiological disorders differs with fruit maturity stage. Disorders related to deficit of calcium where enhanced in 1-MCP treated fruit from early harvest, and as the length of storage increased.

Efficacy of fungicides applied by thermofogging and standard commercial drenching

against postharvest diseases on apple and pear fruit – Peter Sanderson et al., Pace International LLC, Washington State and Chile

Fungicides were applied using a XEDA Electrofog machine to 'Red Delicious' apple and 'd'Anjou' pear fruit in Washington State and 'Fuji' apple fruit in Chile. Formulations of imazalil, thiabendazole (TBZ), fludioxonil, and pyrimethanil were applied to bins of 'Red Delicious' apple and 'd'Anjou' pear fruits immediately after harvest. Decay incidence in both *Penicillium expansum* inoculated and uninoculated fruit was assessed following 6 mo CA storage. Bins of Fuji apples were either fogged with fludioxonil, pyrimethanil, or TBZ, or drenched with TBZ plus DPA from a commercial drencher. Fruit were stored at 10ºC for 8 week and decay incidence in fruit inoculated with *Botrytis cinerea* was assessed. Decay in non-inoculated fruit was assessed after an additional 4 weeks of storage. In all trials, pyrimethanil was significantly more effective at controlling disease in inoculated fruit than all other fungicides. Pyrimethanil controlled 73% of blue mold infections in 'Red Delicious' apples compared to untreated fruit vs. 8•19% control from other fungicides. In pear it controlled 60% of blue mold infections compared to untreated fruit, whereas other fungicides only controlled 1-8% of infections. Gray mold was the predominate disease occurring in non-inoculated fruit. All treatments with exception of imazalil significantly reduced gray mold incidence in both apple and pear fruits. In the second trial, pyrimethanil was again the most effective fungicide for controlling gray mold in inoculated fruit (91.2% control vs. 0% control from fludioxonil, and 29% and 23% control from TBZ fogging and drenching, respectively). In unwounded fruit, however, both pyrimethanil and fludioxonil gave similar levels of disease control (65.9% control and 58.9% control, respectively). Disease incidence in non-inoculated fruit was not affected by fogged TBZ and was 50% greater in TBZ drenched fruit than in untreated fruit. Pyrimethanil appears to be the most promising candidate fungicide for commercial development for fogging applications.

Future of modified atmosphere research – Adel Kader, University of California

It is not possible to discuss the future of modified atmosphere (MA) research without considering the broader aspects of research aimed at maintaining quality of fresh horticultural perishables between harvest and consumption. Providing better flavoured fruits and vegetables is likely to increase their consumption, which would be good for the producers and marketers (making more money or at least staying in business) as well as for the consumers (increased consumption of healthy foods). To achieve this goal, we and all those involved in producing and marketing fruits and vegetables need to: (1) replace poor flavour cultivars with good flavour cultivars from among those that already exist and/or by selecting new cultivars with superior flavour and good texture; (2) identify optimal cultural practices that maximize flavour quality, such as optimizing crop load and avoiding excess nitrogen and water; (3) encourage producers to harvest fruits at partially-ripe to fully-ripe stages and vegetables at their optimal maturity stages by developing handling methods that protect these commodities from physical damage; (4) identify optimal postharvest handling conditions (time, temperature, relative humidity, atmospheric composition) that maintain flavour quality of fruits and vegetables and their value-added products. Postharvest-life should be determined on the basis of flavour rather than appearance. The end of the flavour-life results from losses in sugars, acids, and aroma volatiles (especially esters) and/or development of off-flavours (due to fermentative metabolism or odour transfer from fungi or other sources); (5) develop ready-to-eat, value-added products with good flavour; (6) optimize maturity/ripeness stage at the time of processing and select processing methods to retain good flavour of the processed products. Future MA research can be part of research on strategies number 4, 5, and 6 listed above. Continued improvements in polymeric films and other packaging materials will facilitate expanded use of MA packaging to extend post harvest-life of fresh-cut fruits and vegetables and permit their distribution via vending machines. More cost-effective methods for establishing and maintaining MAs will facilitate their use during storage at shipping points, transportation, and storage at destination points. Maintaining the MA chain is the second most important factor after the cold chain in keeping quality and safety of fresh produce between harvest and consumption. Further evaluations are needed of: (1) the synergistic effects of MA and the ethylene-action-inhibitor, 1-MCP, on delaying ripening of partially-ripe climacteric fruits and senescence of vegetables; (2) MA as a component of post harvest integrated pest management (decay of insect control); (3) MA in relation to food safety considerations; and (4) the biological basis of MA effects on fresh horticultural perishables.

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