



ORCHARD NETWORK

For Commercial Apple Producers

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ORCHARD MANAGEMENT

The Tall Spindle Could be the Shape of the Future

John Gardner, Apple Specialist, OMAFRA, London

Ontario apple growers do not have to look too far back in the past for when the word "spindle" was completely new to them. This terminology had its birth place in the higher density plantings found in progressive apple growing areas in Europe. The spindle tree was characterized as a dwarfish tree that was very busy and productive looking and occupying a relatively small volume of space. This look did not fall too far on the heels of what we called a central leader tree, which could be described as state of the art back longer than I care to remember. Today we can still find well managed high yielding central leader orchards in Ontario and the northeast of North America.

All styles of tree design of the last 30 years have one characteristic in common – they employed varying amounts of structural wood or scaffolding framework that was considered to be integral and semi-permanent.



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Ideally these trees were pyramidal in shape for light distribution benefits and one could easily find branches coming off the main trunk that were 10 cm in diameter. The concept was to build scaffolding as the tree matured and filled its space. Many of these orchards were built to be free standing. Concepts have changed dramatically in the last few years as the vast majority of acreage is now supported and planted to higher density systems.

This is in part a response to the need not only for the production of quality fruit as fast as possible but for the need to do it in ways that have the potential to take advantage of cost saving technologies when it comes to managing the crop from pruning to harvest.

When we incorporate the concept of higher density planting with some moderation and compromise on the cost of plant materials and establishment we arrive at what is now being called the tall spindle system. This system is said to be the best alternative to super spindle without the investment associated with setting out 2000 trees per acre. It would almost appear to me to be a hybrid of a traditional axe planting and a super spindle.



Figure 1 - Tying of limbs on well feathered nursery stock below horizontal is a key feature of the tall spindle training system.

The tall spindle orchard has the following characteristics:

- Planting densities of an estimated 1,000-1,200 trees per acre and possibly up to 1500 trees per acre depending on cultivar
- Fully dwarfing rootstocks employed
- Highly feathered nursery trees used
- Bending and tying of feathers as shown in Figure 1 instead of cutting or pruning when planting
- Limb renewal based on a permitted maximum diameter of around 2 cm
- No permanent scaffolding

What does remain to be seen is how some of our new cultivars will fit this type of planting. Scion varieties that are strong and vigorous may not do well in this type of a planting system. Some cultivars are better suited to confinement in this type of system.

Growth regulators may help keep some varieties in their assigned space while for others it may be too costly to keep trees in check at these spacings.

Ultimately the driver for this type of system will be economics and rate of return on investment for the grower. With some interest in the use of mechanical/platform aids in performing various tasks where workers ride rather than walk and climb, we are going to see more of this type of planting system.

This style of planting will be part of what is now called a revenue driven orchard system as opposed to a cost containment system of management.

Dr. Terrence Robinson and Steve Hoying of Cornell University, New York, have done a lot of work with the tall spindle in comparing it to other systems.

Performance and Availability of the Vineland (V.) Series Apple Rootstocks

Dr. John A. Cline, Associate Professor, and Debbie Norton, Agricultural Technician, Dept. of Plant Agriculture, University of Guelph

Introduction

The Vineland ('V.') series of apple rootstocks originated as open-pollinated hybrids of 'Kerr' crabapples and 'M.9' rootstock that Dr. Aleck Hutchinson selected at the Horticultural Experiment Station, Vineland Station in 1958. The 'Kerr' apple

crab was chosen as the maternal parent because of its exceptional winter hardiness, excellent rooting ability, and resistance to fireblight. A total of seven selections ('V.1'-'V.7') were made based on their desirable characteristics including dwarf growth habit, cold-hardiness, ease of propagation, and disease and insect resistance. Initial experiments revealed after eight years of testing that 'V.3' was found to be in the 'M.9' size class, 'V.1' and 'V.2' in the 'M.26' size class, and 'V.4' and 'V.7' in the 'M.7' size class. 'V.5' and 'V.6' currently remain untested. It was also observed that the Vineland rootstocks were less susceptible to fireblight than other commercially available rootstocks such as M.26.

North American Testing of the Vineland Rootstocks

In 1994 the USDA NC-140 Technical Committee (www.nc140.org) initiated testing of more than seventeen new and advanced rootstocks in over 25 locations throughout Canada and the USA; the scion cultivar is 'Royal Gala'. Three of the V. rootstocks included in this test ('V.1', 'V.2', and 'V.3') has enabled an objective evaluation of their performance in twenty-five contrasting growing conditions in North America and against the industry standard rootstocks 'M.26' and 'M.9 EMLA'. Table 1 summarizes the various characteristics and availability of the Vineland rootstocks.

Table 1. Summary of the characteristic and availability of the Vineland Apple Rootstocks

Characteristic	V.1	V.2	V.3	V.4	V.5	V.6	V.7
Tree Vigor	M.26 size	M.26 Size	M.9E size or slightly smaller	MM.106-MM.111 Size	M.9E Size or slightly smaller	M.9E Size or slightly smaller	M.7 Size
Availability	Cameron Nurseries (Cameronnurseries.com)	Not commercially available	DNA Gardens, Elnora, Alberta (dnagardens.com)	Not commercially available	Not commercially available	Not commercially available	Not commercially available
Yield Performance	Similar or better than M.26	Similar or better than M.26	Similar to M.9E	Similar to M.26	NA	NA	Excellent, better than M.26E
Yield Efficiency	Similar or better than M.26	Similar or better than M.26	Similar to M.9E		NA	NA	Better than M.26
Features	Cold hardy, displays fireblight resistant	Cold hardy, displays fireblight resistant	Cold hardy, displays fireblight resistant	Cold hardy, displays fireblight resistant	NA	NA	Cold hardy, displays fireblight resistant

NA = not available (rootstock has not been tested)

Table 2 indicates the performance results of several of the Vineland rootstocks after seven years of testing in Simcoe. Figure 1 shows the vigour and yield potential of several of the Vineland rootstocks, average across three scion cultivars. Subsequent tests on the Vineland rootstocks have been conducted in Simcoe and the Canadian Prairies since then, and currently an on-going experiment is investigating the performance of 'V.1' and 'V.3' (as well as several

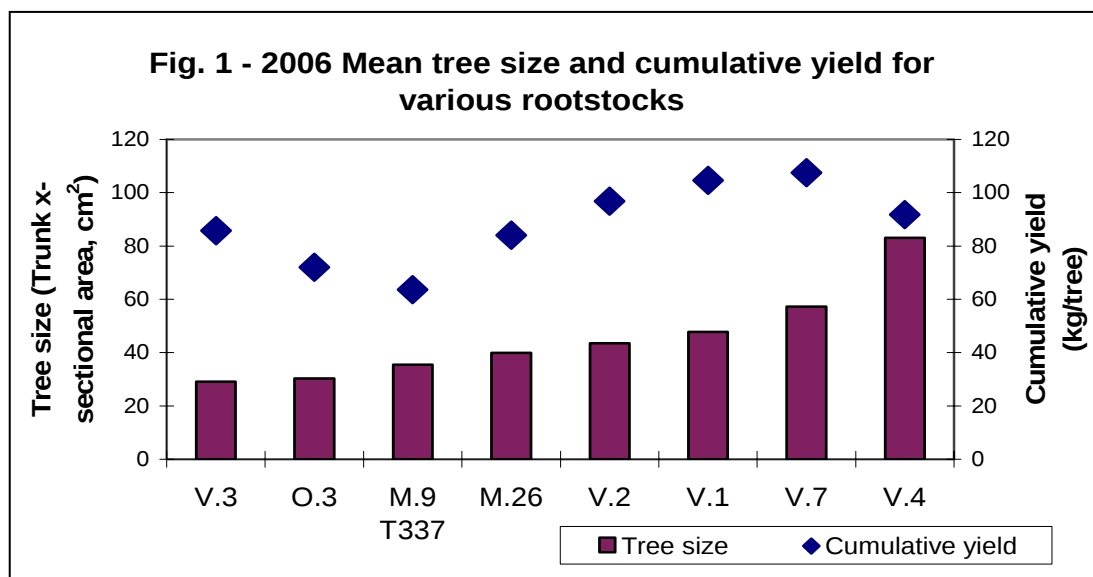
other new and commercial standards) with the scions cultivars 'Honeycrisp', 'Royal Gala', and 'Shizuka.' In the experiment with 'Shizuka' as the scion cultivar (Table 3) for example, 'V.3' and 'V.1' have been more dwarfing than M.9 EMLA and M.26 EMLA, respectively. 'V.1' has had the highest cumulative yields while both the V.1 and V.3 have had high yield efficiencies. Rootstocks have not influenced fruit size.

Table 2. Yield and growth data of 'Empire', 'Jonagold', and 'Northern Spy' on five Vineland series rootstocks in comparison with M.9 (T337), M.26, and O.3 in their seventh leaf. ^y University of Guelph, Simcoe, Ontario.

Cultivar	TCSA 7th leaf (cm ²)	Mean fruit weight - 7th leaf (g)	Cumulative yield (to 7th leaf)		Cumulative yield efficiency (kg.cm ⁻²)
			(kg)	Rank	
Empire	40.6	155.1	87.5	2	2.53
Jonagold	44.3	232.2	116.5	1	3.18
Northern Spy	57.4	279.1	60.1	3	1.30
significance ^z	***	***	***		***
LSD (p=0.05)	7.97	15.29	11.98		0.50
P value	0.0002	<0.0001	<0.0001		<0.0001
Rootstock					
V.3	29.1	227.3	85.7	5	3.10
O.3	30.3	215.2	72.0	7	2.50
M.9 T337	35.5	274.7	63.6	8	2.75
M.26	39.9	203.3	84.1	6	2.32
V.2	43.5	225.9	96.8	3	2.41
V.1	47.8	227.8	104.7	2	2.42
V.7	57.2	222.1	107.4	1	2.47
V.4	83.1	217.5	91.8	4	1.18
significance ^z	***	ns	**		**
LSD (p=0.05)	8.37	41.46	22.72		0.95
P value	<0.0001	0.1766	0.0016		0.0034

^y rootstocks arranged in order of increasing vigour (tcsa)

^z ns, **, ***, indicates not significant, and significant differences at P=0.01 and P=0.001, respectively



Summary

Significant industry interest in the V. rootstocks has been the impetus to objectively assess their horticultural attributes. Their determination of precocity, productivity, vigour, cultivar interactions, cold hardiness, fireblight susceptibility, propensity to sucker, and tree habit are being determined. Commercial development of the rootstocks is also underway jointly by the University of Guelph and the Ontario Ministry of Agriculture, Food and Rural affairs. While 'V.1', and 'V.3' are available commercially, more information is required to determine the suitability of commercializing 'V.5', 'V.6', and 'V.7'. 'V.2' was commercially released but proved difficult to propagate in the nursery.

Since 'V.4' provides limited size control, it will likely not be commercialized in North America.

It is important to emphasise that results of the 1994 NC140 research indicate that rootstocks do not perform similarly at all sites. For this reason, how well the 'V.' rootstock will be adapted to individual grower sites and management practices depends on the local growing conditions including soil texture and fertility, hardiness zone, predisposition to replant disease and fireblight, and rootstock-scion interactions. Further information about the Vineland rootstocks is available through the author or through Dr. Stephen Bowley, Office of Research, University of Guelph.

Table 3. Tree growth and yield measurements from various dwarfing rootstocks on cv. Shizuka planted in 2002 at the University of Guelph, Simcoe, Ontario – 2006.

Rootstock ^z	Cumulative yield ('04,'05,'06)	Rank	Cumulative yield efficiency (kg/cm ²)	Mean fruit weight (g)	Yield efficiency (kg/cm ²)	TCSA (fall 2006) (cm ²)
V.3	18.8	8	1.04	238	0.70	20.8
M.9 EMLA	14.7	9	0.99	245	0.63	21.2
M.9 T337	19.7	7	1.07	256	0.72	22.5
Bud. 9	25.1	3	1.20	230	0.68	24.4
Crispin/M.9	13.3	10	0.70	218	0.51	24.4
Pajam 2	24.9	5	0.90	214	0.67	26.6
M.9 NIC.29	24.9	4	1.02	236	0.68	27.3
PI.80	20.8	6	0.90	234	0.60	29.8
V.1	33.7	1	1.01	223	0.67	34.2
M.26 EMLA	26.8	2	0.77	229	0.49	39.4

^z rootstocks arranged in order of increasing vigour (tcsa)

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Why Improve Weed Management in Young Trees?

Leslie Huffman, Weed Management Specialist
(Horticultural Crops), OMAFRA, Harrow

The investment in a new orchard is large, and poor weed management can reduce the performance of a new orchard for many years. Planning your weed management strategy for the planting year, as well as the following seasons, is an important step in getting the most out of your investment.

Although most growers have a large dislike for weeds in general, it is important to understand the “enemy” and to focus efforts and expense to manage them for the biggest return.

Planting new orchards requires time and labour when orchard growers are busiest– usually the spring – and controlling weeds after planting may become a low priority. We have all heaved a sigh of relief as the last tree is tamped in, and we rush off to catch up on other orchard work. But this is exactly when we should be focusing efforts on keeping weed competition down.

The Goal: Weed scientists have been working to identify the Critical Weed-free Period for each crop. For annual crops this time is early in the season and surprisingly short. This concept is easy – **if a crop is kept weed-free during its Critical Period, no yield reduction from weeds**

will result. Weeds growing within the crop before and/or after this Critical Period will not affect yields.

In perennial crops like fruit trees, the “yield” effect may not be apparent in the first year. But research has shown a direct effect between tree growth in the first year, and yields in each of the subsequent years. The economics of new orchard plantings show that yields early in the orchard life are much more valuable than yields later in the life of the orchard.

As growers, we recognize that there may be reasons other than yield to control weeds at other times eg. to facilitate harvest or to attract PYO customers. But to maximize your dollar return in yield, weeds need to be controlled only for this short period.

Critical Weed Free Period in Fruit Trees:

Research by Dr. Ian Merwin at Cornell University has shown the effects of weeds in new orchards. In a Gala/M26 planting, first cropping 2 years after planting, yields were much larger when weeds were controlled early (May) **in the planting year**, and as well, when weeds were controlled longer (May to July) **in the planting year**. Weed competition occurred even under a full trickle irrigation schedule. Note that these yield effects were measured **2 years** after the weed competition occurred!

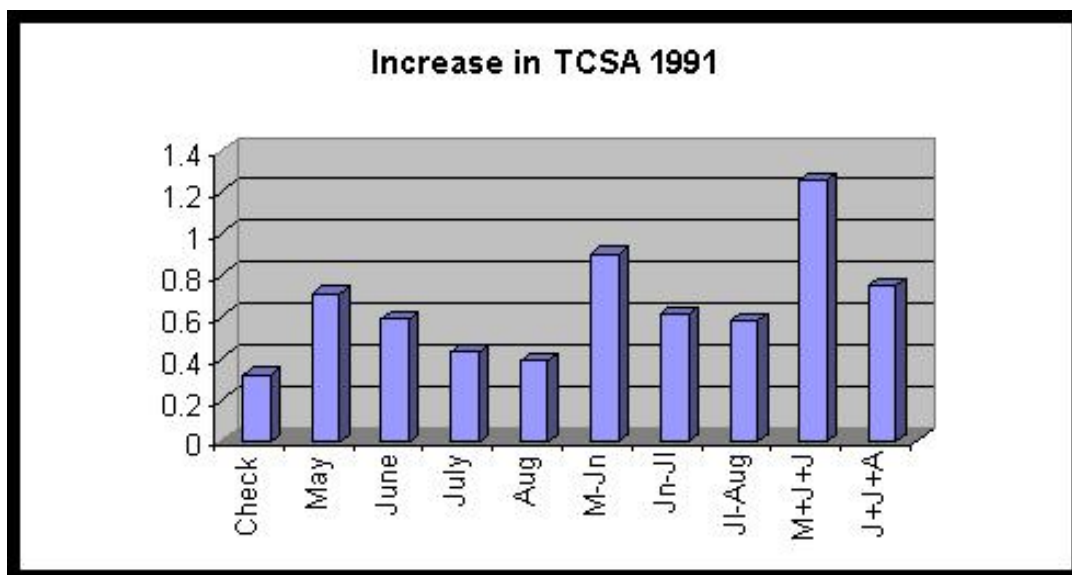
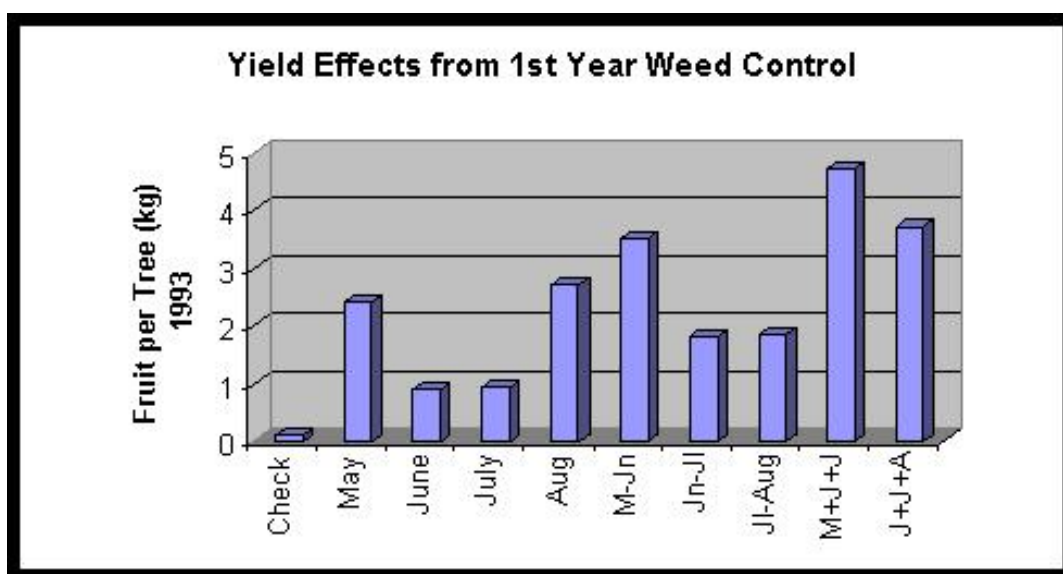


Figure 1. Effect on Trunk Cross-Sectional Area in Newly Planted Gala/M26 Apple

Early weed competition will also have an effect on fruit size. In Dr. Merwin's research with Gala (where size can be a concern), controlling weeds during May and June, as well as during the preharvest month of August, gave better fruit size in the first crop year – again, 2 years after the weed competition occurred.



The strategy: Once we recognize the importance of controlling weeds during the Critical Weed-free Period, we can begin planning how to achieve the weed management needed. Watch for a series of articles in this season's newsletters to outline practical steps to achieve the weed management you need.

Managing Replant Disease in Apple Orchards

John Gardner, Apple Specialist, OMAFRA, London

One of the more outstanding issues around crop culture of apples is the relative inability of growers to exercise a predictable measure of control over the success of replanting nursery stock into old orchards rows when renovating. These problems can vary with differing soil types.

We asked Dr. Ian Merwin of Cornell University to address this problem in the Apple Program at our recent Ontario Fruit and Vegetable Convention (OFVC) at Brock University. Ian has worked on this problem for decades and has tried pretty much everything conceivable in controlled experiments to find out how to beat Replant Disease.

In his talk at the OFVC, Ian recalled his work with pot bioassays of nursery stock planted into treated soils. The use of pasteurization of orchard soils resulted in 2x the growth for most replants into pot culture. However, pasteurization is a costly process and it sometimes results in a complete

physical collapse of the soil. By contrast, in a greenhouse situation, pasteurization works fine where soils are amended with various types of stabilizing materials blended in.

The commercial fumigants Ian used in his research experiments did not work as consistently as he would have liked. He also added compost to the soil without getting any consistent result. Dr. Merwin emphasized that irrigated soils produced better results regardless of how the soil was treated ahead of time.

Other problems Dr. Merwin encountered with management of the young trees were things like leafhoppers taking the vigour out of the trees, tree quality itself, soil drainage, meadow voles and fireblight disease. Oddly enough, it appeared to be that the orchard management problems of getting trees off to a good start were a far worse problem than the soil borne pathogens responsible for replant disease.

Ian has also tried several of the approaches that could be defined largely as Biological Controls. This would include growing nematode resistant

cover crops and plough downs of various types of covers containing biologically active ingredients. The problem was in making these treatments work consistently in the presence of such things like herbicide residues. The other problem with the biological control approach was getting hold of the specialized equipment needed to handle these methods of biological control.

After testing a variety of hypotheses and conducting numerous large scale trials, Dr. Merwin looked at the Geneva rootstocks. He focused on CG 30, CG 6210, and CG 16. To be noted is the fact that M9, B9 and CG series rootstocks are resistant to the Phytophthora fungus pathogen, one of hundreds of soil inhabiting fungi.

Ian found that CG 30 and CG 6210 appeared to overcome the replant problem. Trees planted into the old row or into the grass lane did equally well. With further lab work he found that the roots of these rootstocks did not support the same amount pathogen growth as did other commonly used rootstocks. Ultimately, clones of resistant rootstocks like the CG series would only selectively allow for the growth of specific fungi when comparing to M9. He observed that tree root function and longevity of the CG series rootstocks was 2-3x better than other commonly used rootstocks.

A Discussion on Robotics and Orchard Design

John Gardner, Apple Specialist, OMAFRA, London

It was great to see such a good turnout at the recent Apple Program in February at the OFVC down in Niagara. These programs take a lot of finessing to get them just right with the right mix of topics and speakers with sufficient input from the audience. As organizers, we do appreciate the support.

I have been to many programs like this over four decades. Some are educational and some are a disaster. I can never figure out why organizers of some of the conferences I have been to over the years would spend thousands of dollars to bring in a speaker, have them talk on stuff that is already well known, cut them off early, and send them home without a question and answer session.

Anyway, I thought I would briefly mention some of the issues that Tom Auvil focused on in the recent OVFC program. Tom Auvil is a Horticulturist with the Washington State Tree fruit Research Commission.

Tom emphasized the fact that labour will be the driving force for successful orchard operations in the future. This is with reference to how the grower/manager will get tasks accomplished and has to do with everything from tying limbs to green fruit thinning and ultimately to harvesting the fruit. It may not be enough choosing the right cultivar. With the cost of everything going up, including packing charges and cost of production, you end up with the “double squeeze”. According to Tom, revenues will also drive business and not cost containment

Tom mentioned that the differences between organic and conventional technology will begin to fade. This is already evident with the introduction of many reduced risk strategies in the orchard now being employed by Ontario producers. This is not the first time I have heard this from knowledgeable speakers.

With reference to the use of platforms, Tom talked about the stop and go system, which is not as efficient when compared to a platform moving down between tree rows in a gentle weave at a rate of travel of 30 feet per minute and with automated steering from a row finder device. Workers on these platforms also prefer to be tethered to a central railing rather than having to reach across a railing to accomplish tasks. Workers want to be able to lean into the row and feel safe. Ultimately one could have an articulating, self-leveling, 4 wheel drive, and 4 wheel steer type of rig. These are already in use in some parts of the Northern Hemisphere.

The limiting factor to this whole concept is the “hand taking the apple off the tree” and the need for consistent fruit position in the canopy. This means that the row thickness should only be a few inches and preferably without branches in the way to slow down a robotic arm and hand.

The problem then becomes one of cost and return. A robotic hand could pick a bin for let's say \$15 - \$30 and if the tree is too bushy this could be \$60/bin. Ultimately, the governing factor for employing any technology advances like this, is the potential value of the fruit in the bin.

Orchard Floor Management Affects Soil Structure

*Peter Zwart - Nutrition (Horticulture) Program
Lead, OMAFRA, Guelph*

Most orchards in Ontario maintain permanent sod between the tree rows. This practice makes good sense to protect the soil from wheel traffic, erosion and loss of organic matter.

The area directly under the tree is where the roots are, so it is the critical zone. Orchard trees do not compete well with grass for water and nutrients so it is often kept bare with herbicides. Management choices for this soil area affect tree and root growth, soil water and nutrient availability, fruit yield and quality.

So what would we like from the ideal orchard floor? It should absorb water to prevent runoff and hold this water against gravity until the roots need it. Then, as the roots take up moisture, water from the soil should move freely in to replace it and carry nutrients along with it. After all, pretty much everything that makes an apple tree comes into the roots with water except carbon and oxygen. You can see how beneficial it could be to maintain optimum soil structure under the trees.

Different management methods that make a small change each year can add up to big changes over the lifespan of an orchard. A long-term experiment was done by Dr. Ian Merwin and his research group at an orchard maintained with four different management systems for eight years in Ithaca, New York. Ithaca soil is a Grey-Brown Luvisol derived from limestone like we have in most of Ontario. Directly under the trees, some plots were kept completely bare with a spring application of residual herbicides. Others received Roundup™ in May and July each year which allowed re-growth of vegetation later in the season. The third treatment was turfgrass, which was mowed every two weeks. The final treatment maintained a 6-inch layer of hardwood mulch under the trees.

After eight years, they measured how well the soil absorbed water, how much water it could hold and how easily water could move through the soil. They also measured bulk density, an indicator of compaction. The measurement and treatment areas were the zone directly under the trees as opposed to the area between rows.

The clear winner in this study was mulch, with the herbicide treatments finishing in the middle. Sod, normally associated with improving soil structure, finished last. The researchers think the mowing caused compaction. Of the herbicide treatments, Roundup tended to fare better than the residual herbicide treatment, which was continuously bare. Not taken into account in this study but worth mentioning is that later season re-growth can take up excess nitrogen and potentially improve crop quality, cold tolerance, and groundwater quality.

Herbicide treatments that allow late-season re-growth are not a bad choice, but this study showed that optimum root function is most likely to occur under mulch. Perennially bare soil is at risk for leaching and organic matter loss. Mulch increased water infiltration and movement rates, and hence nutrient transport within the soil. It decreased soil bulk density. Other research has shown it also increases soil organic matter content and root activity near the soil surface while providing insulation to protect the roots from temperature extremes.

It may be worth penciling out the cost of mulch versus herbicides for your orchard.



CROP PROTECTION

Developments In Pesticide Application Technology In the Orchard

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The application of pesticides has been of concern for many years, particularly methods of reducing drift and improving deposition. The majority of growers use traditional airblast sprayers fitted with hollow cone or air shear nozzles, many growers choose not to replace mechanically reliable sprayers and so a large number of orchard sprayers are in excess of ten years old. Many airblast sprayers are too big for modern planting systems, the fan diameter is too large and the volume of air created is too great for the target canopy. Frequently, manufacturers build larger machines with a greater amount of air than is required for modern apple plantings, they are frequently designed for nut trees. Some growers buy them in the mis-guided belief that more air is better than too little air. The ideal air volume should match the tree canopy volume. Progress lies in the direction of more efficient application of power through a better understanding of the factors involved in getting the pesticide from the tank to the plants.

Deposition within the canopy is so important, good coverage throughout the tree is required if satisfactory insect and disease control is to be carried out. Spray drift is also an important and costly problem facing fruit growers. Drift results in damage to susceptible off target crops, environmental contamination to watercourses and an unintentionally reduced rate of application to the target crop, thus reducing the effectiveness of the pesticide. Pesticide drift also affects neighbouring properties, often leading to public outcry.

Traditional airblast sprayers direct the air from a single axial flow fan, mounted directly behind the sprayer, in an upward and outward direction. Axial fans are designed to move large volumes of air at low pressures. In order to accommodate varying crop canopies, e.g. as the season progresses, many modern sprayers are fitted with adjustable pitch propellers to provide variable airflows. Traditional advice to growers has been to use an adjustable deflector plate, fitted at the top and base of the air outlet to direct the air towards, and confine it to the target canopy.

Sprayer design, deposition and drift

Table 1. Inter-related factors affecting pesticide drift and deposition

Sprayer	Application	Target	Weather	Operator
Design	Application rate	Variety	Wind speed	Skill
Droplet size	Nozzle orientation	Canopy structure	Wind direction	Attitude
Fan size	Forward speed	Area	Temperature	
Air volume		Every row	Humidity	
Air velocity & direction		Alternate row		

Even when sprayers are calibrated regularly their accuracy cannot always be relied on. Across the world surveys of the mechanical condition and the accuracy of sprayers show that many sprayers leave much to be desired. A combination of inaccurate speeds, worn nozzles, unsuitable filters and inaccurate gauges caused the problems. Survey and clinic results show how badly maintained many sprayers are on farms and how their operators require training.

The principal involved in traditional orchard spraying is to create enough air from the airblast sprayer to shift and replace the air within the canopy with pesticide-laden air from the sprayer. The leaves have a tendency to shingle in the airflow, altering airflow characteristics and reducing penetration and deposition. Tree canopies vary along the row, sometimes trees are absent presenting no resistance to air movement, resulting in air traveling through the target row and away. When applying pesticides growers know that small or fine/medium droplets give the best coverage, as large droplets (in excess of 300 μm) will run off the leaf onto the ground. Good coverage is critical for all contact pesticides. A traditional airblast sprayer sends air upwards above the canopy, carrying with it a plume of pesticide droplets. Unfortunately small or fine droplets will drift if they don't become attached to the target leaf, insect or apple. Directed deposition is needed if pesticide is to be applied to the target zone.

Airflow

Trials with various types of airblast sprayers were conducted at Cornell University to study how changes in fan speed affect air speed, volume and direction. Indoor trials were conducted using a Gill sonic anemometer (Gill industries, Hampshire, UK) to determine airflows.

It is clear that on the left side of an airblast sprayer, the peak of the air stream centre moves down with increasing distance away from sprayer centre. The rate of descent increases with decreasing air intake, resulting in relatively low velocities in the spray target zone on the left of the sprayer compared to the right side. On the right side, the general trend showed a slightly rising stream due to the counter-clockwise direction of the fan. The air velocity on both sides was highest at maximum fan speed, velocity decreasing when decreasing the fan speed. With the help of air velocity patterns we can see the effect of changes in air output.

Field trials were conducted in an orchard, (20 feet rows, 11 feet trees) using an AgTec P300 (AgTec, Minnesota) sprayer fitted with airshear nozzles operating at two fan speeds, 2076 rpm (540 rpm PTO) and 1557 rpm (405 rpm PTO). Drift was detected using Water sensitive cards (Syngenta, North Carolina) and analyzed using DropletScan (WRK, Cabot, AR) image analysis software. The methodology and results are published in detail, Landers and Farooq (2004). At a fan speed of 2076 rpm, drift was detected up to 80 feet from the target row where 10% card coverage occurred. Reducing fan speed by 25%, resulted in considerably less drift, with card coverage at 20 feet and 40 feet from the target row being 16% and 0.20% respectively. Reducing fan speed increased droplet size from 351 microns VMD at 2076 rpm to 460 microns VMD at 1557 rpm. (Note, no spread factor has been taken into consideration).

Nozzle orientation

In the 2004 growing season, a MIBO vertical patternator was used to evaluate the effect of nozzle orientation on spray deposition, results show great variability in spray pattern. Nozzles set in the “typical growers” pattern, i.e. pointing radially outwards resulted in a large quantity of liquid being blown above the target row. The quantity overshooting the target varied according to tree height, canopy density and size/speed of the fan on the airblast. Different types of airblast sprayer also behaved differently. We tested 20 sprayers at growers orchards and noted the great imbalance on distribution between the left and the right-hand side of the sprayer due to the airflow.

The best spray pattern for most conditions tested occurred when the right hand side nozzles were pointing horizontally to counteract the upward movement of the air from the fan. Best results occurred with the left side nozzles pointing 45° upwards to counteract the downward direction of the air from the fan. The results show the importance

of correct nozzle orientation if pesticides are to be applied effectively onto the target. It should be noted that each sprayer design will vary, due to fan size and air volume, so no “blanket” recommendation can be made.

Correct adjustment of top and base deflector plates on traditional airblast sprayers should also be carried out to direct the air towards, and confine it to the target canopy. Variable pitch blades (if fitted) must be adjusted to vary the amount of air being delivered into the target or alternatively the speed of the fan should be reduced by slowing down the PTO to match the developing canopy.

Conclusions

1. Airblast sprayers, as used in orchards, create a large plume of pesticide spray due to the use of large capacity fans. The resultant plume of pesticide spray frequently misses the target canopy and is accelerated upwards into the air or through the target canopy.
2. Spray drift is inevitable with crop spraying, even when growers follow best management practices. Research since the mid-1960s indicates that pesticide spray droplets will be transported by wind currents for distances ranging from a few feet to many, many miles.
3. Improved designs of sprayers which direct spray into the canopy, increases deposition and reduces drift, but does not eliminate drift completely.
4. The results have shown potential for improving deposition and reducing spray drift by carefully adjusting nozzle orientation. Nozzle orientation needs to be adjusted independently and in consideration of airflow rate and direction on two sides of the air blast sprayers.

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Reference

Landers, A.J. and Farooq M. 2004 Reducing spray drift from orchards – a successful case study. *NY Fruit Quarterly* 12 (3) Autumn 2004 pp 23-26

German Drift Reduction Methods - Registration of BBA – approved plant protection equipment for orchards in the list of loss reducing equipment

Drift Reduction Class	Sprayer	Nozzle Types	Regulations of Use
50%	All air assisted sprayers	ID, TD, AVI, DG, AD Various Sizes	First 5 rows without air towards field edge.
	Foliage Detector	All Types	
	Air assisted sprayers with axial fan.	ID Various Sizes, TD 80-02 Keramik, AVI 80-03	Spray pressure max 58-73 PSI. First 5 rows with reduced air (max 30,000m3/h).
	All air assisted sprayers	All Types	Hail nets above orchards.
75%	All air assisted sprayers	ID, TD, AVI, DG, AD Various Sizes	Hail nets above orchards.
	Sprayers with axial fan with max 30,000 m3/h, at least with first gear.	ID, TD, AVI Various Sizes	Spray pressure max 58-73 PSI. First 5 rows with reduced air (max 20,000m3/h). AVI 80-015 max 44 PSI, ID 90-015 max 44 PSI.
	Tower Sprayer	ID, TD, AVI, DG, AD Various Sizes	First 3 rows spraying without air towards field edge.
	Sprayers with cross flow fan.	ID, TD, AVI, DG, AD Various Sizes	First 3 rows spraying without air towards field edge.
90%	Sprayers with cross flow fan.	ID, TD, AVI, DG, AD Various Sizes	First 5 rows spraying with reduced/sealing #4 towards field edge; sealing #8 inwards.
	Tower sprayers with fan	ID, TD, AVI, DG, AD Various Sizes	First 5 rows spraying without air towards field edge. Partly with reduced spray pressure.
	Lipco Tunnel sprayers		
99%	Lipco Tunnel sprayers	ID, TD, AVI, DG, AD Various Sizes	

Key:

ID = Lechler Air Induction; AD = Lechler Drift Reducing; TD = Agrotop by GreenLeaf

DG = Drift Guard by TeeJet; AVI = Albuz Air Induction

Website: www.bba.de

Life After Guthion Part 2: Incorporating OP Alternatives into Apple IPM Programs

Kathryn Carter, Pome Fruit IPM Specialist, OMAFRA, Simcoe; Hannah Fraser, Entomology Program Lead-Horticultural Crops, OMAFRA, Vineland; and Margaret Appleby, IPM Systems Specialist, OMAFRA, Brighton

Currently, Ontario apple growers rely on the use of broad-spectrum organophosphorus (OP) insecticides (Guthion, Imidan) to manage several economic pests of apple, including plum curculio, apple maggot, European apple sawfly, codling moth and mullein bug. As a result of recent (and anticipated) registrations, the 2008 season will be

the first year that apple growers have access to non-OP alternatives for managing many of these economically important pests. Access to new products and the phase out of Guthion will hopefully result in growers incorporating many reduced-risk products into their IPM programs. Incorporating recently registered products into pest management programs now will help growers and consultants become accustomed to using new chemistries, decreasing the impacts associated with the loss of Guthion.

In preparation for the loss of Guthion growers should become educated about how the new products work, and their timing. Many of the newer products work differently than OP insecticides, may be more selective, and/or more

timing-specific. This must be taken into consideration when using them. Fortunately, a number of the newly registered products (notably several neonicotinoids) control multiple pests simultaneously. When choosing which product to use, it is important to take into consideration the activity of the product on other pests that are present in the orchard - this gives growers better bang for their buck. The best placement for a product in a grower's pest management program will vary from region to region depending on the type of pests present and pest pressure. Be aware that chemicals in the same family (example: Assail, Calypso, Actara) do not necessarily have the same activity or relative efficacy on pests. Check the labeled rates carefully, as these may vary depending on the target pest.

Avoid the temptation to over-use products, or their efficacy will be compromised due to the development of resistance. Multiple generations of a pest should not be exposed to products from the same chemical family.

Options for managing plum curculio

There are several alternatives to Guthion for the management of plum curculio (PC) in apple orchards. These include the OP insecticide Imidan, as well as the neonicotinoids Calypso and Actara. Timing of insecticides for managing PC are recommended at petal fall or when damage is noted on fruit trees located in the orchard perimeter. Calypso or Actara may be applied at petal fall +3 days and/or earlier if monitoring indicates PC is present (petal fall). These products are very effective tools for managing PC. Research conducted in Michigan (Wise et al., 2006) has suggested that these products are lethal to adults and act as oviposition deterrents (insects avoid laying eggs), antifeedants, and have repellency activity. Maintaining good fruit and leaf surface residues are important for achieving good efficacy with both products.

Both Calypso and Actara belong to the same chemical family, but they do not both control the same insect pests. To determine which product will be the best fit in your IPM program, evaluate what other pests are present in the orchard when PC is active. Growers east of Toronto may want to use Calypso at petal fall for PC since research in the US suggests that it also has activity against European apple sawfly, a regional pest in this area. In the Norfolk/Leamington area, growers

who apply Calypso at petal fall will also control oriental fruit moth (OFM), a pest which may be active at the same time within the orchard (make sure to monitor OFM activity with pheromone traps). Note that Actara is not considered to provide effective control of OFM and is not labeled for this insect. Both Actara and Calypso are also effective on mullein bug and spotted tentiform leafminer. Please note that very little research has been conducted on the effectiveness of border sprays using neonicotinoids. Because these products have repellency activity against some insects, it is possible that pests may avoid treated trees and move beyond borders into the orchard interior. As a result, we are not recommending the practice of border sprays for either Actara or Calypso at this time.

Options for managing codling moth

There are several alternatives for managing codling moth (CM) in apple orchard. The traditional timing for OP insecticides (including Imidan) is at 100 DDC after biofix (first sustained moth catch) using base 11°C. OP insecticides kill larvae when they walk on or consume treated fruit. The newer products have different modes of action and consequently, their timing differs. The insect growth regulators Intrepid and Rimon, as well as the neonicotinoids Calypso and Assail, are active on both eggs and larvae. Intrepid should be applied 2-3 days earlier than OP insecticides (just before eggs hatch), so that eggs / developing larvae are exposed to the pesticides. Rimon is best used when applied before egg laying begins (apply at petal fall). Both Intrepid and Rimon have sublethal effects on adults, so that eggs laid by exposed females fail to hatch.

Assail/Calypso work best when applied on top of the eggs and thus are optimally applied 2-3 days earlier than OP insecticides. All of the newer products act as larvicides when consumed by the insect. Residual activity varies from 10-14+ days, depending on the product. Several of the new products are effective against other orchard pests, and their use against CM may provide control of these insects if the activity is synchronous, as indicated by monitoring. Check product labels for recommended timings, rates and pests controlled. The efficacy of border sprays against CM using any of the new chemistries (Calypso, Assail, Intrepid, Rimon) has not been assessed and consequently, we are not recommending their use as such at this time.

Options for managing apple maggot

OP insecticides should be applied 7 days after the first adult fly is caught on a sticky board. In contrast, Calypso is an oviposition deterrent (prevents females from laying eggs in the fruit) and should be applied immediately after first adult fly is caught. Assail is not registered for controlling apple maggot in Canada, however it is used to control this pest in the USA. Both Assail and Calypso are toxic to adults and are oviposition deterrents. Maintaining residue on the fruit is important. Calypso also provides subsequent control of codling moth. Once again, border sprays are not recommended with Calypso and Assail. Surround WP Cop Protectant is also labeled for use against apple maggot. This

product is not an insecticide, but acts as a barrier against oviposition. If using this product to manage apple maggot, maintained coverage is essential, and the product must be applied prior to egg-laying.

Although Guthion has been a staple in pest management for apples over the past few decades, we are now starting to see the registration of some exciting new replacements that are more environmentally friendly, and less harmful to applicators. It is important for apple growers to try to incorporate these new products into their IPM programs to prepare for the loss of Guthion in 2012.

Relative activity spectrum for new materials – Apple Michigan State University (J. Wise and L. Gut)

Insecticide	CM	OFM	OBLR	PC	AM	STLM	RAA	WALH	SJS
Avaunt ¹	**	**	*	***	*		*	*	
Intrepid	**	**	***			**			
Success	**	**	***		*	**			
Rimon	***	***	**			**			
Esteem ¹	**	*	*			**	**		***
Assail	***	***		***	***	***	***	***	
Actara				***	**	***	***	***	*
Admire				*	**	***	***	***	*
Calypso	***	***		***	***	***	***	***	**

¹ Products are not registered in Canada.
More stars indicates higher efficacy.

Insecticide	CM	OFM	OBLR	PC	AM	STLM	RAA	WALH	SJS
Lannate	**	**	*	**	**	**	**	**	
Imidan	***	***		**	***	*			
Guthion	***	***		***	***	*			*
Asana ¹	**	**	***	**	**	**	**	**	*
Danitol ¹	**	**	***	**	**	**	**	**	*
Warrior	**	**	***	**	**	**	**	**	**

¹ Products are not registered in Canada.
More stars indicates higher efficacy.

11 Questions About Using “Bloomtime” and “BlightBan” to Suppress Fire Blight

Neil Carter, *Tender Fruit and Grape IPM Specialist, OMAFRA, Vineland*; and Michael Celetti, *Horticultural Crop Pathologist, OMAFRA, Guelph*

Q: What are Bloomtime and BlightBan?

A: Bloomtime and BlightBan are the product names for two different strains of the non-pathogenic bacteria *Pantoea agglomerans*. Bloomtime is strain E325 and BlightBan is strain C9-1.

Q: How do these products work against fire blight?

A: Both products work to suppress fire blight. *Pantoea agglomerans* is a bacteria antagonistic to *Erwinia amylovora*, the bacteria that causes fire blight. *P. agglomerans* colonizes the same areas of the blossoms and utilizes the same nutrients as the fire blight bacteria, but *P. agglomerans* does not cause any damage or plant disease. These biological control products do not work well if the fire blight pathogen has already colonized the blossoms.

Q: Can I use Bloomtime or Blight Ban instead of streptomycin?

A: No. These products only suppress fire blight; “suppression” indicates around 60% control without additional measures. These products should be used in a management strategy that includes monitoring, predictive models, cultural controls, and the use of streptomycin.

Q: Are these products registered for apples or pears?

A: Both products are registered for pears and apples.

Q: What are the advantages of using *P. agglomerans*?

A: Suppressing the fire blight bacteria can have major benefits to lowering the incidence of the disease. Lower numbers of colonizing fire blight bacteria also mean that streptomycin applications can be more effective and there may be years when less streptomycin can be applied. Fewer applications of streptomycin is one method to help reduce the risk of development of streptomycin-resistant fire blight bacteria.

Q: When should *P. agglomerans* be applied?

A: The labels of both products say that the first application should be made around 15 – 20% bloom with a second application at full bloom. Blooms must be open for *P. agglomerans* to enter and colonize, thereby out-competing the fire blight bacteria. It is

very important to spray these products when blooms are open and before the fire blight bacteria have a chance to colonize the blossoms. Predictive models like Cougar Blight and MaryBlyt are necessary to predict fire blight infection risk periods and enable growers to target the best time to spray.

Q: How many times can I apply *P. agglomerans*?

A: At present, BlightBan is allowed 3 applications per year but Bloomtime is labeled for only 2 applications. That may change in time.

Q: Are there any precautions about using *P. agglomerans*?

A: Yes. Besides the normal safety precautions on the label, it is important to remember that copper is toxic to *P. agglomerans*, so should be avoided leading up to applications of these products. Copper applications during tree dormancy are not likely to affect the performance of Bloomtime or BlightBan. Sulfur is probably fine with these products and no other incompatibilities are known at present. More research into the compatibility of these products is required. At this time it is not advisable to tank mix these products with any other pesticide.

Q: Are there any precautions with storing these products?

A: Yes, biological products are not like chemical pesticides and certain precautions are necessary for storage. These biological products contain living organisms and must be kept frozen in their original container until application. They also have a short shelf life of 5.5 months and therefore unused product cannot be stored for use the following season.

Q: How important is coverage?

A: As with other conventional products, good coverage is important to ensure that the products get inside the bloom. These products are not systemic nor do they actively move into blooms. Applying these products with 1000-2000 liters of water/ha is very important to obtain good coverage.

Q: Where can I buy Bloomtime or BlightBan for next season?

A: We do not yet know who will be distributing these new additions to the fire blight arsenal. For this coming season though, they will likely be in short supply as the companies move slowly into the market and gain field experience in various areas.

Managing Mites in Ontario Apple Orchards Using New Products

Kathryn Carter, Pome fruit IPM Specialist, OMAFRA, Simcoe; Hannah Fraser, Horticultural Entomologist, OMAFRA, Vineland; and Margaret Appleby, IPM Systems Specialist, OMAFRA, Brighton

In the last few years there have been several new products registered for managing mites in Ontario apple orchards. These registrations have provided apple growers with many excellent options for managing mites, and allow growers to follow resistance management strategies. There are several key things that growers should remember to help manage mites effectively.

1. Avoid using products that can cause mite outbreaks. Pyrethroids (Matador, Decis) have been shown to cause mite outbreaks in orchards. Research suggests that repeated applications of some of the new neonicotinoids may increase European red mite egg laying or may be harmful to beneficial mites. As a result, carefully monitor mite populations whenever using any neonicotinoids in orchards.
2. Monitoring mites is an important component of any IPM program and scouts should be taking mite samples and analyzing them under the microscope on a weekly basis. Careful monitoring can allow growers to manage mites before their populations reach damaging levels.
3. Take note of beneficial mites and insects when monitoring; these may be very effective in keeping pest mites below threshold levels.
4. Be aware that miticides are often highly selective. A given product may not be effective on all types of mites (European red mite, two spotted spider mite and apple rust mite), all lifestages (eggs, nymphs, adults), or even both sexes. To optimize spray timing and to assist in choosing an appropriate miticide, it is critical to identify the species and dominant lifestages present. The label rates of some miticides may differ depending on the species - be sure to refer to the label.
5. Some of the newly registered miticides should be applied at a lower threshold than other products to optimize their efficacy.
6. Miticides are most effective when applied alone, using recommended rates and high water volumes (>1000 L of water/ha). Reducing the amount of water applied or decreasing the rate may result in substandard results. Good coverage is essential.
7. Apply each miticide only once per season to delay the development of resistance. If miticides need to be applied two years in a row, be sure to use products from different chemical families to avoid the development of pesticide resistance. To help with this, make sure to check out the "group" number on the label.
8. Some of the newer miticides are slower acting. This must be taken into consideration when applying the product (follow thresholds). For products with slow knockdown, wait 1 to 2 weeks after spraying to determine if the product was effective.

Table 1. Activity of Miticides Registered on Apple and / or Pear in Ontario*

Product (active ingredient)	Mode of action	Chemical Family (Group)	Target Species	Lifestage(s) affected	Preferred timing	Comments on knock-down
Superior oil	physical poison - smoothers the target	--	European red mite	Overwintering eggs, some nymphs	Early-Half-inch green to tight cluster prior to egg hatch	Smothers eggs, primarily a contact product
Acramite (bifenazate)	neuronal inhibitor, chloride channel agonist (nervous system)	carbazate (group 25)	European red mite (apple) Two-spotted spider mite (apple)	Motiles (nymphs, adults)	Use at lower end of threshold for ERM (5 mites/leaf)	Rapid knockdown through contact activity, with good residual control
Agri-Mek (abamectin)	chloride channel activator (nervous system)	avermectin (group 6)	European red mite Two-spotted spider mite	Nymphs	Early season product, apply within 21 days of petal fall	Rapid; translaminar activity, with good residual control

Note: Do not use Agri-Mek plus oil within 14 days of a Captan or Maestro application			Pear rust mite (pear)		For spider mites, apply before a threshold of 5 mites/leaf Product is applied with Superior "70" oil (see label)	.
Apollo (clofentezine)	mite growth inhibitor	tetrazine (group 10A)	European red mite Two-spotted spider mite	Primarily eggs, newly hatched nymphs	Early- no later than 14 days after petal fall. Egg stage, before >3 active mites /leaf	Slow activity Resistance previously detected in Ontario
Carzol (formetanate hydrochloride)	acetylcholine esterase inhibitor (nervous system)	Carbamate (group 1A)	European red mite Two-spotted spider mite	Motiles	Summer miticide	Rapid
Envidor (spirodiclofen)	inhibitor of lipid biosynthesis (IGR-type)	Tetronic acid derivative (group 23)	European red mite Two-spotted spider mite Apple rust mite (apple) Pear rust mite (pear)	Eggs, nymphs, adult females	Post-bloom only, use at lower end of threshold (5 mites per leaf). Optimally use petal fall through 2 nd cover.	Slow activity; a contact product (IGR-type)
Kanemite (acequinocyl)	mitochondrial electron transport inhibitor complex III (affects metabolic process, blocks cell respiration)	Quinolinone (group 20B)	European red mite Two-spotted spider mite	all life stages	Apply when thresholds have been achieved	Rapid with long residual control; primarily a contact product.
Kelthane (dicofol)	unknown mode of action	Diphenylethane (unclassified)	Two-spotted spider mite European red mite Apple rust mite (apple) Pear rust mite (pear)	Nymphs	Summer miticide	Rapid; contact activity. Resistance previously detected in Ontario
Pyramite (pyridaben)	mitochondrial electron transport inhibitor complex I (affects metabolic process, blocks cell respiration)	Pyridazinone (group 21)	European red mite Apple rust mite Two-spotted spider mite Pear rust mite (pear)	All motiles of ERM, ARM and PRM. Nymphs and larvae of TSSM. Not effective on mite eggs.	Summer miticide; apply at or below action thresholds	Rapid with long residual control; primarily a contact product.

* Registered for use on apple or pear unless indicated otherwise. Use established thresholds to time applications. Miticides are most effective when applied alone, using recommended rates and water volumes. Apply each miticide only once per season to delay the development of resistance.

POSTHARVEST

Fruit and Vegetable Wash Has No Effect on Postharvest Decay But May Increase Lenticel Damage in 'Empire' Apples

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Dr. Jennifer DeEll, OMAFRA, Simcoe; Lana
Wainman, AAFC, Vineland; and Jennifer Ayres

According to the Canada Food guide, eating a variety of fresh fruits and vegetables will keep us healthy. Research has shown that eating lots of fresh produce reduces the risk of some cancers and other diseases. It is suggested to wash the fresh produce before eating and in some commercial facilities the produce is washed with *Fruit and Vegetable Wash* (FVW) before shipping to the retailers.

In a preliminary study, we tested the effect of FVW on postharvest diseases and lenticel damage in 'Empire' apples. Prior to this experiment, apples had been stored for 6 months in standard controlled atmosphere storage (~ 2.5% O₂ + 2% CO₂ at 2°C). Half of the fruit were artificially wounded using a nail-like probe, to ensure the uniformity of the size and depth of the wound, and the remaining half were not wounded.

There were four main treatments: 1) no wound, plus FVW, 2) no wound, FVW, and then wax, 3) wound, plus FVW, and 4) wound, FVW, and then wax. Each of these main treatments had 3 sub-treatments, representing 0.1%, 0.2% and 0.3% FVW. All the apples were dipped in the FVW for 1 minute and then rinsed in water for 2 minutes. In addition, there were water only and no dip controls. The fruit received wax after the water rinse, when scheduled. All 12 treatments were replicated three times. Each replicate consisted of 40 fruit. After the treatments, fruit were incubated for 1 week in cold storage at 0°C and then the apples were moved to 20°C for an additional week. Decay and lenticel damage were recorded after 1 week at 20°C.

Results indicate that <10% of blue mold/decay was observed in the apples that were not wounded with or without FVW, and 99-100% of the wounded fruit with or without FVW had blue mold/decay. Therefore, FVW had no significant effect on storage decay in 'Empire' apples.

Lenticel damage was found on some of the fruit, with the higher concentrations of FVW causing increased incidence. Apples treated with 0.1% FVW had 2.5% lenticel damage incidence, whereas 5.4-6.3% of fruit treated with 0.2 or 0.3% FVW exhibited lenticel damage. It is important to note that these data are from 'Empire' apples that were stored in CA storage for 6 months. The effect of FVW on other cultivars and 'Empire' from other storage regimes and durations still needs to be tested.

Factors Affecting Severity of Bruises and Degree of Apparent Bruise Recovery in a Yellow-Skinned Apple

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and R. Hocking, AAFC, Summerland, BC

Malus ×domestica, Borkh., cv. '8S6923' (Aurora Golden Gala™) is a newly released yellow-skinned apple, which is susceptible to bruising. The bruise susceptibility made Aurora Golden Gala an ideal model to determine if simulated harvest and packing line forces led to permanent bruising or if there was potential for recovery during subsequent cold storage. Compression forces of 22.2, 44.5 or 66.7 N were applied via a 2.54 cm diameter wooden ball to simulate light, moderate and heavy harvesting force, respectively.

If the simulated harvesting forces were low and if fruit was cooled to 1°C immediately after harvest, most bruises apparently disappeared over several weeks. If moderate or slight bruising forces were applied, maximum apparent bruise recovery was achieved within three to five weeks of storage at 1°C. However, if bruising forces were too great or there were delays in cooling, apparent recovery from bruising was reduced. Warm (13°C) fruit incurred fewer bruises and less severe bruises than cold (1°C) fruit impacted with a similar force.

Severity of bruising was much less when the impact simulated a collision with a rubber belt in the line, as compared with a simulated apple-to-apple collision. It was concluded that harvest bruises and impact bruises with packing line belts can be managed relatively easily, ensuring almost complete apparent recovery, whereas packing line apple-to-apple impact bruises are more damaging and less likely to recover fully.