Great Lakes Fruit, Vegetable & Farm Market EXPO
Michigan Greenhouse Growers Expo
December 8-10, 2009
DeVos Place Convention Center, Grand Rapids, MI

Apple II

Wednesday afternoon 2:00 pm

Where: Ballroom D

Recertification credits: 1 (1C, PRIV OR COMM CORE)

CCA Credits: CM(2.0)

2:00 p.m. Review of Apple Support Systems

- Mo Tougas, Tougas Family Farm, Northborough, MA

2:30 p.m. Management Strategies for Secondary Apple Pests

- John Wise, MSU Trevor Nichols Research Station

2:50 p.m. How to Grow High Quality Apples

- Mike Wittenbach, Wittenbach Orchards, Belding, MI

3:10 p.m. Summary of Honeycrisp Storage Recommendations Across the US: What is Best for Michigan?

- Randy Beaudry, Horticulture Dept., MSU

3:40 p.m. Technology to Save Energy in Storages

- Phil Schwallier, District Horticulture & Marketing Educator, MSU Extension
- Frank VanKempen, EnerSave, Grand Rapids, MI

Review of Apple Support Systems

Great Lakes Fruit Expo

December 9, 2009

Maurice Tougas

International Fruit Tree Association

- ✓ Feb 27, 2010 “Apple and Cherry High Density Orchard Workshop”
- ✓ Feb 28-March 3 Annual Meeting
- ✓ www.IFruitTree.org

Factors That Influence Choice of Support System

- ✓ 1) Training System
- ✓ 2) Rootstock
- ✓ 3) Management
- ✓ 4) Economics
- ✓ 5) Soils and Terrain
- ✓ 6) Materials and Machinery Available
- ✓ 7) Special Weather Extremes
- ✓ 8) Market

Training Systems

- ✓ FREE STANDING

M26 or stronger Rootstock

Temporary support 2-3 years

Bamboo or Conduit

Aim is to provide for stability to increase rate of growth

SPINDLE HYTEC AXE

- ✓ M26 and Weaker Rootstocks
- ✓ Medium density orchards 600 trees/acre
- ✓ More robust permanent support
- ✓ Minimum 2”wood post, though greatly improved with the addition of one wire
- ✓ With wire, conduit, bamboo or angle iron may be substituted for the 2’ posts
- ✓ 10-14’ line post 30’-50’
- ✓ Good anchor system needed

SPINDLE HYTEC AXE

- ✓ While root system will become somewhat extensive, full dwarf stocks will produce brittle roots, prone to easy breaking
- ✓ Trunk will develop girth over time to help support fruit load

Tall Spindle/ Super Spindle

- M9 strains, B9
- 800 to 2200 Trees per acre
- Closer planting requires more shallow planting
- Closer planting provides root competition
- Little girth will provide no support
- “Sail effect” of tree wall

Tall Spindle/ Super Spindle

- Requires “Total Support” system
- Most robust system to carry 20 tons of apples and more per acre
- 12’X4” Line posts 25-30’ in row
- 12’X5-6” End posts
- Multiple wires for early growth and to support early fruiting
- Multiple wires to provide redundancy

Tall Spindle/Super Spindle

- Trunks only are attached to wires, not branches.
- Need fail proof anchor system

Angled Canopies

- “V” spindle, “Y” trellis, Tatura
- 500 to 1200 trees per acre
- M26 and smaller
- Planting depth dependent upon system
- Permanent support due to 60 degree angle of trees
- Double fruiting walls
- Optimum canopy angle results in heavy cropping

Angled Canopies

- Line Posts 25-30’ apart in row
- Line posts can be a single post with structure, or two posts driven at angles

Angled Canopies

- Two end posts driven at compound angles, ie, 60 degrees and leaning out

Angled Canopies

- ✓ One to three wires per side depending upon system
- ✓ If one wire, then bamboo, conduit or angle iron should be provided at each tree
- ✓ Fail proof anchor system needed

Pedestrian Trellises “Espalier”

- ✓ M9 strains and B9, M26 for spur types
- ✓ 600 to 800 trees per acre
- ✓ Under 7’ tall
- ✓ 10’X4” posts 40-50’ apart
- ✓ 10-12’X5-6” End posts
- ✓ Generally 3 wires
- ✓ Trees are trained to the wires, ie branches attached to wires
- ✓ Numerous training systems

Components of Support Systems

- ✓ Bamboo - Gives several years of support. High Tensile Strength.
- ✓ Conduit - 1/2-3/4” galvanized. Eventually will rust and split. More of a training aid than a support aid unless coupled with one or more wires.

Support Components

- ✓ Angle Iron. “Best Angle”

High carbon rail steel. Various widths 3/4” to 2”. With or without holes punched. PA company.

www.bestangletreestakes.com

Support Components

- ✓ Wood Posts

2” - individual tree posts, not line posts for permanent systems. Improved with addition of one wire overhead.

Support Components

- ✓ 4”+ wood posts.

Must be pressure treated to minimum .40, (not dipped or brushed), or a suitable rot resistant species.

Lodgepole or Yellow Pine

Whole tree, not peelers preferred.

Dimensional lumber can have larger knots in the wrong places, ie, at ground level.

Support Components

- ✓ Concrete posts

- Thousands of acres of Tall Spindle and Super Spindle trees in Europe are supported with concrete posts.
- Can be engineered to specific requirements.
- Uniform sizes and strengths. Extensive Hardware materials available.

Support Components

- ✓ Concrete Posts
- Hail protection systems are built on the posts.
- Cannot be driven, must be vibrated into ground

Support Components

- ✓ Anchors

- Screw type
- Driven Steel
- Driven wood posts
- Various “Back brace” systems
- “Dead Men”

Support Components

- ✓ Anchors are the “Foundation” of your tree support system. Transfer of much of the stress of the system to the ground takes place through the anchor. Have point of attachment of wires as close to the ground as possible to counter leverage affect.

Support Components

- ✓ Wire

- Standard is 12.5g High Tensile steel, Class III galvanized.
- Requires some special tools and supplies to work with
- Hard wire cutters
- Crimper and crimps
- Spinning Jenny

Support Components

- ✓ Tensioners

- “Kiwi” or “Gallagher” round in line
- “Dare”
- “Gripple”
- “Wire Vise”

Post Installation

- ✓ Driven posts are stronger
- Post to be driven should not be pointed, but small end should be down.
- In rocky soils, a pilot will be needed.
- Posts can be vibrated into ground with excavator or backhoe attachment
- Easiest when soil is wet

Post Installation

- ✓ Augered holes
- Not as strong as driven.
- Big end of post down
- More tendency to heave over time
- Should pack in layers when backfilling, preferably with stones

Wire Installation

- ✓ Attach to post with 2” barbed, not notched, staple.
- ✓ Drive staple at angle to grain, not straight causing split
- ✓ Do not drive staple “home”, allow wire to move for tensioning.
- ✓ Spinning Jenny makes wire handling much easier
- ✓ Don’t kink wire and straighten

Wire Installation

- ✓ Use crimps (sleeves) for splicing and tying off ends of wire.
- ✓ Use tensioners to maintain tension.
- ✓ Conduit, bamboo and 2” posts should be attached to wire with a non slip method

Attachment of Trees to Support System

- ✓ To Posts, Conduit, Bamboo, Steel stakes
- Stretchable materials should be used.
- Tapes, tube, rubber bands and plastic chain ties.
- Trees should be tied several times,that is every 2’ or so, and ties need to be replaced over time.

Attachment of trees to Wire

- ✓ Wire clips provide strong positive placement on wire and do not break down.
- ✓ Plastic clips are inexpensive, sizes are limited, and break down from sunlight
- ✓ Rubber ties are reasonably inexpensive, have good longevity but will allow tree to slide

Attachment of Trees to Wire

- ✓ Tapes are inexpensive materials but may have higher labor costs
- ✓ Whatever material is used, care should be taken to prevent trees from sliding down the wire causing “domino” affect

Conclusion

- ✓ The weakest link in your support system may well prove to be the most expensive component in your orchard. Find it and fix before it is too late.
- ✓ Avoid cutting corners with low quality materials that will need to be replaced before the orchard is to be replaced.
- ✓ Install the support system at planting time to encourage rapid filling of space and avoid tree loss.

References

- ✓ Google “Constructing an Orchard Trellis”
- ✓ “Apple Orchard Systems”, Bruce Barritt, Compact Fruit Tree reprint from Good Fruit Grower

Managing Secondary Pests in Apples



John C. Wise, Ph.D.

MSU Department of Entomology
Trevor Nichols Research Complex

Secondary Insect Pests of Apples

WALH

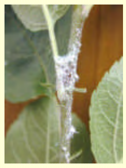
STLM

RAA

PLH

SJS

WAA



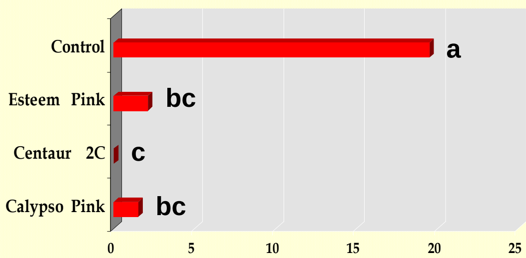
Strategies for Managing Secondary Pests Should Include

- Minimize disruption of biological control.
- Select effective tools for targeted control when pest pressures justify action.
- Control 2nd pest within primary pest program.

Insecticides for Secondary Insect Pests

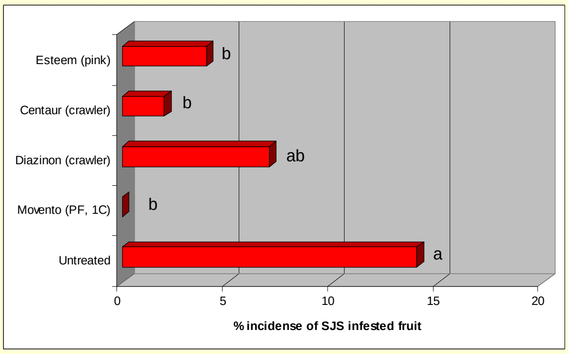
Insect Growth Regulators	Neonicotinoids
Esteem, Centaur	Provado, Calypso
Botanicals	Clutch, Actara, Assail
Requiem, Neem	Pyridine Carboxamides
Tetronic Acids	Beleaf
Movento	Organophosphates
Chlorinated Hydrocarbons	Lorsban, Diazinon
Endosulfan	Supracide

San Jose Scale Control in Apple

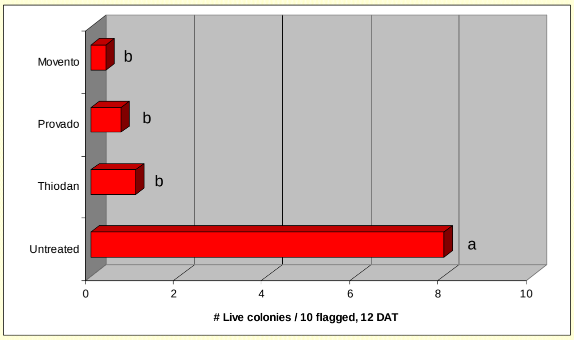


2001 TNRC, Sept., % fruit w/ scale at harvest (P= .05, LSD)

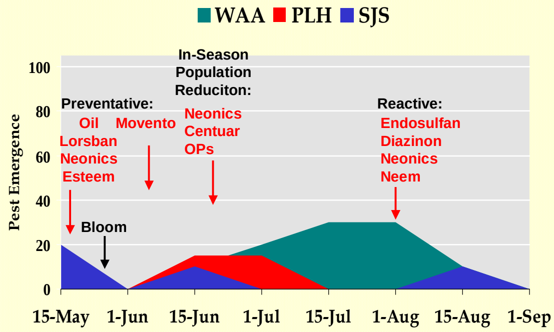
Control of San Jose Scale in Apples



Control of Wooly Apple Aphid in Apples



Optimal Timings for Secondary Insect Control

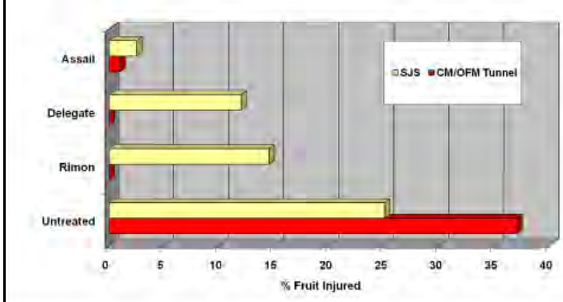


New Insecticides for Codling Moth

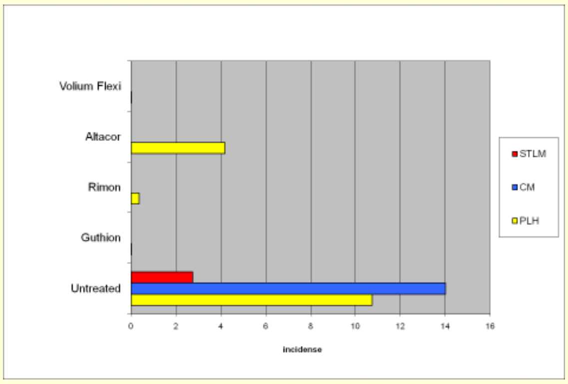
Spinosyns	Neonicotinoids
Delegate	Calypso
Entrust*	Assail
Insect Growth Regulators	Clutch
Rimon	Microbials
Diamides	granulosis virus*
Altacor	Avermectins
Belt	Proclaim

Voliam Flexi (chlorantraniliprole + thiamethoxam)

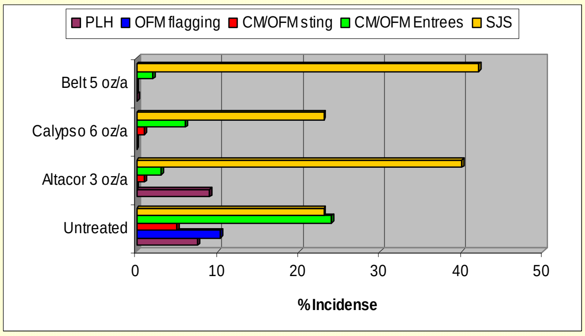
Apple Harvest Fruit Evaluation



Apple Mid-season Evaluation



Apple Harvest Fruit Evaluation



Optimal Partnering for Secondary Pest Control

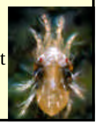
CM/OFM + LH
- Neonics
- Ops
- Voliam flexi

CM/OFM + STLM
- Rimon
- Delegate
- Altacor
- Belt
- Voliam flexi

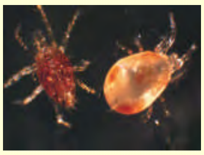
CM/OFM + SJS
- Assail
- Tourismo
- Warrior

Mite Flaring

- There are at least three possible mechanisms responsible for "mite flaring":
  - Hormoligosis - the reproductive stimulation after exposure to sublethal doses of an synthetic insecticide (Luckey 1968).
    - Carbaryl on T. urticae (Dittrich 1974)
    - Pyrethroids on T. urticae (Gerson and Cohen 1989)
    - Imidaclorpid on T. urticae (James and Price 2002)
  - Trophobiosis – enhanced reproduction of herbacious arthropods resulting from altered biochemical state of the plant (ie; health effects) (Chabussou 1970)
    - Carbaryl on T. urticae (Dittrich 1974)
  - Second the reduction of biological control through direct toxicity to or indirect sublethal affects to predacious mites.

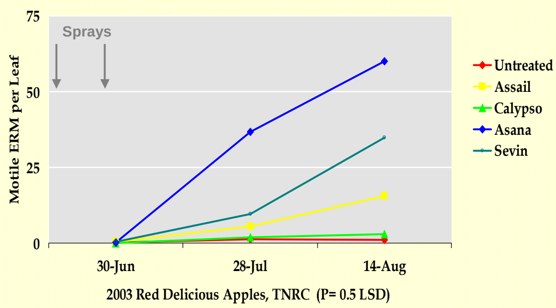


Mite Flaring Study

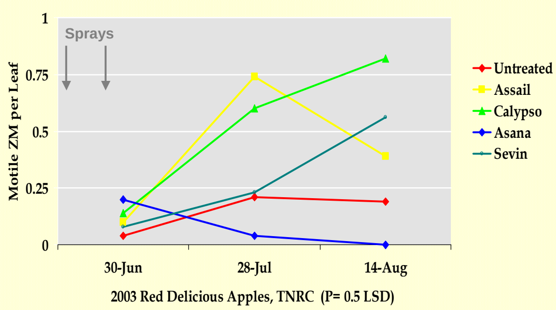


- Objectives:
  - Evaluate the effect of selected compounds on ERM populations over time and toxicity to predacious mites.
  - Evaluate selected new chemistry compounds in tank mixes with Carbaryl (Sevin) to simulate a common post-petal fall scenario.

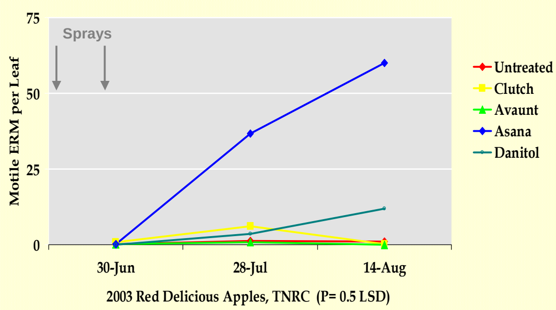
Mite Flaring From Individually Applied Compounds



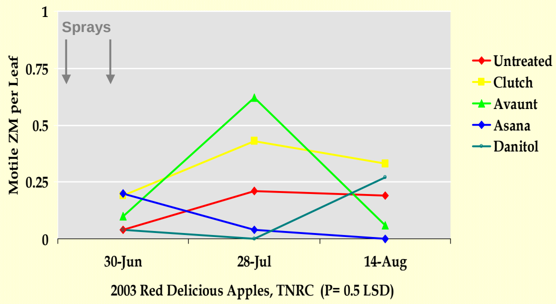
Impact of Insecticides on Predator Mites



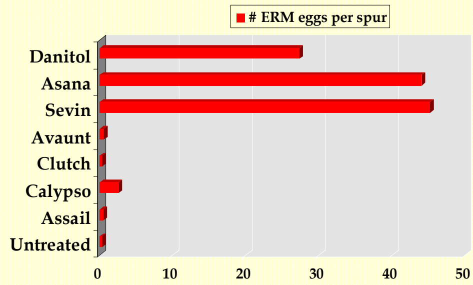
Mite Flaring From Individually Applied Compounds



Impact of Insecticides on Predator Mites

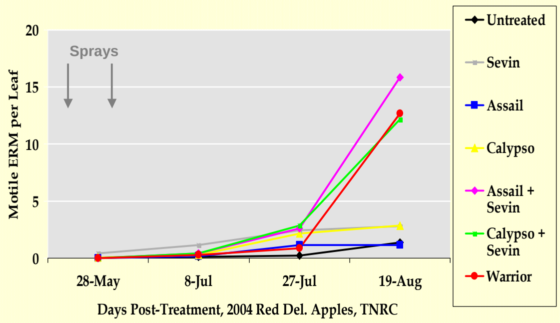


Mite-Flaring Effects on ERM after Harvest



2003 Field Trial, Red Delicious Apples, TNRC (P= .05, LSD)

Mite Flaring From Tank-Mix Treatments



Implications for Mite Pest Management

- Scouting and orchard history provide critical information for effective mite pest management.
- Risks of mite flaring can be minimized by protecting mite predators.
- Impact of fungicides on mite-flaring?

A summary of 'Honeycrisp' storage recommendations across North America: What is best for Michigan?

R.M. Beaudry and Carolina Contreras, Department of Horticulture, Michigan State University
Report to the 2009 Great Lakes Expo

Despite the fact that the Honeycrisp apple fruit has been grown commercially in the US for nearly 20 years (Honeycrisp was first planted in 1962 as seed produced from a 1960 cross of Macoun and Honeygold, as part of the University of Minnesota apple breeding program and released in 1991), its production has only recently been significant enough to warrant the development of storage strategies to hold it beyond three to four months of refrigerated air storage. Significant production acreage can now be found in Michigan, Minnesota, New York, Nova Scotia, Ontario, and, following recent plantings, Washington.

Although the variety was bred as part of a breeding program to develop winter hardy cultivars, the fruit have proven to be quite sensitive to low temperatures encountered in storage (Watkins et al, 2004, 2005). Low temperature injury symptoms include soggy breakdown (Fig. 1) and soft scald (a.k.a. ribbon scald or deep scald, Fig. 2).

Figure 1. Soggy breakdown of Honeycrisp. Internal injury (left) can extend to the surface in severe cases, (right) leading to surface browning that differs from the clean, sharp edges of soft scald (below).

Figure 2. Soft scald on Honeycrisp. Injury begins as a ribbon-like light brown lesion with well-defined edges (left) and over time becomes dark brown as tissues degrade and decay begins (right). May or may not be associated with soggy breakdown.

There appears to be a marked sensitivity to injury from low O_2 and elevated CO_2. Research at Michigan State University since 2002 has revealed that, in addition to sensitivity to low temperatures, controlled atmosphere (CA) storage can also cause internal injury. CA injury looks similar to soggy breakdown, but may be a little less 'wet' in appearance. It can occur in air, but is much exacerbated by exposure to either low O_2 or elevated CO_2 (Fig. 3).

Figure 3. Internal controlled atmosphere injury from low O_2 and elevated CO_2. Injury can be in small patches or large sections, depending on severity (left). The disorder can lead to the formation of more typical CO_2 injury (right) with time.

To-date, no satisfactory method for the controlled atmosphere storage of 'Honeycrisp' apple has been determined here in Michigan. Honeycrisp is the most profitable apple on a per fruit basis grown in our state and the number of bearing acres is increasing dramatically each year. The increased production will require storage of this fruit for longer durations than previously needed in order to market the crop before value is lost due to the deterioration of the fruit. If we do not develop a means to store this fruit satisfactorily, our growers and storage operators will suffer excessive storage losses and be at a marked disadvantage in the marketplace.

Although we have found Honeycrisp fruit to be highly sensitive to CA injury (see report below), anecdotal and limited published reports suggest that CA storage is possible (Nichols et al., 2008). Alternative to the use of CA, use of the ethylene action inhibitor, 1-methylcyclopropene (1-MCP, SmartFresh), has the potential to minimize ripening-related loss in condition (Mir et al., 2001). Air storage in combination with 1-MCP use, even at elevated temperatures, may provide sufficient improvement in storability to enable storage for several months (Mir and Beaudry, 2001).

A pre-storage conditioning treatment involving holding the fruit at temperatures between 50 and 70 °F for five or more days reduces low temperature injury and that, in combination with storage at 38 °F, can nearly completely control this disorder (Nichiols, et al., 2008; Watkins et al., 2004). Contreras et al. (2008) found that a short preconditioning treatment also reduced fruit sensitivity to superficial scald. The use of pre-harvest conditioning to minimize storage stresses has some merit and has been used successfully for some CA storage of Honeycrisp, although published resources are lacking. Use of pre-conditioning treatments will be at the core of research performed here in Michigan oer the next few seasons.

Preliminary work in Michigan.

A research CA system, inspired by leaders in the Michigan apple industry and constructed by Storage Control Systems, was delivered and installed in the Postharvest Biology and Technology

Laboratory in East Lansing in time for Fall 2008 harvest of Honeycrisp. MSU has financed this as a 4-year lease-purchase from funding supplied by the Michigan Apple Committee and the Michigan Ag. Experiment Station. CA Chambers used to house the fruit were purchased separately and have been purchased through several generous donations from growers, storage operators, shippers and other organizations with an interest in apple fruit storage (Table 1).

Table 1. CA chamber donors to-date

Donor organizations:	
AgroFresh	North Bay Produce
Applewood Orchards	Ohio Apple Fruit Growers
Belleharvest	Rasch Brothers Apples
Dietrich Orchards	Riveridge
Heeren Brothers	Roossinck Fruit Storage
Jack Brown Produce	PlantPathology - MSU
Anonymous	USDA - MSU

In 2008, we set up an experiment to determine CA conditions that reproducibly induce the development of atmosphere-dependent injury (see Fig. 3). To this end, 20-bushel lots of field-run Honeycrisp fruit were harvested from four different locations in Michigan in the fall of 2008 and held under six different atmospheres: 1%, 3%, and 21% oxygen combined with either 0% or 3% carbon dioxide using the new CA system. The ethylene action inhibitor 1-methylcyclopropene (SmartFresh) was applied to half of the fruit held under the conditions of 21% oxygen and 0% carbon dioxide (i.e., air). All fruit were held at 38°F, rather than 32°F to minimize chilling injury. In a preliminary experiment, two bushels of fruit from each location were preconditioned for 3 and 5 days at 50°F. Our evaluations were after 1, 3, and 6 months storage.

So far, the results clearly indicate a high sensitivity to both low oxygen and elevated carbon dioxide levels (Fig. 4). As many as 70% of the fruit from individual lots suffered mild to extreme internal browning under low oxygen (both 1% and 3% oxygen) when the carbon dioxide level was at 3%. Interestingly, one lot had no internal injury whatsoever even with CO_2 present. Without CO_2, the internal browning severity was markedly reduced, but still significant as long as the O_2 level was low. When the oxygen level was increased to that of air (21%), internal browning occurred only when the CO_2 was present - although the degree of damage was relatively minor. Not surprisingly, the degree of sensitivity to the CA regimens differed from orchard to orchard.

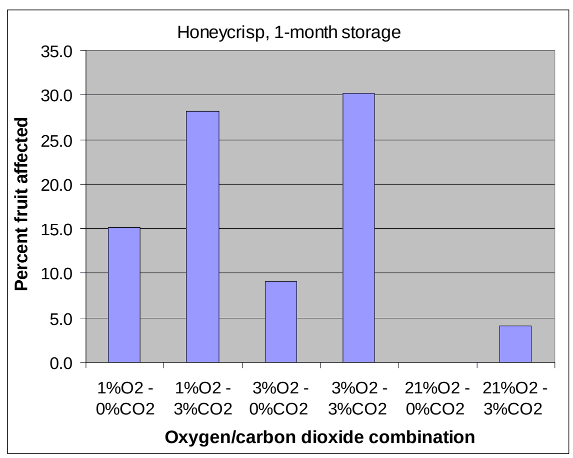


Figure 4. Internal damage incidence for Honeycrisp apple fruit held in CA storage or air at a non-chilling temperature for one month.

The amount of damage did not appear to increase as the storage duration increased, but the distribution of the categories did change (Fig. 5). The data suggest that the tissue damaged by soggy breakdown-like symptoms eventually developed into lens-shaped openings in the brown tissue, resembling CO_2 injury-like symptoms. Fruit (especially the air treatment) eventually displayed senescent breakdown symptoms. Importantly, the extent of the CA injury seems to be near its maximum after only one month in CA. SmartFresh, which was used only on air-stored fruit, markedly reduced the ripening rate, but did cause internal browning, and suppressed senescent breakdown. While these findings are preliminary, they are consistent with our previous findings since 2002 and reinforce our current belief that more work is needed before we can make recommendations regarding appropriate CA storage atmospheres.

Over the next three years, we propose to identify prestorage conditioning treatments to alleviate CA injury and evaluate the use of SmartFresh to avoid use of potentially harmful storage atmospheres. This year, we have 20-bushel lots of fruit in storage from seven different growers representing four different regions of the state including Southeast Michigan (Bob Tritten, cooperator), Southwest Michigan (Bill Shane, cooperator), Fruit Ridge and Belding (Phil Schwallier and Amy Irish-Brown, cooperators), West Michigan (Mira Danilovich, cooperator). Tests include: 1) the impact of temperature and duration of the preconditioning treatment; 2) the potential for 1-MCP to extend storability without use of CA; 3) the potential for DPA to suppress CO_2 injury symptoms.

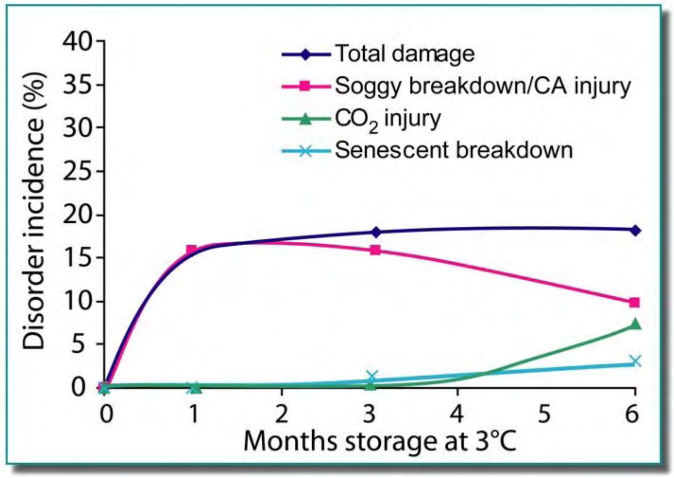


Figure 5. Internal damage incidence for Honeycrisp apple fruit held in CA storage (1.5 or 3% O_2 with 0 or 3% CO_2) at a non-chilling temperature.

Literature Cited

Contreras, C., Zoffoli, J.P., Alcalde, J.A., and Ayala M. 2008. Evolución del daño por insolación de manzanas ‘Granny Smith’ durante el almacenaje refrigerado. Cien. Inv. Agr. 35(2): 147-157. 2008.

Delong, J.M., R.K. Prange, W.C. Schotsmans, D.A. Nichols and P.A. Harison. 2009. Determination of the optimal pre-storage delayed cooling regime to control disorders and maintain quality in ‘Honeycrisp’™ apples. J. Hort. Sci & Biotech. 84:410-414

Kupferman, E., and J. Mattheis. 2009. A Status Report on Honeycrisp Apple Maturity and Storage for Washington (http://postharvest.tfrec.wsu.edu/EMK2009B.pdf), Postharvest Information Network, September 2009, Treefruit Research and Education Center, Wenatchee, WA.

Mir, N. and R. M. Beaudry. 2001. Use of 1-MCP to reduce the requirement for refrigeration in the storage of apple fruit. Proc. 2000 Int’l Postharvest Conference, Acta Horticulturae 553:577-580.

Mir, N.A, E. Curell, N. Khan, M. Whitaker, and R.M. Beaudry. 2001. Harvest maturity, storage temperature, and 1-MCP application frequency alter firmness retention and chlorophyll fluorescence of ‘Redchief Delicious’ apple fruit. J. Amer. Soc. Hortic. Sci. 125:618-624.

Nichols, D., Hebb, J., Harrison, P., Prange, R., and DeLong, J. 2008. Atlantic Canada ‘Honeycrisp’: Harvest, conditioning and storage. Ag. Agri-Food Canada, Cat. No. A52-85/2008E-PDF, ISBN 978-0-662-47677-1, AAFC No. 10541E.

Watkins, C.B., J.F. Nock , S.A. Weis, S. Jayanty, and R.M. Beaudry. 2004. Storage temperature, diphenylamine, and pre-storage delay effects on soggy breakdown, soft scald and bitter pit of ‘Honeycrisp’ apples. Postharvest Biology and Technology. 32:213-221.

Watkins, C.B., M. Erkan, J.F. Nock, K.A. Iungerman, R.M. Beaudry, and R.E. Moran 2005. Harvest date effects on maturity, quality and storage disorders of ‘Honeycrisp’ apples. HortScience, 40:164-169.

REGION-BY-REGION STORAGE RECOMMENDATIONS FOR HONEYCRISP: Responses from apple storage researchers.

Information provided by:
Dr. Randy Beaudry, Michigan State University, East Lansing, MI;
Dr. Cindy Tong, Univ. of Minnesota, Minneapolis, Minn.;
Dr. Chrisopher Watkins, Cornell Univ., Ithaca, NY;
Dr. Robert Prange, Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, Kentville, Nova Scotia;
Dr. Jennifer DeEll, Ontario Ministry of Agriculture, Food and Rural Affairs, Simcoe, ONT;
Dr. Gene Kupferman, WSU and
Dr. Jim Mattheis, USDA-ARS,Wenatchee, Washington

Summary Table for Storage Recommendations for Honeycrisp

State or Province	Primary Harvest Indices	Preconditioning	Pre-storage treatments	Air Storage	CA storage
Michigan	Starch, background color, red coloration	5 days at 50 ºF	SmartFresh	38 ºF	Not recommended
Minnesota	Background color	5-7 days at 55 ºF	None	34-36 ºF w/ Preconditioning	Not recommended
New York	Background color and red coloration	7 days at 50 ºF	None	38 ºF	Not recommended
Nova Scotia	Starch and background color	6 days at 68 ºF	None	37-41 ºF	37-41 ºF w/prec. 2% O_2, 1% CO_2
Ontario	Color, starch, soluble solids	5 days at 50 ºF	SmartFresh	37-41ºF	Not recommended
Washington	Background color, starch	7 days at 50 ºF	SmartFresh	35-36 ºF	35 ºF w/ prec., 2% O_2, 1% CO_2

Michigan – Dr. Randy Beaudry, Michigan State University, East Lansing, MI

HARVEST

Most important harvest maturity indices include: *Starch index (4-6), red coloration, change in background color from green to yellow*

Range in number of harvests/pickings for a single block: *3 to 4*

PRECONDITIONING

Typical preconditioning temperatures and durations for air storage: *50 ºF for 5-7 days*

Typical preconditioning temperatures and durations for air storage + MCP, if different from above: *No difference*

Typical preconditioning temperatures and durations for CA storage: *No recommendation yet; evaluating 50 ºF for 5-7 days, followed by 38 ºF CA storage*

Typical preconditioning temperatures and durations for CA storage + MCP, if different from above: *No difference*

Other (e.g., humidity control, moisture loss): *No recommendation*

PRESTORAGE TREATMENTS

1-MCP application: *Yes, especially for long-term (5-7 mo.) air storage.*

DPA application: *Not advised as a dip to avoid spread of fungal spores. DPA provides only a marginal benefit in the prevention of soft scald. Impact on internal CO_2 injury is being evaluated.*

Fungicides: *Not advised as a dip to avoid spread of fungal spores. Thermofogging needs to be investigated.*

Calcium dip: *Not advised for same reason as for DPA, unless growers have not been spraying calcium in orchard preharvest*

STORAGE TREATMENTS

Air storage

Temperature or temperature range: *38 ºF*

Maximum duration: *3 to 4 months*

Control of CO_2 during room loading: *Advised; CO_2 levels should remain below 1% during loading.*

CA storage – *Not currently advised, although some success has been achieved experimentally and at some storage facilities in Michigan. Marked differences in susceptibility to CA injury were detected between growers and growing regions.*

Temperature or temperature range: *No recommendation, although temperatures will likely have to be greater than 36 ºF, due to sensitivity to chilling injury.*

Maximum duration: *No recommendation*

Oxygen levels: *No recommendation, although 3% yielded less CA injury than 1.5%.*

Carbon dioxide levels: *No recommendation; early research results suggest maintaining CO_2 levels below 1% for at least the first 30 days of storage.*

Control of CO_2 during room loading: *Advised – keep CO_2 levels below 1%.*

OTHER COMMENTS or RECOMMENDATIONS -

Minnesota – Dr. Cindy Tong, Univ. of Minnesota, Minneapolis, Minn.

HARVEST

Most important harvest maturity indices include: *change in background color from green to yellow*

Range in number of harvests/pickings for a single block: *2 or 3*

PRECONDITIONING

Typical preconditioning temperatures and durations for air storage: *55 ºF for 5-7 days*

Typical preconditioning temperatures and durations for air storage + MCP, if different from above: *MCP not used*

Typical preconditioning temperatures and durations for CA storage: *55 ºF for 5-7 days, followed by 34-36 ºF CA storage*

Typical preconditioning temperatures and durations for CA storage + MCP: *no recommendation*

Other (e.g., humidity control, moisture loss): N.R. (no response)

PRESTORAGE TREATMENTS

1-MCP application: *no*

DPA application: *no*

Fungicides: *no, but some commercial use occurs*

Calcium dip: *no, unless growers have not been spraying calcium in orchard preharvest*

STORAGE TREATMENTS

Air storage

Temperature or temperature range: *34-36 ºF*

Maximum duration: *usually done by end of January*

Control of CO_2 during room loading: N.R.

CA storage – *Not recommended, but some success has been achieved at some commercial storage facilities. The following represent commercial practices.*

Temperature or temperature range*: 34-36 ºF*

Maximum duration: *done by end of January or February*

Oxygen levels: *1%*

Carbon dioxide levels: *1%*

Control of CO_2 during room loading: N.R.

OTHER COMMENTS or RECOMMENDATIONS - *A web site on Honeycrisp Apple research results has been developed by Dr. Cindy Tong of Minnesota. The address is: http://smfarm.cfans.umn.edu/Honeycrisp.htm.*

New York State – Dr. Chrisopher Watkins, Cornell Univ., Ithaca, NY

HARVEST

Most important harvest maturity indices include: *Color, flavor*
Range in number of harvests/pickings for a single block: *3-6*

PRECONDITIONING

Typical preconditioning temperatures and durations for air storage: *50 ºF for 7 days*
Typical preconditioning temperatures and durations for air storage + MCP, if different from above: *Not much SmartFresh use, if any*
Typical preconditioning temperatures and durations for CA storage: *None - not recommended, though several folk have had mixed success*
Typical preconditioning temperatures and durations for CA storage + MCP, if different from above: N.R. (no response)
Other (e.g., humidity control, moisture loss): N.R.

PRESTORAGE TREATMENTS

1-MCP application: *Not recommended, but may change because of potential titratable acidity benefit*
DPA application: *I discourage postharvest drenches of any sort because of decay risk - easily damaged apple and even with fungicides not worth the risk*
Fungicides: N.R.
Calcium dip: N.R.

STORAGE TREATMENTS

Air storage

Temperature or temperature range: *38 ºF*
Maximum duration: *not sure there is limit yet; most fruit is marketed pretty promptly*
Control of CO_2 during room loading: *None*

CA storage

Temperature or temperature range: N.R.
Maximum duration: N.R.
Oxygen levels: N.R.
Carbon dioxide levels: N.R.
Control of CO_2 during room loading: N.R.

OTHER COMMENTS or RECOMMENDATIONS - N.R.

Nova Scotia – Dr. Robert Prange, Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, Kentville, NS

HARVEST – *Clip fruit stems to control decay*

Most important harvest maturity indices include: *When considering harvest, the change of fruit starch to sugar is a reliable initial indicator of 'Honeycrisp' readiness. The change in background colour from green to cream is a good visual indicator of when to begin harvest.*

Range in number of harvests/pickings for a single block: *Repeat spot-pick for size and colour*

PRECONDITIONING – *Delay cooling is essential to control disorders*

Typical preconditioning temperatures and durations for air storage: *50-68 ºF (10-20 °C) for 4-7 days,*

Typical preconditioning temperatures and durations for air storage + MCP: N.R. (no response)

Typical preconditioning temperatures and durations for CA storage: (*68 °F*) *20 ºC for 6 days prior to CA conditions*

Typical preconditioning temperatures and durations for CA storage + MCP: N.R.

Other (e.g., humidity control, moisture loss): *Initially, it was believed that the benefit of 6 days at 20 C was due to a slight loss (1%) of moisture from the fruit. However, similar or better benefits are achievable with 1-2 days at 25 C or 1 day at 30 C with minimal moisture loss (Delong et al., 2009) so the control of these disorders is not solely linked to moisture loss after harvest. During delay-cooling treatment, O2 and CO2 should be monitored to avoid the occurrence of unsafe levels for both human activity and the fruit.*

PRESTORAGE TREATMENTS

1-MCP application: *Not recommended, may cause CO_2-like disorders even in air storage*

DPA application: *Do not drench*

Fungicides: *Do not drench*

Calcium dip: *Do not drench*

STORAGE TREATMENTS

Air storage

Temperature or temperature range: *37-41 °F (3-5 °C).*

Maximum duration: < *6 mo.*

Control of CO_2 during room loading: N.R.

CA storage – *Retention of constant firmness throughout the refrigerated air (RA) storage period may cause one to question the necessity for CA for 'Honeycrisp' apples. Controlled-atmosphere storage reduces the incidences of fruit decay and greasinesss, and maintains juiciness and flavor when compared with cold stored apples.*

Temperature or temperature range: *Storage operators must ensure that the desired storage temperature of the fruit is,obtained prior to applying CA conditions to the sealed storage room*

Maximum duration: *6-12 mo.*

Oxygen levels: *0.5%-0.8%, up to 2%*

Carbon dioxide levels: *We have observed experimental evidence of CO_2-related injury. Therefore, (CO_2 should initially be scrubbed to less than 1% for 3 to 4* *weeks prior to allowing it to accumulate up to, but not exceeding 1%, long-term)*

Control of CO_2 during room loading: *See comments above under PRECONDITIONING*

OTHER COMMENTS or RECOMMENDATIONS - *Our research has demonstrated that 'Honeycrisp' fruit harvested during the optimum harvest window and delayed cool-treated at of results in superior fruit quality after storage. 'Honeycrisp' fruit do not have ultra low oxygen (ULO) sensitivity and fruit have been stored experimentally in Dynamic Controlled Atmosphere (DCA) at 0.7% O_2 without injury for 9 months. Waxing should be done with caution as excessively thick wax can cause total deterioration of the fruit within 2-4 days*

Ontario – Dr. Jennifer DeEll, Ontario Ministry of Agr. Food and Rural Affairs, Simcoe, ON

HARVEST

Most important harvest maturity indices include: color, starch, SSC

Range in number of harvests/pickings for a single block: 2 to 4

PRECONDITIONING

Typical preconditioning temperatures and durations for air storage: *5 days at 10 ºC (50 ºF)*

Typical preconditioning temperatures and durations for air storage + MCP: *5 days at 10 ºC (50 ºF)*

Typical preconditioning temperatures and durations for CA storage: *5 days at 10 ºC (50 ºF)*

Typical preconditioning temperatures and durations for CA storage + MCP: *5 days at 10 ºC (50 ºF)*

Other (e.g., humidity control, moisture loss): N.R. (no response)

PRESTORAGE TREATMENTS

1-MCP application: *can reduce greasiness but little effect on firmness or disorders*

DPA application: *never saw an effect on soft scald when tested*

Fungicides: *avoid drenching*

Calcium dip: avoid drenching: *use calcium sprays in the orchard, lots!*

STORAGE TREATMENTS

Air storage

Temperature or temperature range: *3 to 5 ºC*

Maximum duration: *4 to 6 mo.*

Control of CO_2 during room loading: *maybe monitored, but not much more*

CA storage - *no solid recommendation and not used commercially*

Temperature or temperature range: N.R.

Maximum duration: N.R.

Oxygen levels: N.R.

Carbon dioxide level: N.R.

Control of CO_2 during room loading: N.R.

OTHER COMMENTS or RECOMMENDATIONS – N.R.

Washington State - Dr. Gene Kupferman, WSU (Kupfer@wsu.edu) and Dr. Jim Mattheis USDA – ARS

Honeycrisp is likely the most challenging apple variety grown commercially in Washington State. Consumer demand has been exceptional, leading to high returns and a rapid increase in plantings. As volume increases, the necessity to increase the length of the storage season also increases. Limited research experience on Honeycrisp grown in the Pacific Northwest has been undertaken in recent years by scientists at the Tree Fruit Research Laboratory (USDA-ARS) in Wenatchee. This research confirms the challenges facing the industry in judging maturity and storage.

This [response] combines the results of this research with that of scientists in other locations where Honeycrisp has been grown and studied over a longer period of time. Due to the limited timeframe of this research, caution is advised in putting this information to play in a commercial situation. The authors recommend that storage operators set up their own trials on maturity, drenching, pre-storage conditioning and storage to gain first hand experience with this variety under different conditions. A cautionary note: It is critical to be aware that this is a very chilling sensitive apple. The disorders that can develop from rapid cooling or excessively cold storage temperatures include Soft Scald and Soggy Breakdown. The potential for this to happen is very real and often can have serious economic repercussions.

HARVEST - *Judging maturity on Honeycrisp is not simple. Fruit firmness does not change during the maturation stage and in most locations when starch is only moderately cleared the fruit are not commercially acceptable.*

Most important harvest maturity indices include: *Most commercial experience has been to use the change in **ground color** from green to white to time the harvest, providing commercial red color has been reached. Typically, when maturity is judged using background color little **starch** remains in the fruit, thus the life of the fruit in long-term storage is shortened. Research from scientists in the eastern United States has shown that the risk of Soft Scald increases in early-harvested fruit even when caution is taken to avoid chilling after harvest.*

Range in number of harvests/pickings for a single block: N.R. (no response)

PRECONDITIONING - *It is critical to re-iterate that Honeycrisp is a very chilling sensitive apple. The disorders that can develop from rapid cooling or excessively cold storage temperatures include Soft Scald and Soggy Breakdown. The potential for this to happen is very real and often can have serious economic repercussions. These disorders have appeared in as little as 7 to 14 days in fruit that were placed rapidly in storage and held in low temperature (32 ºF).*

Typical preconditioning temperatures and durations for air storage - *Research in Washington and New York has shown success when Honeycrisp is held at or about 50 ºF for 7 days prior to being placed in cold storage. However, when Bitterpit susceptible fruit are held at these warm temperatures this disorder can become a big problem. Therefore, minimization of Bitterpit risk in the orchard is an important component in growing this fruit. There has been little success in increasing calcium in apples (to reduce the potential for Bitterpit) through the use of postharvest calcium drenches.*

Typical preconditioning temperatures and durations for air storage + MCP, if different from above: N.R.
Typical preconditioning temperatures and durations for CA storage: N.R.
Typical preconditioning temperatures and durations for CA storage + MCP, if different from above: N.R.
Other (e.g., humidity control, moisture loss): N.R.

PRESTORAGE TREATMENTS - *Honeycrisp has a high potential for decay. Therefore, the postharvest application of a fungicide drench or preharvest fungicide spray should be considered.*
1-MCP application: *In research trials, the application of SmartFresh has shown to reduce acidity loss, greasiness and internal radial browning. SmartFresh has not been identified as affecting the risk of Soft Scald or Soggy Breakdown.*
DPA application: *Researchers in the eastern United States have not found a benefit from the application of diphenylamine (DPA) and there has been no experience with it in Washington.*
Fungicides: N.R.
Calcium dip: N.R.

STORAGE TREATMENTS - *The delay in temperature reduction has shown to be effective in reducing storage disorders whether fruit are to be placed in controlled atmosphere or air storage.*
Air storage
Temperature or temperature range: *Research with Washington grown Honeycrisp has shown that when the fruit have been stored in the upper 30's (ºF), over time they become greasy, the skin color changes and acidity is lost. Limited storage trials at 35 to 36 ºF have given a better balance of quality and reduction of storage disorders. Temperatures in the lower 30's (ºF) have resulted in an increase of storage disorders.*
Maximum duration: N.R.
Control of CO_2 during room loading: N.R.
CA storage - *Very limited trials in CA. This apple has not easily lost firmness after harvest; but there has been little work on the effect of storage on the retention of the special characteristics of aroma, flavor and texture.*
Temperature or temperature range - *CA storage at 35 ºF has given good results.*
Maximum duration – N.R.
Oxygen levels: *2%*
Carbon dioxide levels: *1%*
Control of CO_2 during room loading: N.R.

OTHER COMMENTS or RECOMMENDATIONS - *A Note on Packing - Researchers in the eastern United States report that the use of wax on Honeycrisp could have led to the development of severe internal breakdown in as little as 5 to 10 days in storage.*

THE ENERSAVE CONTROL SYSTEM

6.6 Million Bushels Of Fruit Now Being Cooled By ENERSAVE Including:

28 Fruit Storage Customers in West Michigan Storing A Combined **4.8 Million Bushels**

2 Fruit Storage Customers in New York Storing A Combined **820,000 Bushels**

1 Fruit Storage Customer in Canada Storing **1,000,000 Bushels**

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Scott received his Bachelor of Science degree in engineering from Michigan State University in 1980 and his Professional Engineering license in 1992. He is the designer of a number of efficient refrigerated systems for fruit growers and is the inventor of the ENERSAVE program.

Frank is Vice President of Van Kempen Electric, a 35 year, family owned electrical business specializing in electrical design, installation and maintenance of agricultural, commercial and industrial facilities.

Scott and Frank started ENERSAVE, LLC. in 2001.

Work Sheet for Storage Cost, Kilowatt Hours per Bushel (October-March)

Three large electrical energy consumers; Nitrogen Generator, Packing Line and Refrigeration System

A) Nitrogen Generator; ___________ x _____________ = ______________ KWH (A)
Horse Power   Running Hours (Oct-April)   7 month total kwh

B) Packing Line; __________________ x .25 = __________________KWH (B)
Bushels Run (Oct-April)   7 month total kwh

C) October – April KWH use; ____________________________KWH (C)
Electrical Utility Bill

D) Refrigeration System KWH Use; C – (A + B) = ___________________ KWH

Refrigeration System KWH Use per Bushel; D / bushels stored = __________ KWH/bu

Target Energy Use with the ENERSAVE Control System; 1 – 1.5 KWH/bu